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Dental caries and associated factors in Mexican schoolchildren aged 6–13 years

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Abstract

The objectives of the present study were to establish dental caries prevalence (percentage with caries) and experience in the primary and permanent dentition (dmft and DMFT) of 6 to 13-year-old schoolchildren in Campeche, Mexico, and to estimate the contributing roles of the likely risk indicators. A cross-sectional study was carried out in 1,644 children aged 6–13 years. Self-administered questionnaires obtained information on social, economic, behavioral, and demographic variables. The primary dentition of 1,309 children and the permanent dentition of 1,640 children were evaluated in the oral examinations. The main outcome measures were DMFT, dmft, and SiC indices. Data were modeled using logistic regression analysis. The overall caries prevalence was 77.4%, 73.6% in the primary dentition (61.6% in 6-year-olds), and 49.4% in the permanent dentition. The dmft and DMFT indices were 2.85 ± 2.73 and 1.44 ± 2.05, respectively (DMFT $= 3.11 \pm 2.62$ in 12-year-olds). The SiC index was 6.05 at 12 years of age. Associated variables to dental caries in both dentitions were presence of enamel defects, presence of dental plaque, low socio-economic status, female sex, and older age. Mother's schooling was negatively associated (OR $= 0.95$) with caries in primary dentition. Caries experience in the primary dentition (OR $= 6.02$) was positively associated with caries in the permanent dentition. Dental caries status in these Mexican children was closer to the goals proposed by the WHO/FDI for 2000 than previous studies. This study has identified clinical, socio-economic, and behavioral determinants for dental caries in primary and permanent dentition on Mexican schoolchildren.

Key Words: *Dental caries, dmft, DMFT, epidemiology, Mexico, schoolchildren, significant caries index*

Introduction

Dental caries is the most prevalent oral disease across all age groups in Mexico and is the main dental public health problem in schoolchildren [1–5]. Caries prevalence has been declining in the majority of developed countries, while in developing countries the change has been slow [6–8]. Epidemiological surveys can improve the monitoring of population-level trends throughout important oral health conditions, i.e. morbidity and treatment needs can help tailor oral health programs to meet real-life health needs.

In industrialized countries, dental caries is mostly concentrated in a small proportion of the population. Predicting the identification of individuals with a high risk of caries could considerably improve care by allocating appropriate preventive and restorative care to those who need it most, particularly in an environment where resources are tightly limited. Because local factors and idiosyncrasies specific to population groups contribute to caries risk, from an epidemiological perspective it is important to identify salient factors that modify this risk in different settings. Using multivariate models, reports from around the world have established the relative importance of specific factors to dental caries experience in children. Among these factors, low income [9], deficient oral hygiene, mother's schooling, and fluorosis [10],

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various measures of low socio-economic status (SES) [3,4,11–13], older age [1,5,14], prior experience of decay in the primary dentition associated with caries experience in the permanent dentition [15,16], female sex [1,17], presence of abnormalities, hypoplasias, or enamel defects [18–21], as well as low level of parental education and cariogenic diet [20–22] all affect caries risk.

While various descriptive epidemiological studies [1–5] of dental caries in children have been undertaken in Mexican populations, they have been carried out in Mexico City, and no multivariate models were included to ascertain the relative role of identified caries risk indicators. The objectives of the present study were to establish the prevalence of dental caries (percentage with caries) and experience in the primary and permanent dentition (dmft and DMFT) of 6 to 13-year-old schoolchildren in Campeche City, Mexico, and to estimate the contributing roles of the likely risk indicators.

Material and methods

Population and sample composition

The study design and completion followed ethical guidelines for conducting studies at the Universidad Autónoma de Campeche. Campeche is one of 32 states of the Mexican Republic and is located in the south-east on the Gulf of México coast. The program of salt fluoridation started in 1991 for this population. The population aged 6–13 years in Campeche was 35,691 and the number attending school was 34,203 [23]. Begun in September 1997 and completed in December 1997, this cross-sectional study's target population was 1,806 schoolchildren 6 to 13 years of age attending one of the 7 elementary schools served by an outpatient peripheral-urban community clinic ("Morelos" Health Center) funded by the Health Ministry. We excluded children with fixed orthodontic appliances, those younger than 6 or older than 13 years of age, and children whose parents did not sign the informed consent form. The final study sample represented 91.0% ($n = 1{,}644$) of the total population.

