Dental plaque, preventive care, and tooth brushing associated with dental caries in primary teeth in schoolchildren ages 6–9 years of Leon, Nicaragua

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Background: Our study aimed to evaluate the effect of various risk indicators for dental caries on primary teeth of Nicaraguan children (from Leon, Nicaragua) ages 6 to 9, using the negative binomial regression model.

Material/Methods: A cross-sectional study was carried out to collect clinical, demographic, socioeconomic, and behavioral data from 794 schoolchildren ages 6 to 9 years, randomly selected from 25 schools in the city of León, Nicaragua. Clinical examinations for dental caries (dmft index) were performed by 2 trained and standardized examiners. Socio-demographic, socioeconomic, and behavioral data were self-reported using questionnaires. Multivariate negative binomial regression (NBR) analysis was used.

Results: Mean age was 7.49±1.12 years. Boys accounted for 50.1% of the sample. Mean dmft was 3.54±3.13 and caries prevalence (dmft >0) was 77.6%. In the NBR multivariate model (p<0.05), for each year of age, the expected mean dmft decreased by 7.5%. Brushing teeth at least once a day and having received preventive dental care in the last year before data collection were associated with declines in the expected mean dmft by 19.5% and 69.6%, respectively. Presence of dental plaque increased the expected mean dmft by 395.5%.

Conclusions: The proportion of students with caries in this sample was high. We found associations between dental caries in the primary dentition and dental plaque, brushing teeth at least once a day, and having received preventive dental care. To improve oral health, school programs and/or age-appropriate interventions need to be developed based on the specific profile of caries experience and the associated risk indicators.

Key words: oral health • dental caries • schoolchildren • primary dentition • Nicaragua • dental epidemiology

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Background

Dental caries is a multifactorial infectious and transmissible disease involving an imbalance of normal molecular interactions between the tooth surface/subsurface and the adjacent microbial biofilm where acids are produced [1]. Dental caries have a high prevalence and incidence around the world and remains the most common chronic disease in many Latin American countries and worldwide [2–10], although it is largely preventable. Disproportionately affecting socially disadvantaged populations, dental caries remains the most common unmet health need among children, primarily manifested as low experience of restorative dental treatment [6,8,9]. It is considered a public oral health problem.

Several studies undertaken in children of pre-school age and in schoolchildren have investigated the relationship between dental caries and relevant variables. For example, as far as socio-demographic factors are concerned, age and sex [2–6,8–10] seem to be associated with caries in different ways, depending on whether the primary or the permanent dentitions are examined. Other studies have found that the order of birth of the child may be a risk indicator for dental caries, but this relationship has not been fully confirmed [11–13]. With regard to socioeconomic factors, it is a common finding that with worse socioeconomic conditions, oral health status is deteriorated [4,6,14]. In terms of health behaviors, they seem to consistently be linked to better oral health status, primarily through adherence to tooth brushing; this is an important factor for dental caries prevention [4,5,14]. Brushing is the most effective way to mechanically remove dental plaque and deliver fluoride through toothpaste. Oral health promotion programs consistently stress brushing in educational messages given to children, adolescents, and adults [15,16]. Periodic use of oral health services, mainly the use of preventive health services [17,18], is another key message.

Epidemiological data about oral health indicators are available for only a few Latin American countries, notably Brazil and Mexico, but few studies have been conducted on oral health status in Nicaragua. In the present study we evaluated the effect of various risk indicators for dental caries on primary teeth in Nicaraguan children (from Leon, Nicaragua) ages 6 to 9.

Material and Methods

This study complied with stipulations for the protection of human subjects and ethical regulations of participating institutions; the protocol was approved by Internal Review Board, Facultad de Odontología, Universidad Autónoma de Campeche. Informed consent was obtained from parents/guardians of children.

Design, population and study sample

Nicaragua has 5,727,707 inhabitants (as of 2012) and is often considered one of the poorer countries in Latin America; about half of the population lives in poverty, and 17% in extreme poverty. Nicaragua's economic sector relies on coffee crops and industries focused on beverages, clothing, textiles, and shoes, as well as banking and commerce. About 3% of children are under 1 year of age, and 15% are younger than 5. Women of child-bearing age (15–49 years) make up 25% of the population. León is a department (state) in Northwestern Nicaragua (181 928 inhabitants in 2002, in 5138 km^2), and is the second largest city in Nicaragua, after Managua. Although 84% of Leon's population can read and write, 20% of children under 5 years of age are considered to be malnourished.

