







ORIGINAL ARTICLE

Pattern of caries lesions and oral health-related quality of life throughout early childhood: A birth cohort study

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Abstract

The aim of this study was to evaluate the impact of different patterns of dental caries on oral health-related quality of life (OHRQoL) throughout early childhood. This birth cohort study followed 277 children from southern Brazil for 6 years. Demographic and socioeconomic variables were collected at birth. At age 3 years, children's dental caries experience was quantified by the decayed, missing, or filled teeth (dmft) index. At age 6 years, parents answered the Early Childhood Oral Health Impact Scale (ECOHIS). Poisson regression models were used to estimate associations between caries experience and later OHRQoL, presented as the ratio of ECOHIS scores between the groups. The prevalence of dental caries at 3 years of age was 37.5%. In children with caries, lesions only in anterior teeth, only in posterior teeth, and in both dental segments at age 3 were associated with age 6 ECOHIS scores that were 2.7, 7.8, and 6.2 times higher, respectively, than in children without dental caries experience. OHRQoL was worse among children with higher dmft scores. Dental caries lesions in posterior teeth by age 3 years was strongly predictive of adverse impacts on later OHRQoL, presumably as an indicator of continued disease experience in the intervening years.

KEYWORDS

child, dental caries, longitudinal study, oral health, quality of life

INTRODUCTION

Oral health-related quality of life (OHRQoL) has been considered one of the most relevant outcomes in dentistry. Studies over the last decade have been consistent in demonstrating that OHRQoL is negatively affected by different clinical factors, notably dental caries, especially in early childhood [1–3]. Most existing studies generally compare the quality of life

of children and their families between children with or without dental caries. Several recent studies further reported that greater caries lesion depth, as well as progression from superficial to deep lesions, is associated with a more negative impact on OHRQoL than superficial lesions [4, 5].

Early childhood caries (ECC) can be highly variable in its presentation, including the number of teeth affected from 0 to 20, and the dental segment affected—anterior, posterior,

or both [6–8]. Sugar consumption is the primary cause of dental caries, but the pattern of the teeth affected may depend on specific risk factors and dietary practices. For example, an anterior caries pattern may appear in children who drink sugary liquids in a bottle while sleeping or between meals [9]. The pattern of caries presentation can determine the appropriate treatment strategy and treatment complexity, from the choice of dental materials to the need for treatment in a hospital setting [7, 9]. Likewise, certain caries patterns could impose a heavier OHRQoL burden than others on children and their families. Prioritizing ECC management of disease patterns most likely to impact quality of life may be particularly important in scarce resource settings.

Many existing investigations have shown strong concordance between OHRQoL and ECC prevalence or the total number of caries-affected teeth [1–4]. However, most studies have been cross-sectional and few have considered the dental segment location where caries occurs. While one study reported a negative impact of dental caries in both the anterior and posterior segments, another investigation found that only lesions on the posterior teeth impacted OHRQoL [10–11]. Segment-specific and longitudinal data may prove especially valuable for early identification of children and families most likely to experience meaningful negative quality of life impacts over time, allowing for more intensive secondary prevention and management interventions to target children with the most impactful disease presentation.

Thus, the aims of the present study were as follows: (i) to assess whether a greater number of teeth affected with dental caries lesions will correspond to worse OHRQoL; and (ii) to evaluate the dental segment affected as a predictor of future OHRQoL. We hypothesized that a greater number of caries-affected teeth will present worse future OHRQoL, and that children with anterior segment caries will present worse future OHRQoL than children with posterior segment caries.

MATERIAL AND METHODS

Study design and sample

This birth cohort study with 6 years of follow-up is nested in a randomized clinical trial carried out in 2008 beginning with a sample of pregnant mothers from Porto Alegre, in southern Brazil (clinicaltrials.gov: NCT00635453). The municipality has 1.43 million inhabitants, a Human Development Index of 0.805, and fluoridated water supplies (0.7 ppm F). At baseline, a total of 20 basic health units (BHU) were randomly selected among the 31 eligible BHU in the municipality. Subsequently, all pregnant women who attended the BHU were invited to participate in the study. However, HIV-positive pregnant women were excluded. The aim of the intervention was to investigate the effectiveness of providing training in

infant feeding guidelines to health workers at public primary care health centers on various child health outcomes. The intervention was effective in reducing sugar consumption in early childhood but there was no reduction in dental caries at age 3 years [12]. Other methodological details and previous results have been previously published [12, 13]. At baseline, 715 mother-infant pairs were enrolled.

