

# Chronic malnutrition and oral health status in children aged 1 to 5 years

## An observational study

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### Abstract

To evaluate the effect of chronic malnutrition on the oral health of children aged 1 to 5 years.

An observational, analytical, cross-sectional study was conducted and involved 82 children (12–71 months of age). Nutritional status was evaluated using anthropometric indicators and oral health status/caries prevalence was measured. Non-stimulated saliva was collected and flow rate and buffering capacity was measured.

The mean dmft index was 1.38 for the adequately nourished children, 3.04 for those with mild malnutrition, 2.5 for those with moderate malnutrition and 2.4 for those with severe malnutrition. 69 of the 82 children had low to very low buffering capacity. No significant differences among the groups were found between malnutrition and age, buffering capacity or the dmft index ( $P > .05$ ). However, significant differences in salivary flow were found among the different malnutrition categories ( $P < .05$ ). Spearman correlation coefficient revealed a weak negative correlation between nutrition and salivary flow ( $r = -0.267$ ).

Malnutrition exerts a negative impact on the oral cavity of children and a reduction in salivary flow rate was observed with the increase in malnutrition. Diagnosing the effects of malnutrition in oral environment of children is important because it could improve the quality of life and give them an adequate treatment.

**Abbreviations:** ANOVA = analysis of variance, dmft = decayed, missing and filled teeth, HCl = hydrochloric acid, SBC = salivary buffering capacity.

**Keywords:** children, dental caries, mouth, protein malnutrition, saliva

## 1. Introduction

A balanced diet capable of providing adequate nutrition contributes to a desirable oral health status. Therefore, inadequate nutrition and the ingestion of specific foods exert an influence on the oral cavity.

Energy-protein malnutrition occurs when the body does not receive the nutrients necessary for its physiological metabolism due to the deficient intake of protein and energy or a defect in the use of the nutrients offered.<sup>[1]</sup> In the clear majority of cases,

malnutrition is secondary to a diet lacking in basic nutrients because of insufficient intake or chronic famine.<sup>[2,3]</sup>

Malnutrition in the first years of life, as reflected by anthropometric indicators of nutritional status, is one of the major health problems facing developing countries. There is exhaustive evidence that growth deficits in childhood are associated with a higher mortality rate, an increased occurrence of infectious diseases, impaired psychomotor development, a poorer academic performance and a lower productive capacity in adulthood.<sup>[4,5]</sup>

Despite steady improvements in oral health indicators, dental caries remains a serious public health problem in Brazil. Prenatal, intrauterine and postnatal factors have been associated with protein-caloric malnutrition.<sup>[6,7]</sup> Social, political, and cultural determinants are pointed as distal causes of child malnutrition because they influence the child's health care and illness. From this perspective, childhood caries also has a clear social component that is more prevalent in situations of social inequality, in both developed and developing countries.<sup>[8,9]</sup>

Episodes of malnutrition in early childhood, along with calcium, phosphate and vitamin A, C and D deficiencies, can increase one's susceptibility to dental caries through 3 probable mechanisms: defects in tooth formation (odontogenesis), the delayed eruption of teeth, and alterations in the salivary glands.<sup>[6]</sup> Thus, nutritional disorders exert a significant effect on dental formation due to the interference in cell development, contributing to the formation of hypoplastic enamel, which is more susceptible to caries.<sup>[7–9]</sup>

One of the factors that maintain oral cavity homeostasis is saliva. This fluid, which constantly bathes the teeth and the entire

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oral cavity, is produced in different quantities and with different compositions by glands major (parotid, submandibular, sublingual) and minors glands. The salivary flow measurement helps to assess the risk of installation and development of oral infectious diseases, including dental caries. According to the literature,<sup>[7–11]</sup> the severe reduction in saliva production causes deterioration in oral health and may also have an impact on the quality of life.