A cross-sectional study was conducted in the city of León, Nicaragua, to collect information on various events related to oral health. Some of the methods have been previously published [16,19,20]. In a first phase, 25 elementary schools were randomly chosen. Following the sampling strategy proposed by the WHO [21], 56 children from each school were randomly selected. The final sample was distributed similarly by age and sex: 4 boys and 4 girls in each age group studied, for a total of 1400 children. To be included in the present analysis, children had to: 1) be enrolled in an elementary school, 2) between 6 to 9 years of age, 3) have parents granting written consent to participate in the study, 4) have no fixed orthodontic treatment appliances, 5) show no systemic diseases affecting the mouth, and 6) not refuse to be examined. Six of the children 6–9 years old did not have at least 1 primary tooth or the dental exam was unfeasible and they were eliminated from the analysis. The final sample was 794 schoolchildren. We present analyses only for the primary dentition because of the age range of the study population, as children older than 9 years of age could have exceedingly low numbers of primary teeth.

Variables and data collection

The dependent variable was dental caries in the primary dentition, used to calculate the dmft index and caries prevalence (dmft >0). The independent variables were current age of the mother; and for the child, sex, frequency of tooth brushing, presence of dental plaque, dental care utilization of the child as described by the mother/guardian (and what type: preventive, restorative, etc.), family size, and birth order of the study child among his/her siblings. Also, we collected information on the occupation and the maximum level of formal education of the mother and the father, and the mother's attitude towards the importance of the oral health of the child (see description below) [14,15,22]. Questionnaires were distributed to mothers through the schools and collected later in the same way.

The dental plaque was recorded (visible: presence or absence) using the modified Silness and Löe index. We recorded the extent of dental plaque (number of teeth with presence of dental plaque, divided by total number of teeth present in the mouth, multiplied by 100) and was coded as 0= low presence of dental plaque (subject that presented an extent lower than 20%) and 1= high presence of dental plaque (individual who presented a dental plaque extent greater than 20) [23]. The importance ascribed by mother/caregiver to the child's oral health was derived from the following questions: 1) *Is it important that your child keeps his/her teeth in good condition?* and 2) *Have you ever examined his/her teeth to ascertain if they are healthy?* Responses were aggregated into a positive attitude (1) if "*yes*" was answered to both questions, or a negative attitude (0) if "*no*" was answered to any of them. This variable has been described previously in validation studies [14,15,22]; the variable is pertinent, specifically the environment and interactions expected for this type of Latin American setting.

Principal components analysis (PCA) was undertaken, specifically polychoric correlation [24], to reduce the dimensions of certain variables and to construct the socioeconomic position variable (SEP). SEP was determined by using the maximum level of schooling and the occupation of both parents; these variables have been used in various health surveys involving children and adolescents in Mexico. With the generated variables, 80.2% and 55.8% of the variability was explained, respectively. Following this analysis, the component generated was divided into SEP tertiles – the first tertile represented the group with the lowest SEP, and the third tertile represented the highest SEP.

The oral examination identified caries experience (cavitated decayed primary teeth, teeth with fillings, and missing teeth due to caries) to calculate the dmft index. Incipient decay data were not collected. All subjects were examined by 1 of 2 examiners trained and standardized (Kappa >0.85) in the caries criterion, using a flat dental mirror and natural light.

Data analysis

An exploratory analysis examined the variables to evaluate the quality of information and to initially describe the population under study. Measures of central tendency and dispersion for continuous variables were calculated. For categorical variables, the frequencies of each category were obtained, as well as the corresponding percentages. For bivariate analyses we used Spearman's correlation test, chi-square test, and non-parametric test for trends, according to the scale of measurement of the variables. Bivariate tests were subsequently performed with negative binomial regression (NBR).

