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Caries experience, obesity and demographic factors in school children: A cluster analysis

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Objective: To determine the association between caries experience, obesity, and socioeconomic and environmental factors in 2, 5 and 12 years-old schoolchildren. Secondarily, the influence of school infrastructure was assessed. ***Methods***: Primary data from 1762 schoolchildren from the municipality of Cajamar (SP, Brazil) and socioeconomic and environmental secondary data (Brazilian Census 2010, School Census, Prova Brasil/2017) were used. Caries and treatment experience (dmft/DMFT indices), dental occlusion, visible biofilm, weight and height were assessed. ***Results***: Caries experience was found in 6.5%, 40.2% and 46.5% of children at 2, 5 and 12 years, respectively. At 12y, greater caries experience was observed among children financially assisted by the Bolsa Família governmental program. Excess weight was found in 30%, 35% and 34% at 2, 5 and 12 years. At 2 and 5 years, the highest dental caries indices were associated with disadvantageous socioeconomic indicators (households water supply and sewage system, garbage collection, literate head and income), while overweight was associated with female sex and better socioeconomic aspects. At 12y, the group with obesity was characterized by low dmf+DMFT index and better household aspects, while the group with greater dmf+DMFT index comprised normal-weight children. A correlation between the percentage of caries experience and student/employee ratio of the school was observed. ***Conclusion***: An association between disadvantageous socioeconomic and environmental aspects and dental caries was observed, while obesity was associated with better socioeconomic status of the schoolchildren. While no direct association was found between obesity and dental caries, the results emphasize the influence of socioeconomic/environmental variables on health outcomes.

Keywords*: Dental Caries, Child, Childhood Obesity, Demographic factors*

Introduction

Brazil is experiencing a substantial increase in the prevalence of childhood obesity. The prevalence of overweight in children aged 5 and under increased from 6.6% in 2006 to 10% in 2019, and a pre-pandemic survey found overweight in 18.9%, 14.3% and 29.3 % in <2, 2-4 and 5-9 years-old children, respectively (Ministry of Health, 2019).

As in many countries, tooth decay is the most common chronic disease in childhood in Brazil (Kassebaum *et al*., 2017; Ribeiro *et al*., 2017). The high content of sugars and fermentable carbohydrates in the diet is an important predisposing factor for dental caries, characterized as a sugar/biofilm-dependent disease (Tinanoff *et al*., 2019). Past studies and systematic reviews have examined the relationship between childhood obesity and dental caries and observed that under/normal-weight children had lower frequencies of active caries than children who were overweight, suggesting that weight gain could be a risk factor for caries, or a bidirectional association might exist (Panwar *et al*., 2014; Manohar *et al*., 2020).

Different results were found in Mexican children (Aceves-Martins *et al*., 2022), and authors concluded that there was no conclusive association between obesity and dental caries. Instead, both conditions shared common risk factors, including the high consumption of fermentable carbohydrates and socioeconomic and behavioural factors (Tinanoff *et al*., 2019). As well as the consumption of processed foods, others pointed to the role of micronutrient deficiencies, low parental literacy, socioeconomic status, and cultural and environmental factors in the coexistence of obesity and tooth decay (Aceves-Martins *et al*., 2022; Fernandes *et al*., 2023). It appears that isolated analysis of individual susceptibility is insufficient to explain the occurrence of and progression both diseases and multidisciplinary research must consider all influencing aspects, identifying determinants and possible confounders of both conditions.

Assistance and nutritional programs, in addition to health education at school, have been implemented in Brazil over the years. The *Bolsa Família Program* (PBF) was created in 2003 and consists of financial assistance to families in poverty (Petrola *et al*., 2016), with the counterpart that beneficiary families keep children attending school. Considering the amount invested, it is important to evaluate its impact on nutritional and dental health outcomes.

While the use of primary data assists in making decisions about care at the individual level, the use of large sets of secondary data allows for strategic planning that, together with primary data, can improve health planning based on socioeconomic and cultural characteristics of the population.

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The main hypothesis of this study is that caries experience, childhood obesity and socioeconomic and environmental factors are associated. The secondary hypothesis is that the school structure may have an influence on health outcomes, since school is considered a privileged environment for health education (Haque *et al*., 2016). Thus, the objective was to determine the association between caries experience and obesity and whether the socioeconomic characteristics of the household and school infrastructure can influence this relationship in 2, 5 and 12 years-old schoolchildren in the city of Cajamar (SP), Brazil.