Episodes of malnutrition can also have a continuous effect on salivation, as chronic malnutrition in early childhood is directly correlated with a reduction in salivary flow in adolescence.<sup>[10,11]</sup> A reduction in salivary flow due to the atrophy of the salivary glands increases the susceptibility to dental caries. The main protective function of saliva against caries is the buffering effect, which prevents the intraoral reduction in pH following the ingestion of sucrose (sugar). Saliva also assists in the removal of cariogenic microorganisms from the oral cavity due both to the effect of salivary flow and the capacity to agglutinate bacteria.<sup>[12]</sup> The significant increase in susceptibility to dental caries in malnourished individuals is likely due to changes in the velocity of salivary secretion and a reduction in salivary flow also increases the possibility of dental erosion.<sup>[13,14]</sup> Also, salivary hypofunction can cause problems such as dry lips and mouth, dysgeusia, dysphagia, gingivitis, halitosis, chewing problems, difficulty with sleep and difficulties with phonation.<sup>[10]</sup>

The identification of collective risk factors for dental caries, such as social, economic and cultural conditioners, constitutes a strong tool that can help dentists understand the health-illness process in specific social groups.<sup>[6]</sup> At 5 years of age, the average child in Brazil has 2.43 teeth with caries experience, with a predominance of the decayed component, which accounts for 80% of the decayed, missing and filled teeth (dmft) index.<sup>[15,16]</sup> In Brazil, the National Policy for the Health Promotion, and the Health Pact, emphasize the importance of the role in promoting health, its determinants and common risk factors that act in chronic diseases.<sup>[16]</sup>

Oral health services present inequalities as to the identified in various countries, regardless of the nature, scope, and efficiency of their health systems. Since oral health services are limited a significant proportion of people are underserved. A group less likely to receive oral/dental care and therefore with unmet oral needs are children and adolescents.

Nutritional deficiency in early childhood can impact several of these factors, with the potential to change the conditions present in the oral cavity environment. Thus, the evaluation of social and biological factors that influence the development of oral problems can contribute to population-based studies aimed at identifying a preferential target public to receive care at public dental services, considering the scarcity of resources destined for the health sector and the vastness of accumulated needs.<sup>[17,18]</sup>

The aim of the present study was to evaluate the effect of chronic malnutrition on the oral health status of children aged 1 to 5 years by conducting an analysis of caries experience stratified by the degree of malnutrition and determine whether an association exists between nutritional status and both the quality and quantity of saliva.

## 2. Methods

An observational, analytical, cross-sectional study was conducted at the Nutritional Recovery Center in the city of Maceió,

Brazil, and involved 82 children between 12 and 71 months of age. This type of epidemiological study was chosen due to the need for studies that evaluate nutritional status as a risk factor for dental caries. Moreover, this design has the advantage of being straightforward and inexpensive.<sup>[19]</sup>

This study received approval from the Human Research Ethics Committee of University Center of Maceió (certificate number: 57811316.7.0000.0039). Clinical Trial registry: Clinical.trials.gov as NCT03529500, Last update in July 5, 2018.

### 2.1. Sample characteristics and size

The sample was consisted of 82 male and female children aged 12 to 71 months enrolled at the in the city of Maceió, state of Alagoas, Brazil. These children were chosen because they all were diagnosed with primary malnutrition. The convenience sample was used in this study, since children from slums close to the Center for Educational and Nutrition Recovery, were screened to attended the Center.

Alagoas is situated in the Northeast of Brazil. Alagoas has 140,000 children under 5 years of age, which 4% have chronic malnutrition. The greater vulnerability of these child group is even more worrying when it comes to children living in slums. The Center for Educational and Nutrition Recovery is situated in the seventh administrative region of Maceió, which has residents of 23 slums and the lowest human development index of the state. All the 100 children who were enrolled at the Center for Educational and Nutrition Recovery were invited to participate in the research.

Given the housing/socioeconomic situation, these children/families are categorized as being in poverty and extreme poverty facing situations of multiple vulnerabilities. The parental education was majorly limited to primary education. The context of life in which the child is inserted has a great influence on its growth and development. Children under 5 years of age are more vulnerable to nutritional problems, given their intense growth and loss of passive immunity. Therefore, in addition to reflecting a long-standing food deprivation framework, this deficit expresses negative environmental influences on childrens health, such as poor housing conditions, sanitation, hygiene, and food.