Because data did not fit the distribution for the Poisson regression model upon graphic evaluation, this option was discarded

and we chose the negative binomial regression model to model the dmft index while incorporating risk indicators. We chose this approach because: a) the dmft is a discrete variable (count) that can have only integer values (since there is no continuous variable, the linear regression model was discarded), b) there was data overdispersion (the variance (9.79) was greater than the mean (3.54), c) NBR has the advantage of modeling the results of dental caries on a quantitative variable rather than the dichotomic perspective used in the binary logistic regression. The NBR model allows evaluating the association of exposure variables with disease severity, not just presence or absence of the event.

We included in the NBR multivariate model those variables that yielded a significance p<0.25 in the bivariate analyses. An analysis of variance inflation factor (VIF) was undertaken to detect and, if necessary, avoid multicollinearity between independent variables [25]. In bivariate and multivariate analyses the confidence intervals were calculated with robust standard errors, which allowed valid estimates even in the case of correlation between groups [26]. This strategy was adopted because data were obtained from children from different schools, but it was assumed that a correlation of scores existed within each one of those schools. The statistical program used was STATA 9.0®.

Results

Descriptive analysis

This analysis included 794 schoolchildren aged 6 to 9 years. Table 1 shows the descriptive data of the sample: mean age was 7.49±1.12 years, and boys accounted for 50.1% of subjects studied. The overall mean for the sample was 3.54±3.13 and the caries prevalence (dmft >0) was 77.6%.

Bivariate analysis

Table 2 presents caries prevalence (dmft >0) across independent variables. P values reported are those obtained when comparing the percentages in the categorical variables; for quantitative variables, the values correspond to Spearman's correlation test. Similarly, Table 3 shows the distribution of the index for the categories of independent variables together with the bivariate negative binomial regression (NBR) analysis. The variables age, sex, frequency of brushing, the high presence of dental plaque, and having had at least 1 dental visit for preventive dental care in the last year, were found to be associated with. Because neither the mother's age, family size, child's birth order, or SEP variable (parental occupations) were significant, we did not take it into account in the final model. The variable SEP (parental education) was incorporated since obtained a value of p less than 0.25.

Table 1. Characteristics of children included in the study of Leon, Nicaragua.

Variables	Mean ±SD	Min–Max
Age (years)	7.49±1.12	6–9
Mother's age (years)	31.49±5.62	20–48
Mother's schooling (years)	7.55±4.12	0–20
Father's schooling (years)	7.70±4.27	0–21
Family size (number of children)	2.90±1.38	1–9
	n	(%)
Sex		
Boys	398	50.1
Girls	396	49.9
Birth order of the child in the family		
First	301	37.9
Second	220	27.7
Third	143	18.0
Fourth or more	130	16.4
Mother's attitude toward oral health		
Negative	309	38.9
Positive	485	61.1
Tooth brushing frequency		
Fewer than 7 times/week	432	54.4
At least once a day	362	45.6
Dental plaque		
Low presence	19	2.4
High presence	775	97.6
Received dental care (last year)		
Without care	581	73.2
Preventive	24	3.0
Restorative	147	18.5
Both	42	5.3
SEP (schooling)		
Low	276	34.8
Medium	254	32.0
High	264	33.2
SEP (occupation)		
Low	287	36.1
Medium	323	40.7
High	184	23.2

Table 2. Bivariate analysis for dental caries in primary dentition as dependent variable and independent variables included in the study.

Variables	% dmft >0	P value
Age (years)	77.6	0.2576*
Mother's age (years)	77.6	0.6918*
Family size (number of children)	77.6	0.7532*
Sex		
Boys	79.2	
Girls	76.0	0.289**
Birth order of the child in the family		
First	78.7	
Second	77.7	
Third	76.9	
Fourth or more	75.4	0.889**
Mother's attitude toward oral health		
Negative	78.6	
Positive	76.9	0.568**
Tooth brushing frequency		
Fewer than 7 times/week	80.6	
At least once a day	74.0	0.028**
Dental plaque		
Low presence	26.3	
High presence	78.8	0.000**
Received dental care (last year)		
Without care/not preventive	78.2	
Preventive	58.3	0.022**
SEP (schooling)		
Low	79.4	0.146**
Medium	79.9	0.012***
High	73.5	z=−2.50
SEP (occupation)		
Low	77.7	0.755**
Medium	76.5	0.855***
High	79.4	z=0.18

* Spearman correlation; ** Chi square; *** non parametric test for trend.