Follow-up evaluations

After 3 and 6 years, all children and their mothers evaluated at baseline were invited to participate in a further assessment. The data collection period for the first follow-up took place during 2011, and for the second follow-up in 2014. Follow-up visits, including oral examinations, took place in participants' homes.

Data collection

For the present study, variables of interest included socioeconomic and demographic data at birth (baseline), clinical dental caries and dental trauma data at age 3 years, and OHRQoL at age 6 years. Socioeconomic and demographic data were collected through interviewer-administered, closed-ended structured questionnaires. Oral examinations followed protocols standardized by the World Health Organization for oral health surveys [14].

Dental caries was assessed at age 3 years in participants' homes using the decayed, missing, or filled teeth (dmft) index for primary dentition [14]. After the teeth were brushed and dried with gauze, two trained and calibrated examiners performed the dental clinical examination with the help of a lighted intra-oral mirror. Non-cavitated caries lesions were recorded but not included in this analysis due to low expected progression and impact on OHRQoL over time, as suggested by a previous cohort study in a similar age group [4, 15]. For data analysis, children were categorized as without cavitated caries lesions (dmft = 0), low severity (dmft = 1), medium severity (dmft = 2–4), and high severity (dmft ≥ 5). The severity categories were defined from the empirical distribution of children in this sample, dividing the number of children with dmft > 0 into three similarly sized groups. Furthermore, children were also categorized according to the dental arch segment affected by caries lesions [without caries, anterior (incisors and canines only), posterior (molars only), and anterior and posterior]. The inter- and intra-examiner reproducibility values for dental caries were $\kappa = 0.75$ and $\kappa = 0.83$, respectively.

At age 6 years, caregivers answered the Brazilian version of the Early Childhood Oral Health Impact Scale (ECOHIS) [16, 17] to measure the OHRQoL of their children, the main

outcome variable of this study. This instrument contains 13 questions in six domains. The instrument has two sections: (i) the child impact section; and (ii) family impact section. Response to each item is coded on a Likert scale: 0 = never; 1 = almost never; 2 = occasionally; 3 = frequently; 4 = very often; and don't know (later categorized as non-response) [16]. Printed cards with answer options were displayed while the interviewer read each question, as recommended in the literature [16]. In addition, the item referring to missing school was modified to include impact on daily activities such as running, playing, and jumping [17]. Responses were summed to total ECOHIS scores, ranging from 0 to 52. Higher scores represent worse OHRQoL.

Demographic and socioeconomic variables as well as traumatic dental injuries were collected as possible confounding factors. At baseline, demographic variables included maternal age (in years) and child's sex (boy or girl). Socioeconomic variables included maternal education, family structure, household income, and social class. Maternal education was collected in complete years of education and categorized into <8, 8–10, and >10 years of formal education. Family structure was evaluated according to composition as nuclear (0 = child living with both parents) or non-nuclear (1 = living with only one parent or another person). Household income was measured in reais (Brazilian currency) and categorized according to Brazilian Minimum Wages (BMW, equivalent to US\$211 monthly) as <2 BMW or \geq 2 BMW. Social class was measured and categorized following criteria of the Brazilian Association of Market Survey Institutes (ANEP – ABIPEME), which includes five levels (A, B, C, D, E) [18], subsequently categorized as \leq C (lower socioeconomic status) or \geq B (higher socioeconomic status). At age 3 years, clinical evaluations of dental trauma were recorded according to the Andreasen classification [19] and categorized into the presence or absence of clinical signs of dental trauma.