### 2.2. Inclusion criteria

Children aged 1 to 5 years-old enrolled at the Center for Educational and Nutrition Recovery in the city of Maceió whose parent/guardians signed as statement of informed consent agreeing to the participation of the children.

### 2.3. Exclusion criteria

Children aged 1 to 5 years-old not enrolled at the Center for Educational and Nutrition Recovery in the city of Maceió and children whose parents/guardians did not sign a statement of informed consent, teachers, caregivers, health professionals, and voluntary interns.

### 2.4. Evaluation of nutritional status

The children were weighed on a previously calibrated electronic scale (capacity: 150 kg; precision: 100 g) barefoot and wearing light clothing in the presence of the mother or caregiver. Height was determined using a non-flexible metric tape (maximum

length: 2 m; precision: 0.1 cm). Each measurement was made twice and the mean was used for the calculation height for age, weight for height, and weight for age. The guidelines of the World Health Organization<sup>[20]</sup> were the reference for the evaluation of nutritional status. Children with a cutoff point (z-score) between +1.5 and -1.5 standard deviations of the median of the reference were classified as having an adequate nutritional status, those with a z-score  $\leq -1.5$  were classified as having mild malnutrition, those with a z-score  $\leq -2$  were classified as having moderate malnutrition and those with a z-score  $\leq -3$  were classified as having severe malnutrition.

To avoid bias, the researchers did not know the nutritional status of the children during the whole experiment.

## 2.5. Evaluation of oral health status

**2.5.1. Dental caries.** The dental examination was performed by trained examiners using standardized techniques. The data collection was conducted in the Dentistry Sector of the Nutritional Recovery Center in a dental chair under conventional light. Prior to the examinations, the childrens teeth were cleaned with a toothbrush and fluoride toothpaste. A flat mouth mirror, tongue depressor and gauze (to clean and dry the teeth) were used during the examinations to enable the visualization of areas with non-cavitated lesions (white spots – areas of demineralization of the enamel with the loss of translucence – opaque white coloration without cavitation). No exploratory probes were used to avoid the transference of microorganisms from one surface to another and the possibility of damaging the demineralized surface of the enamel.<sup>[21]</sup>

Dental caries experience was recorded using the dmft index, which was employed following the recommendations of the World Health Organization<sup>[22]</sup> to establish the prevalence and severity of caries. Active visible white spots were also recorded. The examinations were performed in duplicate for each child with the aim of establishing inter-examiner agreement using the Kappa statistic,<sup>[23]</sup> which demonstrated good agreement ( $K=0.81$ ).

The criteria adopted for the determination of prevalence followed by guidelines of the Oral Health Surveys – Basic Methods, 4th edition<sup>[24]</sup> described in the examiners manual and annotators manual produced by the coordination team of the Brazil Oral Health Project.<sup>[15]</sup> The severity and prevalence of dental caries were determined based on the dmft index. In children, less than 3 years of age, any sign of caries on a smooth surface is indicative of severe early childhood caries. Between 3 and 5 years of age, severe early childhood caries is defined as 1 or more smooth surfaces with a cavitated carious lesion, missing surfaces (due to caries), restored surfaces on maxillary anterior primary teeth or when 4 or more surfaces are affected by caries at 3 years of age, 5 or more teeth are affected at 5 years of age and 6 or more teeth are affected at 5 years of age.<sup>[25,26]</sup>

**2.5.2. Saliva.** Samples of non-stimulated saliva were collected from the participants for 5 minutes using 2 aspirator tubes connected to a 15-ml Falcon tube. One aspirator tube was positioned under the child's tongue and the other was attached to the aspirator device. After 5 minutes, the amount of saliva was measured for the determination of salivary flow. Collections were performed between 9 and 11 AM and the time of the last meal was recorded. At least a 1-hour interval was required between the last meal and the collection of the saliva sample. The volume of saliva was measured. The salivary flow volume was calculated and

expressed as ml/minute. The following categories were considered in the analysis of salivary flow:  $<0.1$  ml/minute = xerostomia; 0.1 to 0.6 ml/minute = very low flow; 0.7 to 0.9 ml/minute = low flow; 1.0 to 2.0 ml/minute = normal flow; and  $>2.0$  ml/minute = high flow.<sup>[27]</sup>