Multivariate model

In the multivariate RBN model (Table 4), 4 variables were statistically associated ($p < 0.05$) to dmft. For each year of increasing age, the expected mean dmft decreased 7.5%. Similarly,

Table 3. Bivariate analysis of negative binomial regression for dental caries in primary dentition.

Variables	dmft	Coef	% change	P value
Age (years)	3.54±3.13	−0.0700	−7.3	0.011
Mother's age (years)	3.54±3.13	−0.0018	−0.2	0.777
Family size (number of children)	3.54±3.13	0.0078	0.8	0.735
Sex				
Boys	3.81±3.30	1*		
Girls	3.26±2.93	−0.1563	−16.9	0.046
Birth order of the child in the family				
First	3.54±3.12	0.1086	11.5	0.303
Second	3.59±3.12	0.1212	12.9	0.186
Third	3.78±3.34	0.1728	18.9	0.102
Fourth or more	3.18±2.92	1*		
Mother's attitude toward oral health				
Negative	3.66±3.07	1*		
Positive	3.46±3.17	−0.0584	−6.0	0.426
Tooth brushing frequency				
Fewer than 7 times/week	3.93±3.20	1*		
At least once a day	3.07±2.98	−0.2483	−28.2	0.000
Dental plaque				
Low presence	0.79±1.75	1*		
High presence	3.60±3.13	1.5183	456.5	0.004
Received dental care (last year)				
Without care/not preventive	3.59±3.14	1*		
Preventive	1.75±2.15	−0.7191	−205.3	0.006
SEP (schooling)				
Low	3.82±3.16	0.1846	20.3	0.059
Medium	3.60±3.14	0.1242	13.2	0.151
High	3.18±3.06	1*		
SEP (occupation)				
Low	3.52±3.00	−.0547	−5.6	0.457
Medium	3.45±3.11	−.0749	−7.8	0.374
High	3.72±3.36	1*		

Estimates were calculated with robust standard errors (*clustering*).

among children brushing their teeth at least once a day and having received preventive dental care in the last year, the expected mean dmft declined 19.5% and 69.6%, respectively. Finally, the high presence of dental plaque massively increased the expected mean dfmt: 395.5%.

While it was noted a slight trend existed in relation to sex (girls had an expected mean dmft 13.8% lower than boys), the relationship was not statistically significant (p<0.10).

Discussion

Although it seems that there has been a significant reduction in dental caries globally in the last 40 years [27], this group of Nicaraguan children had high values for both prevalence and dmft, similar to values pertaining to other Latin American countries with a high prevalence of caries and a large number of untreated caries [2–10]. When we examined the association between dental caries in the primary dentition and

Table 4. Multivariate model of negative binomial regression for primary dentition in children 6-9 years old in Leon, Nicaragua (n=794).

Variables	Coef	% change	P value
Age (years)	−0.0721	−7.5	0.007
Sex			
Boys	1*		
Girls	−0.1296	−13.8	0.092
Tooth brushing frequency			
Fewer than 7 times/week	1*		
At least once a day	−0.1784	−19.5	0.003
Dental plaque			
Absent	1*		
Present	1.3749	395.5	0.008
Received dental care (last year)			
Without care/not preventive	1*		
Preventive	−0.5283	−69.6	0.029

Estimates were calculated with robust standard errors (*clustering*).

certain clinical, demographic, socioeconomic, and behavioral variables in these Nicaraguan children, our findings suggested that dental plaque plays a markedly important role in dental caries (as measured by the composite dmft). But the multivariate model did not support a strong association between socioeconomic variables and dental caries.