Method

This cross-sectional ecological study was approved by the Research Ethics Committee of the Universidade Federal de São Paulo (CAAE 78235517.6.0000.5505). The Term of Assent and the Term of Free and Informed Consent were obtained from all the children and their guardians.

The primary data came from an oral health survey carried out between April and June 2017 with children aged 2, 5 and 12 years-old from public and private schools of the municipality of Cajamar (SP). All schoolchildren aged 2, 5 and 12 years were invited. In 2017, the public education network comprised 3892 children enrolled in kindergarten (1704 in day care centres and 2188 in preschools) and 5136 students enrolled in elementary schools; in the private network, the number of students were 283, 285, and 939, respectively, totalling 14,928 students aged 0-14 years-old. The municipality is located approximately 30 km from São Paulo, south-eastern Brazil, with a population of 79,034 inhabitants and a schooling rate of 96.5% for children aged 6 to 14 years.

Clinical oral examination was carried out in the schools using personal protective equipment, clinical mirror, probe and cheek retractors (WHO, 2013). The team comprised five examiners (dental surgeons, staff of the Public Health System of Cajamar, SP), previously trained and calibrated by a "gold standard" examiner (DSA), specialist in Paediatric Dentistry and Public Health (kappa statistics ranging from 0.84 and 0.95). The assessments recorded: number of decayed, extracted/lost/exfoliated and filled teeth in the primary and permanent dentitions (dmf and DMFT indices, respectively); visible dental biofilm, scored as "yes" when at least one tooth surface had biofilm visible on visual inspection (Amato *et al*., 2023); Index of Orthodontic Treatment Need/Dental Component (IOTN), with grades 4 and 5 considered as needing orthodontic treatment (Uçüncü & Ertugay, 2001); presence of dental pain, reported by the child/parent/guardian (yes/no); and anthropometric assessment using a stadiometer and digital scale to obtain the body mass index (BMI, Kg/m^2) and nutritional classification (WHO, 2007). Data related to BFP beneficiaries were obtained through school records.

Secondary data were extracted on household socioeconomic and environmental characteristics (Brazilian Demographic Census 2010) and school performance and infrastructure (*Prova Brasil* 2017 and School Census 2017). Aggregated data from the last Brazilian Demographic Census available were extracted from each participant's address in the following categories: Basic, Household, Neighbourhood, Responsible, Income, Race and Schooling.

The *Prova Brasil* database was developed to evaluate the quality of education based on standardized tests and socioeconomic metrics applied to the 5th and 9th grades of elementary school; students answer Portuguese language (reading), and Mathematics (problem solving) Questions. The following information was extracted from the 2017 edition: administrative department (public/private school), teacher training (%), and number of participants (%) of the 5^{th} and 9^{th} years.

The School Census 2017 database provided data on the number of students, school performance and infrastructure (including the number of teachers, nurses, school leaders and administrators) (https://www.gov.br/inep/pt-br/areas-of-activity/research-statistics-and-indicators/school-census). Supplementary information was provided by the Department of Education of the Municipality of Cajamar.

Analyses were performed using SPSS 28.0 software by an Applied statistics specialist (PMC). An alpha level of 5% was adopted and analyses were performed separately for the ages of 2, 5 and 12 years. Exploratory analysis consisted of mean, standard deviation, and proportions. Comparison between continuous and categorical variables was performed using one-way ANOVA and Chi-square tests, respectively. Correlations between continuous data were assessed using the Spearman correlation test with Bonferroni correction.

To summarise and reduce the number of variables, principal component analysis was used to extract components from the secondary socioeconomic and environmental variables of the Brazilian Census database including: average number of residents per household; percentage of owned/acquired homes; percentage of households supplied with water from a well/rain/other; percentage of households without a bathroom; percentage of households with a garbage collection network; percentage of residents served by sewage system; percentage of female-headed households; percentage of households with a literate head; percentage of households earning at least the minimum wage. To fulfil the assumptions of the test, a correlation matrix of the standardized variables was examined and the number of components to be retained was based on the eigenvalues and explained variance. Varimax rotation was applied to maximize interpretation and the Kaiser-Meyer-Olkin measure and Bartlett test of sphericity were examined to observe the adequacy of the analyses. K-means cluster analysis identified groups of participants based on the correlations of clinical, socioeconomic and environmental variables. The final number of clusters and taxonomy were based on biological plausibility and interpretability of the clustering solution, and differences were described by the F-test for validation and interpretation purposes.