Data analysis

Data analysis was performed using SPSS version 20.0 (IBM). A post-hoc power calculation demonstrated 80% power of the present study population to detect a difference in OHRQoL scores of 1.8 between children with and without dental caries lesions. A descriptive analysis of the sample according to demographic, socioeconomic, and clinical characteristics was performed. Participants followed and lost to follow-up were compared using chi-square tests and *t*-tests.

Total ECOHIS score and specific ECOHIS domain scores were compared between children with and without cavitated caries lesions at age 3 years, according to the segments affected by dental caries (anterior and posterior), and dmft severity (0, 1, 2–4, and \geq 5) using Mann–Whitney and

Kruskal–Wallis tests. The same tests were used to compare the total ECOHIS scores between categories of the adjustment variables, using Bonferroni's correction for variables with three or more categories. Subsequently, multivariable adjusted Poisson regression analysis with robust variance was performed. Two multivariable models were run: a model with adjustment only for demographic and socioeconomic variables, and another for demographic, socioeconomic, and oral health variables, as proposed by the hierarchical approach [20]. Considering that the mean number of affected teeth varied according to the segment, the comparison between the segments was also adjusted for the number of teeth affected by caries. The allocation group in the original trial (intervention or control) was used as an adjustment variable in all models. The results are presented as the ratio of ECOHIS scores between the groups with 95% confidence intervals (CI).

The study was approved by research ethics committees of the Federal University of Health Sciences of Porto Alegre and the University of California Berkeley. After investigators explained the study protocol, mothers signed an informed consent form.

RESULTS

Of the 715 mothers evaluated at baseline, 475 (cohort retention: 66.4%) and 337 (cohort retention: 47.1%) were evaluated after 3 and 6 years, respectively. The final sample consisted of 277 children who were evaluated at 3 and 6 years for the variables of interest in this study (Figure 1). Losses to follow-up were mainly due to changes of address or study withdrawal. There were no meaningful differences in baseline characteristics between participants followed and lost to follow-up; maternal education was statistically significantly but not meaningfully lower among dropouts ($p = 0.03$).

The sample characteristics for children evaluated at 3 and 6 years were similar (Table 1). The study population was predominantly of low socioeconomic status as measured by educational attainment and social class. At age 3 years, more than one-third (37.5%) of children presented with dental caries; 22.4% of children presented with dental caries lesions in anterior teeth and 29.2% in posterior teeth. The dmft index ranged from 1 to 15, with a mean of 1.3 (SD 2.6).

The overall and specific domains of ECOHIS scores at age 6 years were strongly associated with dental caries status at age 3 years (Table 2). ECOHIS scores ranged from 0 to 33 with a mean of 3.2 (SD 5.2), and 49.5% of caregivers reported some OHRQoL impact (score \geq 1). Total and specific domains of ECOHIS scores were higher among children with any caries lesions than among children with none and were the highest among children with the highest scores on the dmft index.

TABLE 1 Demographic, socioeconomic and clinical characteristics for children evaluated at childbirth, at 3 years (initial cohort), and at 6 years of age (analytic sample), in Porto Alegre, Brazil

Variables	Initial cohort (n = 458)		Analytic sample (n = 277)	
	%	mean (SD)	%	mean (SD)
Maternal characteristics				
Age at childbirth (years)		25.9 (6.6)		25.6 (6.4)
Education attained (years)		8.5 (2.7)		8.8 (2.4)
Social class ^a ≤ C	78.2		77.3	
Child characteristics				
Sex (boys)	50.8		51.3	
Birth weight (g)		3288 (516)		3297 (529)
Length at birth (cm)		49.0 (2.5)		49.0 (2.5)
dmft ≥ 1 at 3 years old	39.5		37.5	

Abbreviations: cm, centimeters; g, grams; SD, standard deviation; dmft, decayed, missing and filled teeth.

^aBrazilian Association of Economic Research Institutes classification system; C or below indicates greater socioeconomic disadvantage.

