

Oral health status of schoolchildren living in rural and urban areas in southern Brazil

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Abstract: This study assessed the effect of area of residence (rural vs. urban) on dental caries experience among southern Brazilian schoolchildren. This cross-sectional survey was conducted in Rosário do Sul, southern Brazil, and included 373 9–14-year-old schoolchildren attending public municipal schools (122 living in the rural area, and 251, in the urban area). Data collection included a questionnaire and a clinical examination. Clinical examination of the permanent dentition involved visible plaque index, gingival bleeding index and dental caries experience (non-cavitated and cavitated, inactive and active lesions). Samples of water were collected to check the fluoride concentration. Caries prevalence and extent using different criteria were compared between rural and urban schoolchildren using the chi-square test and the Mann-Whitney test, respectively. The association between explanatory variables and the extent of caries activity (number of active caries lesions) was assessed using Poisson regression. When caries was recorded at the cavity level (WHO criterion), no difference was observed between rural and urban populations ($p \geq 0.05$). Conversely, higher caries prevalence and extent were found among urban schoolchildren when active non-cavitated lesions were also computed ($p < 0.05$). In the adjusted Poisson regression model, urban schoolchildren were 57% more likely to present more active lesions than rural students (RR = 1.57; 95%CI = 1.29–1.92). Rural communities did not have sufficient fluoride in the water supply, whereas ideal concentrations were detected in the urban areas. In conclusion, this cross-sectional study found that urban schoolchildren showed greater caries experience than rural students, and that this increment was related to active non-cavitated lesions.

Keywords: Dental Caries; Rural Population; Epidemiology; Students; Fluorides.

Introduction

Despite the significant decline in caries prevalence and progression over the last decades, dental caries remains a global public health challenge.¹ One of the issues of public health strategies involves managing distribution of the disease in different geographical areas, and in rural versus urban households,^{2,3,4,5} since place of residence has the potential

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of shaping the behavior and lifestyle of individuals, and can influence access to health services, including dental treatment.

Previous studies have investigated whether there are differences in the caries experience between rural and urban populations. Some studies have reported poorer oral health conditions with a higher caries experience in small cities and rural communities.^{2,5,6,7,8} In this sense, rural life could expose individuals to limited access to both health services and fluoridated water, as well as to a low educational level,^{9,10} all of which notably play a role in dental caries development. Whereas Al-Rafee et al.¹¹ found no difference between rural and urban schoolchildren in this regard, controversial results revealed higher caries experience in urban populations.^{12,13} This finding is conceivable, since living in an urban setting is known to increase exposure to unhealthy dietary habits,^{12,14,15,16} and to allow easier access to industrialized and processed food. The differences in caries prevalence between these populations are not clear, even when comparing areas with and without fluoride in the public water supply system.^{17,18}

Considering that further evidence is needed on this issue, the aim of this study was to assess the effect of the area of residence (rural vs. urban) on the dental caries experience among southern Brazilian schoolchildren according to two different detection criteria.

Methodology

Study design and sample

This cross-sectional survey was conducted in Rosário do Sul, a small-sized city located in southern Brazil, with an estimated population of 39,707 inhabitants in 2010.¹⁹ According to the guidelines set by the Brazilian Institute of Geography and Statistics, the city's population resides in two contrasting geographical settings: rural (4,776 inhabitants) and urban (34,931 inhabitants) areas.¹⁹ Whereas the urban population is supplied with fluoridated water (0.7–0.9 ppm F), and has local access to public dental service, the rural population does not have these facilities.

The selection process of the individuals for the survey was based on two distinct strategies, according

to the area of residence. In the urban area, a simple random sampling strategy was adopted to select the required sample of schoolchildren. All the municipal schools were included in the study ($n = 4$). A list of all the eligible schoolchildren was compiled for each school, and those eligible were selected using a table of random numbers. The number of enrolled individuals was proportional to the school size. Considering a finite population of 607 schoolchildren (data provided by the municipal authorities), an expected dental caries prevalence of 50% (worst case scenario), a power of 80% and a confidence level of 95%, 236 urban students had to be examined. A dropout rate of 10% was added, and 260 students were invited to participate. Alternatively, considering the reduced number of schoolchildren in rural villages, a demographic census was performed in the rural area. Accordingly, all the eligible students attending the 6 rural municipal schools were invited to participate. The eligibility criteria dictated that the schoolchildren had to attend public municipal school regularly, and be 9–14 years old. Considering that a) most schools in the rural area were municipal (except for one), and that b) students from the municipal schools were taking part in a program in which they regularly received fluoride toothpaste and toothbrush from the public health system, whereas students from the state schools did not, we opted to include only municipal schools to avoid introducing a possible bias in the study. In both settings (urban and rural), individuals using fixed orthodontic appliances or presenting special needs were considered not eligible for the study. Children living in the rural area, but studying in urban schools were also considered not eligible, to avoid biasing the study results.