After the measurement of salivary flow, an aliquot of 1 ml was transferred to a test tube with 3 ml of hydrochloric acid (HCl 5 mM) for titration and the determination of Salivary Buffering Capacity (SBC). The saliva/acid solution was shaken in a q 220 vortex tube agitator (Quimis, Diadema, SP, Brazil) for 15 seconds. Next, pH was determined in a portable pH meter (KASVI K39-0014P, Curitiba, PR, Brazil) for the determination of the SBC. The following categories were considered:  $\geq 5.5$  = very good buffering capacity; 5.4 to 5.0 = good buffering capacity; 4.9 to 4.5 = medium good buffering capacity; 4.4 to 4.0 = low buffering capacity; and  $\leq 3.9$  very low buffering capacity.<sup>[28]</sup>

## 2.6. Statistical analysis

The Shapiro–Wilk normality test was used to determine the distribution of the data. The Chi-squared test was used to compare the proportions of the different degrees of malnutrition among the children. ANOVA was used to compare age and mean salivary flow. The nonparametric Kruskal–Wallis test was used to compare the dmft index and buffering capacity categories. The level of significance for all tests was set at 5% ( $P < .05$ ). When ANOVA demonstrated a difference in mean salivary flow, Tukeys post hoc test was applied.

## 3. Results

No significant difference was found in the proportions of the sample distributed among the different nutritional status categories ( $P > .05$ ) (Table 1).

In the evaluation of the oral health status of the children at the Nutritional Recovery Center stratified based on nutritional status, the mean dmft index was 1.38 among those with an adequate nutritional status, 3.04 among those with mild malnutrition, 2.5 among those with moderate malnutrition and 2.4 among those with severe malnutrition. The mean dmft index of the children in this study was 4.57.

Girls in the present investigation ( $n=40$ ) had a mean dmft of 1.87, whereas the boys had a much higher index (2.83).

Forty two of the 82 children had active white spots. Mean salivary flow was  $0.35 \pm 0.14$  ml/minute (range: 0.10 to 0.66 ml/minute), which is in the very low category.

Sixty nine of the 82 children studied exhibited low to very low salivary buffering capacity.

The Shapiro–Wilk normality test for the comparison of age and salivary flow demonstrated normal distribution in all groups

**Table 1**  
Nutritional status of sample.

NUTRITIONAL STATUS	N	%
Mild malnutrition	24	29.3
Moderate malnutrition	22	26.8
Adequate nutritional status	18	22.0
Severe malnutrition	18	22.0
Total	82	100.0

Source: data from present study.

**Table 2**  
**Comparison of salivary flow, buffering capacity and dmft (decayed, missing and filled teeth) index among different nutritional status categories.**

VARIABLES	Mild Malnutrition		Moderate Malnutrition		Adequate Nutrition		Severe Malnutrition		P value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
SALIVARY FLOW (mL/min)	0.39	0.15	0.34	0.11	0.39	0.12	0.27	0.13	.012
BUFFERING CAPACITY	3.73	1.02	3.75	1.47	3.20	0.52	3.67	0.92	.243
dmft	3.04	4.40	2.50	4.03	1.39	2.40	2.44	4.73	.669

SD = standard deviation. Source: data from study.  $p < 0.05$ .

except the severe malnutrition group. In the comparison of buffering capacity and dmft index, none of the groups demonstrated normal distribution. Thus, the comparison of age and mean salivary flow was performed using ANOVA, whereas the comparison of buffering capacity and dmft index was performed using the nonparametric Kruskal–Wallis test. A 5% significance level ( $P < .05$ ) was adopted for all tests (Table 2).