Results

In total, 1,762 children aged 2, 5 and 12 years participated from 32 of the 33 schools in the municipality. The clinical characteristics regarding caries indices, BMI and frequency of excess weight are shown in Table 1. Anthropometric assessment was carried out only in public schools and some students were absent on the day of collection. The dmf index was higher at 5 years-old compared to 12 years, while more children had caries

at 12 years. At 5 years, 59.8% of the children were free of caries. The dmft and DMFT indices of public schools were higher than those of private schools, although the small sample of private schools prevents further analysis. The BMI also increased with age, and the proportion of children who were overweight/obes varied between 30 and 35% in public schools.

Information regarding BFP beneficiaries was obtained from 836 children enrolled in public schools, of whom 27% belonged to beneficiary families. There was no difference in the dmf and DMFT indices between children incleuded or not in the program at 2, 5, and 12 years, nor in caries experience at 2 and 5 years. However, at 12 years, 57% of beneficiary children had caries experience, compared to 44% of children who were not included in the program (p=0.032). BMI showed no difference between those groups.

Data for 2 year-old children were summarized into three components that explained 66% of the total variance (Data available at: https://hdl.handle.net/20.500.12682/rdp/62U7GY): Component 1 included the proportion of households supplied with water from a well/rain/other, garbage collection, households earning at least the minimum wage, and those with literate head, in addition to the percentage of residents served by sewage system; Component 2 included having a literate or female head of household, number of households without bathroom; and Component 3 included the number of residents per household and the proportion of owned households. Cluster analysis identified three groups (Table 2): Cluster 1 'Higher dmf' included children with worse household socioeconomic and environmental aspects. As few children had caries experience at this age (6.5%), Cluster 1 included few individuals. Cluster 2, 'Better clinical indicators' included most of the children with better socioeconomic aspects regarding property ownership. Cluster 3 'Excess Weight' included more female children and those with better socioeconomic/environmental household parameters.

Table 1. Caries experience and anthropometric assessment of students divided by age and school funding.

School Administration	*Total students in 2017 (all ages)*	*Health outcome*	*2 years*	*5 years*	*12 years*
Private schools (n=6)	unknown	n included dmf+DMFT Mean (SD) % with caries experience	34 0.03 (0.17) 3	36 0.86 (2.0) 28	41 0.39 (0.77) 24
Public schools (n=26)	9515	n included dmf+DMFT Mean (SD) % caries experience	365 0.20 (0.87) 7	788 1.51 (2.52) 41	492 1.26 (1.77) 48
		n included BMI Mean (SD) % excess weight†	179 16.5 (1.7) 30	498 16.3 (2.6) 35	330 20.3 (4.4) 34

† Assessment carried out only in public schools.

Table 2. Clusters of demographic, clinical and socioeconomic variables associated with higher dmft, better clinical indicators and excess weight in 368 2-years-old.

	Cluster 1 'Higher dmf' (centroid mean)	*Cluster 2 'Better clinical indicators' (centroid mean)*	*Cluster 3 'Excess weight' (centroid mean)*	*F-test*
Number of cases	12	282	74	
Sex	0.50	0.37	0.82	27.48
dmf index	4.42	0.07	0.00	708.87
Reported dental pain	0.00	0.00	0.00	0.15
Visible dental biofilm	0.00	0.01	0.00	0.45
Severe malocclusion	0.00	0.00	0.00	0.15
BMI	16.65	16.35	24.31	29.92
Component 1 (socioeconomic and environmental aspects)	-0.89	-0.02	0.47	6.19
Component 2 (households with female as head)	-0.17	-0.01	-0.04	0.11
Component 3 (property ownership)	-0.42	0.18	-1.27	33.67

Converted in 5 iterations. Differences that identify the cluster are shown in dark gray.
dmf, number of decayed, exfoliated and filled teeth; BMI, body mass index. The answers 'Female gender' and 'Yes' to the questions were coded as 1.