Data collection

Data collection was performed from March 2015 to October 2015, including clinical examinations and a questionnaire. Clinical examinations were conducted at the schools, with schoolchildren in a supine position. Portable equipment (artificial light, air compressor and suction system), a clinical flat mirror and a WHO probe were used. First, the examiner assessed the visible plaque index (VPI)²⁰ and the gingival bleeding index (GBI)²⁰ in four sites per tooth. After

professional tooth cleaning with toothbrush and dental floss, tooth isolation with cotton rolls and air drying, the dental surfaces were classified according to the following criteria adapted from Maltz et al.:²¹ (0) sound surface; (1) inactive non-cavitated lesion; (2) active non-cavitated lesion; (3) inactive cavitated lesion; (4) active cavitated lesion; (5) underlying dentin shadow without enamel breakdown; (6) restoration; (7) sealant; (8) indicated for extraction due to caries; (9) extracted due to caries. Caries activity assessment was performed based on visual-tactile inspection and evaluation of the clinical characteristics of the lesion, such as surface roughness, color, and light reflection (opacity/brightness). Clinical examination included all erupted permanent teeth.

A questionnaire was self-completed by the parents/legal guardians of the participants. Information on sociodemographics included age, sex, skin color, mother's and father's education and family structure. Oral health-related habits included tooth brushing frequency and amount of toothpaste, collected with the aid of drawings illustrating the categories. Access to dental services included questions on the last visit to the dentist, reason of the last visit and type of dental service.

The fluoride concentration available in the water supply of the two geographical areas was checked by collecting two samples of water from each school. An amount of 500 ml of water was collected with clean bottles from the taps where the students were used to drinking water. The samples remained in a refrigerated environment until analysis.

Reliability

Clinical examinations were performed by a single examiner (ADN), who was trained for VPI and GBI, and calibrated for dental caries and lesion activity criteria by a reference examiner (JEAZ). The training sessions included photographic assessment and clinical examinations. Examiner calibration was verified by double examinations of 10 children, with a 2-day minimal time interval between examinations. Unweighted kappa values of 0.83 for lesion activity and 0.84 for dental caries index were obtained (intraexaminer reliability). Interexaminer unweighted kappa values of 0.83 and 0.82 were observed for

lesion activity, and dental cares index, respectively. No formal calibration was attempted for VPI and GBI, owing to the modifiable nature of the indexes.

Fluoride analysis

Fluoride concentration of the samples was determined with a calibration curve using standard solutions at concentrations ranging from 0.25 to 2.00 µg F/mL, containing 50% of TISAB II. Triplicate samples and the calibration curve were analyzed using an ion-specific electrode (Orion 96-09, Thermo Scientific, Waltham, USA) coupled to an ion analyzer (Procyon, São Paulo, Brazil).

Data analysis

The primary outcomes of the study were caries prevalence (proportion of individuals presenting caries experience in the permanent dentition; binary outcome) and caries extent (number of permanent teeth with caries experience; count outcome). Estimates were computed using different criteria to define the D component: WHO criterion,²² including only cavitated lesions; modified WHO criterion, including the active non-cavitated and all the cavitated lesions.²³ Both criteria were used to calculate the DMFT index, defined as the number of decayed, missing or filled teeth. The different components of the index (DT, MT, FT) were also described separately. In addition, caries experience was analyzed considering just active caries lesions, whether cavitated or non-cavitated.