TABLE 2 Distribution of overall and specific domains of ECOHIS scores at age 6 years according to dental caries status at age 3 years

Variables	Symptoms Mean (SD)	Function Mean (SD)	Psychological Mean (SD)	Self-image Mean (SD)	Parent distress Mean (SD)	Family function Mean (SD)	ECOHIS Mean (SD)
Total	0.6 (1.0)	0.7 (1.5)	0.3 (1.0)	0.2 (0.8)	1.2 (2.2)	0.2 (0.7)	3.2 (5.2)
Dental caries							
Absent	0.3 (0.7)	0.3 (1.0)	0.1 (0.4)	0.1 (0.4)	0.4 (1.2)	0.1 (0.3)	1.2 (2.8)
Present	1.1 (1.2)	1.2 (1.9)	0.7 (1.4)	0.4 (1.1)	2.5 (2.7)	0.5 (1.0)	6.4 (6.5)
<i>p</i> -value ^a	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
dmft index							
0	0.3 (0.6)	0.3 (1.0)	0.1 (0.4)	0.1 (0.4)	0.4 (1.2)	0.1 (0.3)	1.2 (2.8)
1	0.8 (1.3)	0.9 (1.7)	0.3 (1.0)	0.2 (0.7)	1.1 (1.9)	0.3 (0.9)	3.7 (5.4)
2–4	1.1 (1.3)	1.2 (2.2)	0.8 (1.7)	0.2 (0.8)	2.4 (2.7)	0.6 (1.2)	6.4 (7.2)
≥5	1.4 (1.1)	1.5 (1.8)	0.8 (1.4)	0.8 (1.6)	3.8 (2.8)	0.6 (0.9)	8.9 (5.6)
<i>p</i> -value ^b	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Anterior dental caries							
Absent	0.5 (1.0)	0.6 (1.4)	0.3 (0.9)	0.1 (0.6)	0.7 (1.7)	0.2 (0.6)	2.4 (4.7)
Present	0.9 (1.1)	1.0 (1.6)	0.4 (1.1)	0.5 (1.3)	2.7 (2.8)	0.4 (0.8)	5.9 (6.0)
<i>p</i> -value ^a	0.002	0.024	0.057	0.001	<0.001	0.001	<0.001
Posterior dental caries							
Absent	0.3 (0.7)	0.3 (1.1)	0.1 (0.4)	0.1 (0.4)	0.5 (1.4)	0.1 (2.9)	1.4 (3.0)
Present	1.3 (1.3)	1.4 (2.0)	0.8 (1.6)	0.5 (1.3)	2.9 (2.7)	0.7 (1.1)	7.6 (6.6)
<i>p</i> -value ^a	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Abbreviations: ECOHIS, Early Childhood Oral Health Impact Scale; SD, standard deviation; dmft, decayed, missing and filled teeth.

^aMann–Whitney *U*-test.

^bKruskal–Wallis test.

ECOHIS scores were distributed such that children with more caries-affected teeth and with dental caries lesions in both the posterior and anterior sections at age 3 years experienced the greatest OHRQoL impact at age 6 years (Figure 2). All children with 6 or more affected teeth reported some OHRQoL impact (score ≥ 1). The category of greatest OHRQoL impact (ECOHIS ≥ 9) was uncommon among

children with only anterior caries lesions but comprised one-third of children with posterior caries lesions and nearly half of children with both anterior and posterior lesions (Figure 2).

After adjustment for maternal and child variables, associations persisted such that children with dental caries lesions in both anterior and posterior teeth, with caries lesions only in posterior teeth, and children with a higher total dmft index