No statistically significant associations were found between nutritional status, buffering capacity or dmft index ( $P > .05$ ). However, significant differences in salivary flow were found among the different nutritional status categories (ANOVA,  $P < .05$ ). Tukeys post hoc test revealed significant differences between children with mild and severe malnutrition as well as between those with an adequate nutritional status and those with severe malnutrition (Table 2).

The Nutritional Status only presents correlation with salivary flow rate, meaning that when the nutritional status gets more severe, the flow rate tendency to gets lower (Table 3).

Spearman correlation coefficient revealed a weak negative correlation between nutritional status and salivary flow ( $r = -0.267$ ), demonstrating a reduction in salivary flow with the increase in malnutrition. No significant correlations were found between nutritional status and age, buffering capacity or dmft index (Fig. 1).

#### 4. Discussion

The 2008 to 2009 Household Budget Survey reports that the northeastern region of Brazil has the second most frequent low weight for age rate (5.9%) in the country, behind only the northern region (8.5%).<sup>[29]</sup> In the city of Maceió, 50% of the population live in subnormal conditions and a large part of this group resides in the seventh administrative district of the city. In this district, which is where the Nutritional Recovery Center is located, more than 81,000 individuals inhabit informally constructed communities (slums) and approximately 10% of these individuals have some nutritional problem.<sup>[30,31]</sup> Although the prevalence of malnutrition has diminished greatly in Brazil, it continues to be an important public health problem, especially in

some “pockets” of poverty found on the outskirts of large cities, as demonstrated in the present study.<sup>[32,33]</sup> The role of malnutrition among children in less privileged social classes is of the utmost importance, as these children are deprived not only of a healthy diet, but are also often deprived of culture, education and affectivity, which causes even greater harm.<sup>[34]</sup>

Early childhood caries is recognized as a significant public health problem,<sup>[11,35]</sup> the prevalence of which varies across populations.<sup>[36–38]</sup> In Brazil, approximately 53.4% of 5-year-old children have caries experience and the mean dmft index among these children is 2.43 teeth, with a predominance of the decayed component, which accounts for more than 80.0% of the index.<sup>[16]</sup> The mean dmft index among the malnourished children was like the national average and the decayed component was also predominant. High dmft scores was found in malnutrition children like in other dental studies in low- and middle-income countries.<sup>[39–42]</sup>

The results, in this study, showed no statistically significant association between nutritional status and dmft index ( $P > .05$ ) in accordance within 3 studies,<sup>[43–45]</sup> different from other studies.<sup>[34,41,42]</sup>

Since the National Oral Health Survey only reports the dmft for 5-year-old children, the national average dmft index reported was 2.43. The mean dmft index of the children in this study was 4.57 for 5-year-old children, which was higher when compared to the National Oral Health Survey and is also higher than the average for the northeastern region (2.89).<sup>[15]</sup> This high index may be explained by environmental factors that exert an influence on both malnutrition and dental caries, such as socioeconomic aspects and inadequate diet/nutritional status (vitamin D, C, B, and A deficiencies).<sup>[8,9]</sup> Chronic malnutrition in early childhood is strongly associated with poorer cognitive and educational outcomes throughout childhood, lower wages, and productivity in adulthood.<sup>[42,46]</sup>

Like data described in other studies,<sup>[47,48]</sup> girls in the present investigation ( $n = 40$ ) had a mean dmft of 1.87, whereas the boys had a much higher index (2.83). This association may be due to socio-cultural and psychosocial factors, as previous studies report greater awareness and self-care among the female sex,<sup>[49–52]</sup> although the studies cited involved adolescents.