The main predictor variable was area of residence (rural or urban). Sociodemographics (age, sex, skin color, mother's and father's education, and family structure), behavioral variables (tooth brushing frequency and amount of toothpaste), access to dental services (last visit to the dentist, type of dental service and reason for the last visit to the dentist), and clinical variables (VPI and GBI) were considered possible confounders of the relationship between area of residence and caries. Age was dichotomized as ≤ 10 years or > 10 years. Skin color was dichotomized as "white or "non-white." Mother's and father's education was categorized as ≤ 8 years or > 8 years. Family structure was classified as nuclear (schoolchildren living with both father and mother) or non-nuclear (schoolchildren living with only

father or mother or other guardians). Tooth brushing frequency was dichotomized as ≥ 2 times/day or < 2 times/day. The amount of toothpaste usually applied on the toothbrush was classified as “fully covered bristles” or “rice grain or pea.” Last visit to the dentist was classified as < 12 months or ≥ 12 months. The reason for the last visit to the dentist was classified as routine examination, pain or other. The type of dental service was classified as private or public. Clinical variables included the VPI and the GBI, classified according to tertiles.

Statistical analysis was performed using STATA 12.0 software (Stata Corp, College Station TX, USA). Rural and urban populations were compared according to explanatory variables using the chi-square test. Caries prevalence and extent using different criteria were compared between rural and urban areas, using the chi-square test and the Mann-Whitney test, respectively. The association between explanatory variables and the extent of caries activity (number of active caries lesions, both cavitated and non-cavitated) was assessed using unadjusted and adjusted Poisson regression models. All explanatory variables were maintained in the adjusted model irrespective of their p-values, because our intention was to remove any possible effect of other variables from the association between area of residence and caries. Rate ratios (RR) and their respective 95% confidence intervals (CI) were estimated. The level of significance was set at 5%.

Ethical aspects

The study protocol was approved by the Federal University of Santa Maria Research Ethics Committee (CAAE 37862414.5.0000.5346). All participants and their legal guardians signed an informed consent form. Students received a report of their oral health status, and were referred to dental treatment, as needed.

Results

Ten schools were included in the study, 6 being rural and 4, urban. A total of 373 out of 390 schoolchildren were included in the study, yielding an overall response rate of 95.6%. Based on the area of residence, a response rate of 93.8% was obtained in rural schools

(122 included out of 130 invited), and 96.5%, in urban schools (251 included out of 260 invited). Table 1 shows a significant difference between rural and urban students in relation to their mother’s and father’s education, family structure and VPI. Schoolchildren living in the rural area had less educated parents, a greater proportion of nuclear families and lower levels of plaque accumulation than their urban counterparts ($p < 0.001$).

Distinct results were observed when analyzing caries prevalence and extent, according to the criteria used (Table 2). When dental caries was assessed according to the WHO criterion (cavity level), no difference was observed between the rural and urban populations ($p \geq 0.05$). Similarly, when this index was decomposed, no significant difference was found for DT, MT or FT between the two populations studied ($p \geq 0.05$). On the other hand, higher caries prevalence and extent were found among urban schoolchildren when the modified WHO criterion was used to compute the DMFT index ($p < 0.05$). Furthermore, the same tendency was observed when analyzing only the D component and the activity criterion ($p < 0.05$).

Table 3 shows the association between explanatory variables and the extent of caries activity (number of active caries lesions). In the unadjusted models, area of residence, age, skin color, reason for last visit to the dentist, VPI and GBI were significantly associated with the outcome. With the exception of skin color, all the variables remained significantly associated with the extent of caries activity in the adjusted model. In the adjusted Poisson regression model ($n = 263$), urban schoolchildren were 57% more likely to present more active lesions than rural students ($RR = 1.57$; $95\%CI = 1.29-1.92$). In addition, students who were older ($RR = 1.72$; $95\%CI = 1.43-2.06$), who visited the dentist due to pain ($RR = 1.25$; $95\%CI = 1.07-1.47$), and who had greater VPI (3rd tertile, $RR = 1.32$, $95\%CI = 1.06-1.64$) and GBI (2nd tertile, $RR = 1.43$, $95\%CI = 1.18-1.74$; 3rd tertile, $RR = 1.68$, $95\%CI = 1.35-2.10$), were also more likely to have a greater number of active lesions than their counterparts.

The analysis of fluoride concentration in the water samples revealed that rural communities did not have sufficient fluoride in the water supply, whereas ideal concentrations were detected in the urban areas, as shown in Figure.