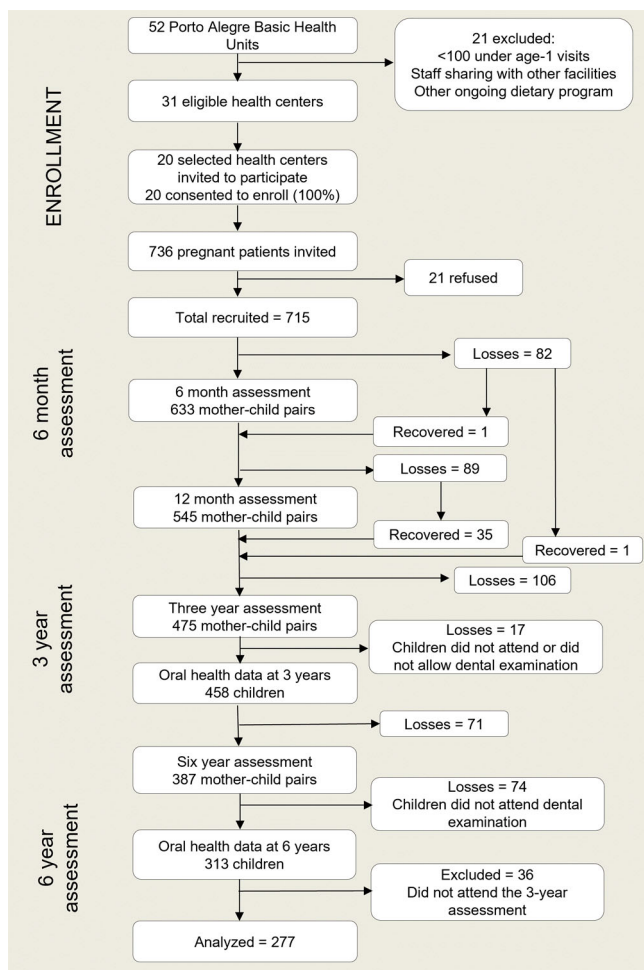


FIGURE 1 Cohort study flowchart

experienced the worse OHRQoL (Table 3). In the fully-adjusted model, children with dental caries only in anterior teeth, only in posterior teeth, and in both segments presented overall ECOHIS scores of 2.7, 7.8, and 6.3 times greater than children without dental caries, respectively. Similarly, overall ECOHIS scores were 2.6, 4.7, and 6.5 times greater in children with one dental caries lesion, 2–4 lesions, and 5 or more lesions than in children without caries lesions, respectively. Additional sensitivity analysis with adjustment for the occurrence of exfoliation of anterior deciduous teeth indicated that the estimates remained similar.

DISCUSSION

This study aimed to evaluate the impact of the number and location (anterior or posterior) of dental caries lesions in the primary teeth on OHRQoL throughout early childhood. The findings of the study partially confirmed the conceptual hypothesis. Higher OHRQoL scores were observed among children with a greater number of caries-affected teeth, as

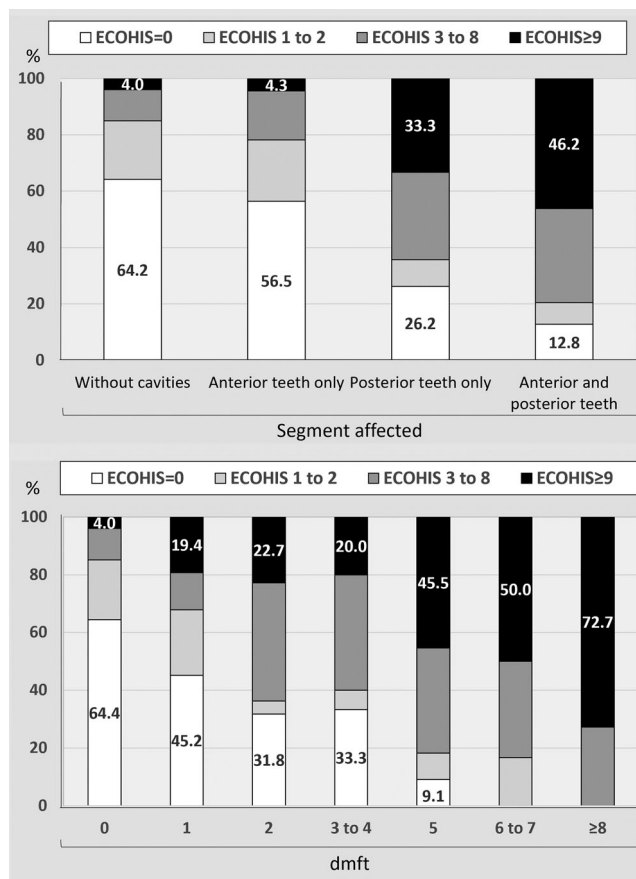


FIGURE 2 Distribution of Early Childhood Oral Health Impact Scale (ECOHis) scores according to the caries-affected dental segment and number of teeth with dental caries lesions. The decayed, missing, or filled teeth (dmft) index categories of 3 to 4, 6 to 7, and ≥ 8 were collapsed to allow at least 10 children in each category