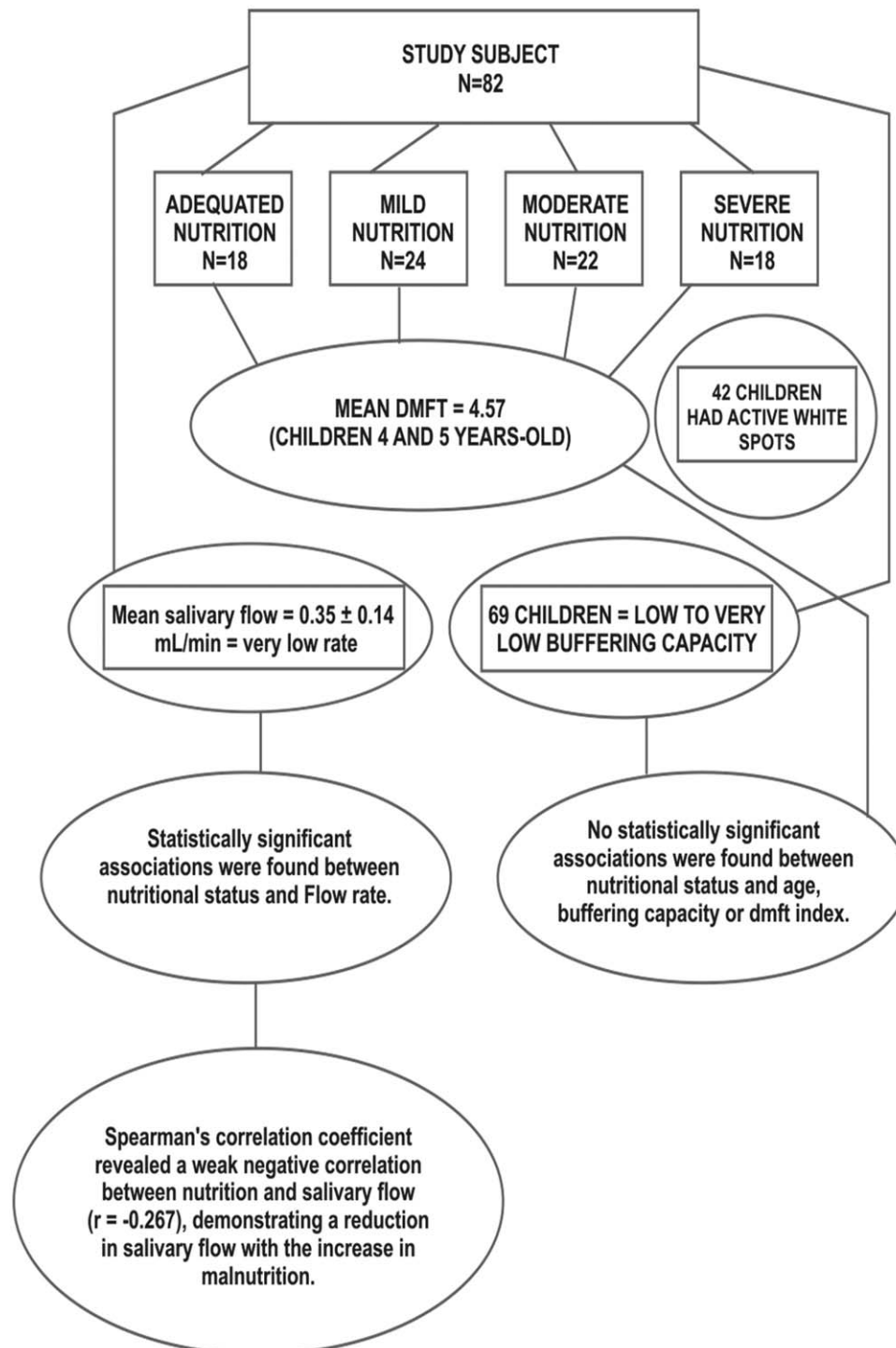
Forty two of the 82 children had active white spots, which suggests a high concentration of *Streptococcus mutans* as well as an insufficient protective effect of saliva, inadequate oral hygiene and deficient nutrition (defects in the enamel due to inadequate nutrient intake).<sup>[53,54]</sup>

Mean salivary flow was  $0.35 \pm 0.14$  ml/minute (range: 0.10 to 0.66 ml/minute), which is in the very low category. The normal functioning of salivary glands is required for maintaining a healthy oral cavity and hypofunction of the salivary glands is reported in individuals with malnutrition,<sup>[8,55]</sup> which results in reductions in

**Table 3**  
**Correlations with nutritional status.**

Variables	Coefficient (r)	P value
Nutritional status $\times$ age	0.110	.327
Nutritional status $\times$ salivary flow	-.267*	.015
Nutritional status $\times$ buffering capacity	-0.078	.486
Nutritional status $\times$ dmft (decayed, missing and filled teeth)	-0.091	.419

Source: data from study,  $P < .05$ .