In terms of oral hygiene, 2 variables have been consistently studied: the frequency of tooth brushing and the presence of dental plaque. The dental environment of a young child becomes complicated by the fact that beliefs and practices of mothers directly affect oral health [28]. Taking into account that dental plaque is considered an etiologic agent of dental caries, several human studies have shown that dental plaque control is a key factor in preventing dental caries and may be used to assess oral hygiene behaviors. Tooth brushing with fluoride toothpaste is the most important oral health habit. Tooth brushing alone has not been linked with caries prevention; tooth brushing must include fluoridated toothpaste to lead to caries reduction. Tooth brushing (with fluoride toothpaste) carried out regularly is effective in preventing caries; some variability has been ascribed because of motivation, instructions, assistance, manual dexterity, and other, different variables [15,16]. Patterns of tooth brushing in children as reported by their mothers/guardians have been used to assess oral hygiene [29]. We found that the presence of dental plaque increased the expected caries index, and that more frequent tooth brushing decreased it. These findings are consistent with those reported in studies elsewhere [4,5,14,18].

Some socio-demographic variables, especially age and sex, are the 2 factors commonly associated with the prevalence of dental caries. Studies show that as age increases, so does the presence of dental caries in either dentition: 3 to 6 years for primary teeth [7,8,14] or 6 to 12 for permanent teeth [3,4,10]. In the present study we observed that as age increased in children 6 to 9 years old, dmft decreased. This same finding was obtained in a study conducted in Mexico in children 6 to 10 years old, in which both the dmft and the prevalence of caries (dmft >0) decreased with age [5], and partially corroborated in another study (also in Mexico in children 6 to 9 years old), as this effect was only observed for prevalence in primary teeth but not the dmft. Such trends may be ascribed to the shedding of primary teeth with age, thereby affecting the surfaces available to be affected by caries. The trend may be offset by an increase in caries experience in permanent teeth, as more surfaces become available.

A necessary first step in preventing dental caries in preschool children is the assessment of caries risk factors. Such assessment may run the gamut of options from ascertaining socioeconomic status, previous experience of caries, the presence of white spot lesions, the presence of visible dental plaque, the risk perceived by dental professionals, and even microbiological testing to quantify cariogenic microorganisms. Based on this information, different preventive strategies and different intensities of preventive therapies may be employed. Prevention strategies may include dietary modifications to reduce high sweetener consumption, supervised tooth brushing,

systemic fluoride supplements for children living in areas without public health fluoridation, and professional delivery of fluoride varnish and sealants [30]. This study shows that when subjects have a pattern of utilization of preventive dental services, the expected mean dmft decreases. Vadiakas et al. [18] observed in Greek youngsters that caries experience and untreated caries were higher in those who visited the dentist only when they were in pain of dental origin or to restore a tooth, compared to those who visited the dentist for a check-up, for preventive reasons, or to receive topical applications of fluoride. A methodological improvement when studying this relationship in future studies would be to ensure separately recording the reasons for dental care as preventive or curative; when studied as a single category (regardless of being preventive, curative, or emergency), it may suggest that the likelihood of carious lesions increases [8]. As demonstrated in the present study, when the patterns of dental care are preventive (*vs.* any other service or lack of services' utilization) the risk of carious lesions decreases.

In recent years, dental public health research has increasingly emphasized social determinants of health. We included 2 indicator variables for SEP, education and occupation of parents; according to Galobardes et al. [31] these are valid indicators to measure the SEP. However, contrary to other studies in others countries [4,6,12,14,15,32–37] where oral health indicators held well defined trends associated with SEP variables, this study failed to confirm this association. We can speculate that the reason for this finding could be the relatively narrow

distribution of SEP in the Nicaraguan study population. Finally, although some studies mention birth order as a risk indicator for the presence of dental caries [11,12], we did not find this association, just as it has not been found in other studies [12,13].

Conclusions

We conclude that the proportion of children affected by caries in this cross-sectional sample was high, as was their dmft. We identified various indicators (e.g., the high presence of dental plaque, the utilization of oral health preventive services, tooth brushing, and age) as factors associated with dental caries experience. The sophistication of the statistical analysis approach used in the present study is higher than many conventional approaches used in the past. Design and creation of school- and community-based programs to help reduce caries experience in this population should be supported by targeting those subgroups at higher risk using the risk indicators and factors identified.

Acknowledgments

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