Table 1. Sample distribution according to explanatory variables (n = 373).

Variable	Rural area	Urban area	p-value
	n (%)	n (%)	
Socio-demographics			
Age (years)			
≤ 10	53 (43.4)	91 (36.2)	0.18**
> 10	69 (56.6)	160 (63.8)	
Sex			
Female	59 (48.4)	125 (49.8)	0.79**
Male	63 (51.6)	126 (50.2)	
Skin color*			
White	85 (72.0)	149 (66.2)	0.27**
Non-white	33 (28.0)	76 (33.8)	
Mother's education* (years)			
> 8	12 (10.1)	71 (31.6)	< 0.001**
≤ 8	107 (89.9)	154 (68.4)	
Father's education* (years)			
> 8	7 (6.2)	63 (29.2)	< 0.001**
≤ 8	106 (93.8)	153 (70.8)	
Family structure*			
Nuclear	90 (76.9)	128 (56.1)	< 0.001**
Non-nuclear	27 (23.1)	100 (43.9)	
Behavioral variables			
Tooth brushing frequency*			
≥ 2 time/day	99 (83.9)	193 (83.9)	1.00**
< 2 time/day	19 (16.1)	37 (16.1)	
Amount of toothpaste*			
Fully covered bristles	58 (48.7)	131 (57.0)	0.14**
Rice grain or pea	61 (51.3)	99 (43.0)	
Access to dental services			
Last visit to the dentist*			
< 12 months	79 (80.6)	139 (72.4)	0.13**
≥ 12 months	19 (19.4)	53 (27.6)	
Type of dental service*			
Private	31 (32.0)	49 (25.7)	0.26**
Public	66 (68.0)	142 (74.3)	
Reason for the last visit to the dentist*			
Routine examination	48 (49.0)	86 (44.6)	0.51**
Pain (trauma, caries, fracture)	39 (39.8)	76 (39.4)	
Others (extraction, orthodontics...)	11 (11.2)	31 (16.0)	
Clinical variables			
Visible plaque index			
1 st tertile	70 (57.4)	60 (23.9)	< 0.001***
2 nd tertile	36 (29.5)	83 (33.1)	
3 rd tertile	16 (13.1)	108 (43.0)	
Gingival bleeding index			
1 st tertile	38 (31.1)	95 (37.8)	0.34***
2 nd tertile	46 (37.7)	82 (32.7)	
3 rd tertile	38 (31.1)	74 (29.5)	
Total	122 (100)	251 (100)	

*Missing data; **Chi-square test; ***Chi-square test for linear trend.

Table 2. Caries prevalence and extent according to different criteria.

Variable	Rural area	Urban area	p-value
DMFT (WHO)			
Extent (mean, SD)	1.33 (1.64)	1.03 (1.37)	0.07*
Prevalence (%)	59	48	0.05**
DMFT (modified)			
Extent (mean, SD)	2.72 (2.26)	3.64 (2.68)	0.001*
Prevalence (%)	81	89	0.03**
DT (WHO)			
Extent (mean, SD)	0.87 (1.25)	0.75 (1.21)	0.45*
Prevalence (%)	45	41	0.50**
DT (modified)			
Extent (mean, SD)	2.29 (2.07)	3.39 (2.49)	< 0.001*
Prevalence (%)	76	88	0.003**
MT			
Extent (mean, SD)	0.15 (0.75)	0.60 (0.31)	0.22*
Prevalence (%)	74	44	0.23**
FT			
Extent (mean, SD)	0.33 (0.83)	0.23 (0.70)	0.38*
Prevalence (%)	18	15	0.41**
Activity			
Extent (mean, SD)	2.02 (1.92)	3.21 (2.45)	< 0.001*
Prevalence (%)	70	86	< 0.001**

*Mann-Whitney test; **Chi-square test.

Discussion

This study was conducted to compare dental caries distribution between rural and urban schoolchildren in a southern Brazilian municipality, aiming to investigate whether the area of residence affected caries patterns. Considering only cavitated lesions, no difference was found between the two populations studied. However, when active non-cavitated lesions were also considered, urban schoolchildren showed higher disease estimates.