Data for five-year-olds were also summarized into three components that explained 66.1% of the total variance: Component 1 included socioeconomic and environmental aspects, Component 2 summarized data regarding the percentage of female-headed households and the average number of residents per household; finally, Component 3 summarized data regarding property ownership and household head's literacy (Data available at: https://hdl.handle.net/20.500.12682/rdp/62U7GY). Three clusters were generated (Table 3): Cluster 1 'Higher dmf+DMFT index' with high frequency of dental pain and lower rate of property ownership, Cluster 2 'Normal-weight' and Cluster 3 'Excess Weight', which included children with higher BMI, lower caries index and better socioeconomic and environmental aspects.

Data for 12 year-olds were reduced into three components that explained 71% of the total variance (Data available at: https://hdl.handle.net/20.500.12682/rdp/62U7GY). Component 1 included socioeconomic and environmental factors; Component 2 included the proportion of female-headed households, owned households and income and Component 3 related to household infrastructure. Three clusters were generated: Cluster 1 included children with higher BMI, fewer female-headed households, more owned households and income, besides the lowest dmf+DMFT index; Cluster 2 "Greater dmf+DMFT index" comprised children with normal-weight; and Cluster 3 "Lean" included children were thin or had normal-weight, more boys, and the worse household infrastructure aspects of the census sector (Table 4).

Table 3. Clusters of demographic, clinical and socioeconomic variables associated with higher dmft, better clinical indicators and excess weight in 789 5-year-olds.

	Cluster 1 'Higher dmf+DMFT' (centroids; means)	*Cluster 2 'Normal-weight' (centroids; means)*	*Cluster 3 'Excess weight' (centroids; means)*	*F-test*
Number of cases	129	374	286	
Sex	0.55	0.50	0.49	0.77
dmf+DMFT index	6.36	0.82	0.23	1091.01
Reported dental pain	0.06	0.02	0.01	5.62
Visible dental biofilm	0.08	0.06	0.06	0.17
Severe malocclusion	0.02	0.01	0.01	0.02
BMI	16.37	15.07	19.85	300.03
Component 1 (socioeconomic and environmental aspects)	-0.07	-0.06	0.25	5.04
Component 2 (households with female as head)	0.09	0.14	0.08	0.21
Component 3 (property ownership and head's literacy)	-0.29	0.00	0.02	2.81

Converted in 10 iterations. Differences that identify the cluster are shown in dark gray.
dmf, number of decayed, exfoliated and filled teeth; BMI, body mass index. The answers 'Female gender' and 'Yes' to the questions were coded as 1.

Table 4. Clusters of demographic, clinical and socioeconomic variables associated with higher dmft, better clinical indicators and excess weight in 492 12-year-olds.

	Cluster 1 "Obesity" (centroids; means)	*Cluster 2 "Greater dmf+DMFT index" (centroids; means)*	*Cluster 3 "Lean" (centroids; means)*	*F-test*
Number of cases	146	146	200	
Sex	0.55	0.55	0.35	10.17
dmf+DMFT	0.36	2.05	1.34	39.42
Reported dental pain	0.08	0.06	0.05	0.47
Visible dental biofilm	0.37	0.39	0.40	0.89
Severe malocclusion	0.11	0.09	0.10	0.83
BMI	28.49	21.86	17.17	824.93
Component 1 (socioeconomic and environmental aspects)	-0.12	0.006	0.04	0.90
Component 2 (female-headed households, owned households and income)	-0.14	-0.055	0.04	1.15
Component 3 (household infrastructure)	-0.12	-0.19	0.14	4.40

Converted in 10 iterations. Differences that identify the cluster are shown in dark gray.
BMI, body mass index. The answers 'Female gender' and 'Yes' to the questions were coded as 1.