expected. Contrary to the hypothesis, OHRQoL was more affected by dental caries lesions in the posterior segment than the anterior segment. Previous studies have reported the association between the location of dental caries lesions, as well as the severity, with OHRQoL [10, 11]. However, to our best knowledge, the longitudinal assessment of these factors has not previously been explored.

Dental caries lesions were associated with worse OHRQoL regardless of location in the mouth. However, lesions in the posterior segment presented three times greater impact compared to the anterior ones. Several considerations may contribute to this finding. Dental caries lesions in the anterior segment are primarily associated with nutritious sucking habits and occur in the early years of life [9, 21, 22]. At age 6 years, when the outcome of the present study was collected, dental caries lesions in the posterior teeth may be a more relevant cause of pain, compromising child and family well-being. Furthermore, by this age, parents and children may have adapted to presumably longer-standing anterior lesions that plausibly began during bottle-feeding on these

TABLE 3 Unadjusted and adjusted associations between dental caries at age 3 years and overall ECOHIS scores at age 6 years

Variables	Unadjusted model			Adjusted (Model 1) ^a			Adjusted (Model 2) ^b		
	Ratio	(95% CI)	<i>p</i> -value	Ratio	(95% CI)	<i>p</i> -value	Ratio	(95% CI)	<i>p</i> -value
Dental segment affected									
Without caries lesions	1.00	(reference)		1.00	(reference)		1.00	(reference)	
Anterior teeth only	1.74	(0.77–3.91)	0.179	1.69	(0.75–3.78)	0.214	2.69	(1.15–6.29)	0.023
Posterior teeth only	5.64	(3.58–8.90)	<0.001	5.18	(3.30–8.12)	<0.001	7.80	(4.68–13.00)	<0.001
Anterior and posterior teeth	6.53	(4.35–9.80)	<0.001	6.15	(4.04–9.36)	<0.001	6.30	(4.07–9.77)	<0.001
dmft									
0	1.00	(reference)		1.00	(reference)		1.00	(reference)	
1	2.93	(1.60–5.36)	<0.001	2.65	(1.44–4.89)	0.002	2.62	(1.42–4.81)	0.002
2–4	5.11	(3.11–8.38)	<0.001	4.75	(2.95–7.65)	<0.001	4.73	(2.93–7.65)	<0.001
≥5	7.11	(4.78–10.59)	<0.001	6.65	(4.40–10.06)	<0.001	6.48	(4.23–9.93)	<0.001

Abbreviation: ECOHIS, Early Childhood Oral Health Impact Scale; CI, confidence interval.

^aModel 1: Adjusted for maternal variables (demographic and socioeconomic) and intervention group allocation in nesting clinical trial.

^bModel 2: Adjusted for maternal variables (demographic and socioeconomic), intervention group allocation, plus child variables (sex and dental trauma) and for analysis of affected dental segment, total number of dental caries lesions.

earlier-erupted teeth. Disease resilience and adaptability increase over time, potentially lessening the impact on OHRQoL [23, 24].

Another explanation is that anterior dental caries lesions, despite being more visible, may have a limited impact on the social well-being of the family and child, whose stage of social and cognitive development is just beginning conscious social interaction [25]. In the present study, all ECOHIS domains were affected by dental caries lesions in the posterior segment, while the anterior segment did not impact the child's psychological domain, in agreement with previous studies [11]. Thus, impacts on OHRQoL were mainly related to dental pain and family function, which was more linked to the posterior segment in this sample. While differential OHRQoL impacts by domain may partially explain the differences in total ECOHIS scores observed between anterior and posterior teeth, a definitive explanation remains elusive. Only two previous studies have compared ECOHIS scores between segments, and the results were divergent [10, 11].