The population of this municipality may be considered as one of low-carries, with a mean DMFT of 1.03 for the urban area and 1.33 for the rural area, in contrast to the national mean of 2.07 among 12-year-old Brazilian children.²⁴ Although we did not detect a significant difference between urban and rural populations using the WHO criterion (neither the whole DMFT index nor its components), higher caries estimates were found in children living in urban areas when the modified WHO criterion was used. These results corroborate those of previous

studies assessing place of residence. Irigoyen et al.¹² evaluated the difference in the distribution of dental caries between a rural and an urban population, and found lower DMFT rates for those living in the rural community.¹² Similarly, Levin et al.,¹³ showed that children living in rural and remote areas appear to have better oral health than those living in the city.¹³ The study by Kalita et al.²⁵ assessing 3–17-year-old Indian schoolchildren showed that students living in urban areas were twice as likely to develop dental caries as those living in rural areas.

The fact that urban schoolchildren were more likely to present caries activity may be related to behavioral and dietary habits. People living in urban areas are more exposed to cariogenic diets, rich in sugary foods and drinks, offered or available even at school.^{12,13,14} Conversely, healthier dietary habits seem favored in rural areas, where shopping centers, supermarkets and snack bars are not common, thereby restricting access to processed and industrialized products.^{12,13} This situation is the case in Rosário do Sul, considering that rural schools are located at a distance ranging from 5 to 58 km from the city center. The oral health condition of rural schoolchildren was better than that of urban students, despite the absence of an ideal fluoride concentration in the water supply. Notwithstanding, all students received fluoride toothpaste and toothbrush regularly from the public health system. This information led us to infer that the widespread use of fluoridated toothpaste observed in the rural and urban areas may have offset the unequal availability of fluoridated water. Regular access to fluoridated toothpaste and toothbrush observed in the schoolchildren population of Rosário do Sul may explain the disagreement between our findings and those by Antunes et al.² and by Mello et al.,⁷ who found a greater caries experience among rural schoolchildren.

In regard to the other explanatory variables included in the final model for adjustment, all are supported by the current literature. Considering the cumulative aspect of the disease, the relationship between age and caries experience is clear.^{1,24} Studies have consistently shown better oral health conditions among children with more educated parents.^{23,26} The association between plaque and gingivitis, in

Table 3. Association between explanatory variables and the extent of caries activity (number of active caries lesions). Unadjusted and adjusted Poisson regression analysis.

Variable	Unadjusted analysis			Adjusted analysis		
	RR	95%CI	p-value	RR	95%CI	p-value
Sociodemographics						
Area of residence						
Rural	1.00			1.00		
Urban	1.59	1.38–1.84	< 0.001	1.57	1.29–1.92	< 0.001
Age (years)						
≤ 10	1.00			1.00		
> 10	1.67	1.46–1.91	< 0.001	1.72	1.43–2.06	< 0.001
Sex						
Female	1.0			1.00		
Male	1.08	0.96–1.22	0.21	1.01	0.87–1.18	0.90
Skin color						
White	1.00			1.00		
Non-white	1.25	1.09–1.42	0.001	1.07	0.91–1.26	0.39
Mother's education (years)						
> 8	1.00			1.00		
≤ 8	1.05	0.90–1.22	0.51	1.12	0.93–1.36	0.24
Father's education (years)						
> 8	1.00			1.00		
≤ 8	0.96	0.82–1.12	0.60	1.11	0.92–1.34	0.29
Family structure						
Nuclear	1.00			1.00		
Non-nuclear	1.02	0.89–1.16		0.99	0.84–1.16	0.86
Behavioral variables						
Tooth brushing frequency						
≥ 2 time/day	1.00			1.00		
< 2 time/day	0.97	0.81–1.15		0.85	0.69–1.06	0.15
Amount of toothpaste						
Fully covered bristles	1.00			1.00		
Rice grain or pea	1.12	0.99–1.27		1.13	0.97–1.31	0.12
Access to dental services						
Last visit to the dentist						
< 12 months	1.00			1.00		
≥ 12 months	1.12	0.96–1.31		1.04	0.88–1.23	0.62
Type of dental service						
Private	1.00			1.00		
Public	1.02	0.87–1.19		0.92	0.78–1.09	0.36
Reason for last visit to the dentist						
Routine examination	1.00			1.00		
Pain (trauma, caries, fracture)	1.27	1.09–1.46		1.25	1.07–1.47	0.01
Others (extraction, orthodontics)	0.97	0.78–1.20		1.00	0.79–1.27	0.98
Clinical variables						
Visible plaque index						
1 st tertile	1.00			1.00		
2 nd tertile	1.37	1.16–1.61		1.22	0.99–1.49	0.06
3 rd tertile	1.98	1.70–2.31		1.32	1.06–1.64	0.01
Gingival bleeding index						
1 st tertile	1.00			1.00		
2 nd tertile	1.49	1.27–1.75	< 0.001	1.43	1.18–1.74	< 0.001
3 rd tertile	2.03	1.74–2.37	< 0.001	1.68	1.35–2.10	< 0.001