**Figure 1.** Nutrition Status, dmft (decayed, missing and filled teeth), Salivary flow rate and Buffering capacity of children.

the salivary flow rate, storage capacity, and salivary components, especially proteins.<sup>[10,56]</sup> Protein and vitamin A deficiencies are associated with atrophy of the salivary glands, consequently reducing the defense capacity of the oral cavity against infection and the buffering capacity of acids stemming from plaque.<sup>[55]</sup>

The salivary flow rate is directly related to caries through oral depuration as well as in terms of buffering capacity and antimicrobial components.<sup>[56]</sup> Sixty nine of the 82 children

studied exhibited low to very low salivary buffering capacity. According to other studies,<sup>[8,57,58]</sup> malnutrition, particularly the inadequate intake of proteins and micronutrients, such as vitamins, zinc and iron, limits the protective effect of saliva in the oral cavity by altering its composition, which may have occurred in the present sample.

A review in malnutrition<sup>[8]</sup> found that different degrees of malnutrition can cause different changes in the salivary glands.

When nutritional status is adequate or malnutrition is mild, salivary flow does not undergo large changes. However, in cases of chronic malnutrition (height for age <90%), salivary flow tends to become deficient, which can trigger other health problems, such as respiratory problems due to the improper functioning of the protective factors of the oral cavity (saliva). As found in the present investigation, a study in involving children in India<sup>[59]</sup> demonstrated a reduction in the salivary secretion rate in cases of severe malnutrition.

The negative impact on salivary flow with the increase in the degree of malnutrition is of extreme importance. One retrospective cohort study,<sup>[10]</sup> found a continuous effect of malnutrition in early childhood on the reduction in salivary gland function in adolescence, demonstrating that exocrine gland systems can be impaired for long periods after malnutrition. This has important implications for the systemic antimicrobial defenses of the body.<sup>[8]</sup> A protein-deficient diet during childhood even leads to a persistent functional impairment of the salivary glands, which may have lasting effects on the immune defenses in the adult and be associated with significantly greater pathological conditions of the teeth.<sup>[60,61]</sup>

A limitation of this study was its sample size. The possible influence of potential confounders determined the establishment of strict inclusion/exclusion criteria, which may explain the limited number of participating children. In the present study, the risk of experiencing dental caries was elevated, since a reduction in salivary flow rate and decreased buffering capacity was observed in undernourished children as have been previously described.<sup>[9,10,26,62]</sup> Therefore, the results of this study showed that reduction in salivary flow rate had a correlation with the increase in malnutrition. This finding is extremely important because children with moderate and severe malnutrition should be better evaluated about salivary conditions to reduce caries and possibly other opportunistic diseases, since saliva is an important means of defense of the organism. Restricting the study sample to children from lower social classes while reducing the possibility of confounding bias may have implications for the external validity of the study. Thus, caution should be exercised when extrapolating the results of this study to different populations with other social classes or age groups.

## 5. Conclusion

Dental caries and malnutrition are public health problems that are concentrated in less privileged socioeconomic groups. The prevalence of caries was high in the present study, beginning in the first year of life and increasing in a constant manner thereafter. No significant differences in dental caries were found among the different categories of nutritional status. The relationship between weight/height and dental caries could also be confounded by other factors. However, salivary flow was found to diminish with the increase in malnutrition, which could aggravate the vulnerability of these children regarding both dental caries and opportunistic infections. This studied showed that there is a correlation between malnutrition and saliva flow rate which should be looked with more attention in the malnutrition children.

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