Compared to children without caries, OHRQoL scores doubled in children with one lesion, quadrupled in those with 2–4 lesions, and were six times higher in children with five or more lesions, a clear disease gradient of worsening of quality of life. This finding mirrors well-documented social gradients in oral health [3, 26]. Individuals of low socioeconomic status are more susceptible to multiple risk factors that affect general and oral health, such as less access to services, the practice of unhealthy behaviors, and greater psychosocial stress [26]. Similarly, low socioeconomic status has been closely associated with worse OHRQoL [27]. In the context of worse OHRQoL at each level of caries experience, even if complete dental caries prevention is not achieved, any reduction

in the number of caries lesions experienced has the potential to reduce negative OHRQoL impact.

Previous findings reported that deeper caries lesions have a greater OHRQoL impact than moderate or non-cavitated lesions [4, 28]. Fewer studies have compared child OHRQoL according to the number of teeth affected by caries [1, 29, 30]. In a cohort study of Brazilian preschool children, a greater number of new dental caries lesions in 2 years had a greater impact on OHRQoL [30]. The results of our present analysis suggest that both the number of affected teeth and where in the mouth those teeth are located are predictive of OHRQoL longitudinally.

Clinical implications emerge from our findings. The natural history of dental caries in early childhood shows that the maxillary incisors are often the first teeth to be affected, and the lesions, in general, are associated with behaviors such as using bottles for liquids containing sugar. Posterior teeth erupt between 12 and 24 months, and depending on the frequency of consumption of sugary foods or beverages, they may present with caries lesions soon after eruption, being heavily affected thereafter [9, 31]. There is a need to guide and support caregivers in controlling plaque in primary molars soon after their eruption, as well as reducing consumption of sugary foods and beverages. Oral health service delivery demands special human and material resources to manage posterior teeth lesions in young children. Dental sealant application can effectively prevent initial lesions in posterior teeth but is a more sensitive technique that requires more training than gel or fluoride varnish application, the strategies of choice for anterior teeth [9, 32, 33]. Dentin caries lesions are usually controlled in anterior teeth with the application of silver diamine fluoride, but in posterior teeth such lesions

more often require restorative treatment [9, 34]. However, there are substantial limits to addressing oral health quality of life through dental service delivery. Children with five or more caries-affected teeth all experienced some negative quality of life impact in this study, and widespread occurrence of that level of disease experience in the population is well beyond the service delivery capacity of most countries, where most caries lesions in childhood remain untreated [6, 35]. Broadly, there remains an unmet need for strong prevention-focused public policies to improve population oral health, reduce oral health inequalities, and preserve child well-being.

This study has some limitations. The location and number of caries-affected teeth is unlikely to remain constant over time. Thus, children without caries lesions or with lesions limited to the anterior region at age 3 years could develop new posterior lesions by age 6 years. We theorize the results demonstrate that general patterns of caries at an earlier age persist over time, exerting an OHRQoL impact that may not be fully realized until months or years of disease experience. Any children classified as anterior-only or without caries lesions who later developed posterior caries lesions would presumably make it more difficult to discern differential OHRQoL impacts by segment, suggesting the present result may understate underlying differences by segment. Losses to follow-up were substantial, although not atypical of similar studies of preschool children [13]. While attrition is a potential threat to the representativeness of our sample, the aggregate sample characteristics at 3 and 6-year follow-up remained similar. Our sample is representative of a population reliant on public health medical facilities, a less advantaged group to whom public policies should be directed. As strengths, this longitudinal study assessed relevant issues from the patient's perspective in an important developmental period, since adverse conditions in early childhood can have impacts throughout the life course [36].

In conclusion, our findings demonstrated that dental caries lesions in anterior and posterior segments impacted the children's OHRQoL, with a greater impact arising from posterior teeth. Furthermore, each higher number of teeth affected by caries lesions in early childhood was associated with worse OHRQoL over time. Both clinical and policy efforts to prevent and manage dental caries from an early age, particularly when molars are affected, are critical to reducing long-term adverse quality of life impacts.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

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