Some elementary schools did not participate in the *Prova Brasil* Program in 2017. Of the 32 municipal and private schools included, two were not served by the general water supply network and used water from well/cistern/bucket (which is not artificially fluoridated). Five schools were not served by the general sewage network and, therefore, used sanitary septic tanks; but they were all served by the periodic garbage collection service. There was no library in 15 of the 32 schools, and three did not have any playing fields, court or green area. Two schools did not have a computer but most had one or two computers for use by staff and/or students. The proportion of children with caries experience (Median=33.5%) correlated with student/employee ratio (Med=7.9) of the school (rho=0.67; $p<0.001$), while no correlation was found between school infrastructure and overweight prevalence. Of note, schools that scored higher in Portuguese language and Mathematics had more employees per student, lower caries indices and fewer overweight 12-year-old children (Data available at: https://hdl.handle.net/20.500.12682/rdp/62U7GY).

Discussion

At 2 and 5 years of age, the highest dmf indices were associated with disadvantageous socioeconomic and environmental indicators, such as fewer households served by the water and sewage system, garbage collection, not having a literate head of household and lower income. At 5 years, an association was also observed between higher caries indices and living in an area with fewer owned households. Conversely, overweight was associated with female sex and better socioeconomic factors, but not with dental caries. These results corroborate previous studies (Fernández *et al*., 2015; Amato *et al*., 2021) that pointed to common risk factors including signs of vulnerability and unfavourable living conditions, such as lack of sanitary sewage and overcrowded houses, and episodes of violence in the school environment, that are related to caries experience.

At 12-years-old, the cluster that included children with obesity was characterized by better household and income parameters of the census sector, besides the lowest caries index, while the group with greater dmf+DMFT index comprised children with normal-weight. Again, there was no apparent direct relationship between dental caries experience and obesity. Additionally, the "Lean" Cluster included more boys, children who were thin or had normal-weight and aspects of worse household infrastructure. The association between excess weight and better socioeconomic and environmental aspects conflicts with previous results in Korea (Lee *et al*., 2002), where obesity was associated with lower family income and nutritional status was associated with that of their parent. Better education may have a positive impact on health indicators, as the population would be more likely to make healthier choices (Mishra *et al*., 2018), although it should be noted that better education may also represent a confounder that influences the access to health care. Besides, regional and cultural differences between groups must be considered, challenging comparisons between different populations.

No difference in nutritional status was observed between children included or not in the financial assistance program. Previous studies have failed to associate receipt of this governmental assistance with children's health (Oliveira *et al*., 2013; Wolf & Barros, 2014). Wolf and Barros (2014) reported that beneficiary families consumed a greater variety of foods but tended to choose those with high calories and low nutritional value. Thus, sugar exposure may explain the higher prevalence of caries experience at 12 years. Oliveira et al. (2013) observed that the caries index at age 12 was twice as high in beneficiary students than those from private schools. In these analyses receipt of benefits may be a stronger indicator of deprivation than it is of the effect of the benefits.

The association between caries experience and the student/employee ratio of the school suggests an influence of school human resources on health outcomes (Haque *et al*., 2016). However, it is important to emphasize that school indicators may confound or mask broader social problems, such as the lack of financial support for schools located in unfavourable areas and their environmental problems that also impact health outcomes; thus, future longitudinal studies are needed to ascertain causality with either outcome.

Both childhood obesity and tooth decay are preventable diseases that have impacts on adulthood when left untreated (Tinanoff *et al*., 2019). Research on food consumption at school shows that, whether purchased in the school cafeteria, taken from home or provided by the institution, students still consume large quantities of foods with low nutritional value and high energy density (Rossi *et al*., 2019). The promotion of healthier environments should be a goal for reducing inequalities, as the exposure to adversity throughout life, especially during vulnerable periods, influences subsequent oral health (Singh *et al*., 2019; Amato *et al*., 2021).

The main limitation of the study is the lack of data regarding diet, which occurred due to the low adherence of parents/guardians in completing questionnaires. However, the use of secondary data provided important details that characterise the social, economic and environmental context in which the children live and develop.

In conclusion, in this study of Brazilian school children, dental caries was associated with disadvantageous socioeconomic and environmental factors, while obesity was associated with better socioeconomic status. No direct association between obesity and dental caries was found and a correlation between better school infrastructure in terms of human resources and lower caries experience was observed. Finally, proportionately more 12-year-old children who were received financial assistance from the *Bolsa Familia* Program had caries experience. We identified groups of children with specific profiles and needs for which health professionals and policy makers should develop targeted interventions.

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