RR: Rate ratio; CI: Confidence interval.

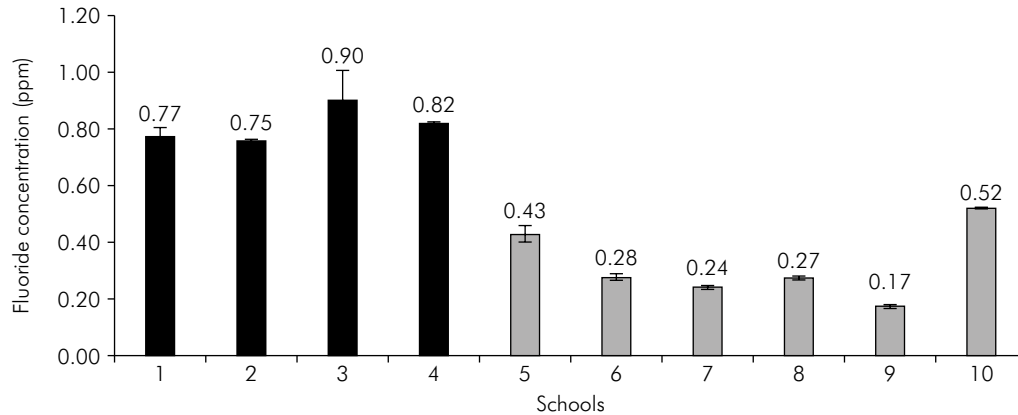


Figure. Fluoride concentration (ppm F) in water samples collected from the 10 schools included (urban schools in black, and rural schools in gray).

relation to a higher caries index, has been frequently reinforced in epidemiological studies.^{27,28,29} Regarding the dental attendance pattern, it is known that those who visit the dentist motivated by pain tend to show poorer oral health than those who visit the dentist for a routine examination.^{30,31,32} Regular visits to the dentist for preventive purposes demonstrate parents' motivation to maintain their children's oral health.

Among the strengths of this study, we can emphasize the clinical examination protocol adopted, including tooth cleaning and drying, and the inclusion of active non-cavitated lesions, which was a determinant for the study findings, since the difference between rural and urban students was related to these lesions. Our findings emphasize the importance of including caries activity assessment in epidemiological studies.^{23,33} Among the measures adopted to avoid potential sources of bias, we would like to highlight our training and calibration processes (measurement bias), as well as our sample selection strategy, which included a census in the rural area and the selection of a representative sample in the urban area (selection bias). Even under field conditions, it was possible to obtain "almost perfect" kappa values according to Landis and Koch.³⁴ These measures reinforce the internal validity of our study. The lack of dietary information could be considered a limitation of our study. An imbalance between the number of rural and urban schoolchildren could be seen as another possible limitation of our study; however, in calculating the statistical power of the study to

compare the DMFT according to the modified WHO criteria, we obtained a value of 93.4%. The number of participants with missing data due to incomplete questionnaires may have introduced some bias into the risk assessment analysis; however, no significant difference was detected between schoolchildren with complete data and those with incomplete data regarding age, sex, area of residence and dental caries ($p > 0.05$, data not shown). Therefore, we do not believe that this had a major effect on the study associations. Within the limitations of this study, we could infer that preventive strategies based on the availability of fluoridated toothpaste in rural populations without access to fluoridated water can achieve similar or even better caries rates than those in urban populations.

In conclusion, this cross-sectional study found that urban schoolchildren showed a greater caries experience than rural students, and that this increment was related to active non-cavitated lesions. No difference was detected at the cavity level, according to the WHO criterion.

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