Data collection and variable construction

Examinations were carried out by one of three examiners calibrated and standardized in diagnostic criteria (intra- and inter-examiners kappa > 0.85 at the child level) using a flat dental mirror under natural light, and following the WHO (World Health Organization) guidelines [24]. The child's assent for the examination was sought and obtained. No radiographs were used. The primary dentition of 1,309 children and the permanent dentition of 1,640 children were evaluated in the oral examinations. Four children had only primary dentition, 335 had only permanent dentition, and 1,305 had mixed dentition. Dmft and DMFT scores were computed from the data obtained, along with the Significant Caries Index (SiC) [1]. This index highlights the individuals with the highest caries scores in each population under investigation. The one-third of the population with the highest caries scores was selected from individuals ordered according to their DMFT values, and the mean DMFT for this subgroup was calculated [25].

Dental plaque was measured using a modification of the Silness & Löe index [26]. The operational definition of this index was used, and we measured all teeth present in the mouth. Plaque was considered present if identifiable on more than 20% of teeth, and absent if it could not be identified in at least 20% of teeth.

We constructed the clinical-behavioral scoring system for oral hygiene in children as described by Medina et al. [27]. Briefly, two variables constituted the combined index: a clinic component (presence of dental plaque) and a behavioral component (frequency of toothbrushing). Past reports were consulted to ascertain how willingly members of the lay public would volunteer information of patterns of toothbrushing [1,28,29], and how adaptable measures of plaque would be to epidemiologic assessment efforts in various population groups in Mexico [29,30]. After discussion and consensus within the research group, toothbrushing frequency and plaque control were categorized in one dimension as: (1) *adequate* hygiene, whereby subjects had no detectable plaque and their mothers/guardians indicated that the children had brushed their teeth daily. (2) *Moderate* hygiene, a category that included two scenarios: children with no detectable plaque and a report indicating that teeth were brushed occasionally or never (< 7 times/week), and children with plaque whose mothers/guardians asserted that the children had brushed their teeth daily. (3) *Inadequate* hygiene, whereby subjects had detectable plaque and their mothers/guardians indicated that the teeth were brushed only occasionally or never. Values of the combined index and the constituting variables were weighted separately: 0 for a positive feature and 1 for a negative one. Final weighting was structured so that daily brushing (at least once a day) was 0, while occasional brushing was 1; presence of plaque was 0 for no detectable plaque present and 1 for plaque being present (assuming exchangeable values from dichotomic to ordinal scales). Values for the combined index were also simple, in an ordinal scale: 0 = adequate; 1 = moderate; and 2 = inadequate.

Enamel defects were recorded as enamel opacities classified as demarcated or diffuse, and enamel hypoplasia [31]. Enamel opacities were differentiated clinically from fluorosed tissue when the latter occurred in symmetrical teeth.

The dependent variables were dmft and DMFT indices, recoded for analyses as (0) if dmft = 0 and (1) if dmft > 0, and as (0) if DMFT = 0 and (1) if DMFT > 0. Data on independent variables were

obtained, from the mothers who agreed to participate in the study, by means of a structured questionnaire. The instrument included questions on the following socio-economic and socio-behavioral aspects: sex of child, family size (number of children in the family), mother's highest level of schooling and current occupation, child's toothbrushing frequency. SES was assigned according to father's occupation (as per the actuarial tables that IMSS social workers use to appraise socio-economic level across insureds) [1].

Statistical analysis

Data were entered into DBASE© and analyzed in STATA 7©. We computed measures of central tendency and dispersion for continuous variables; for nominal variables, we obtained each category's frequency and percentage. Non-parametric tests were used when we ascertained the non-normal distribution of caries indices. To explore the bivariate relationships between independent variables we used logistic regression and outlined their odds ratios (OR), 95% confidence intervals (95% CI), and *p*-values.

Two logistic regression models were developed, one for each dentition. In the final models, we included the variables from the bivariate analysis that had $p < 0.25$ [32]. The variables used in multivariate analyses were tested for multicollinearity. All possible interactions were tested and included if their statistical significance was < 0.15. The adjustment of the models was verified with the Hosmer-Lemeshow goodness-of-fit test using $p > 0.10$ as a cut-off point for considering the adjustment to be adequate. A specification error test (linktest) was used to verify the assumption that the outcome *logit* was a linear combination of the independent variables. For the continuous variable in the model, we tested whether the change in the *logit* was of similar magnitude (Box-Tidwell test) [33].

Results

Of the 1,644 schoolchildren included in the study, 836 (50.9%) were boys. Mean overall age was 9.06 ± 2.02 years; other children's and parents' characteristics are given in Table I. Caries prevalence (overall) was 77.4%, 73.6% in primary dentition, and 49.4% in permanent dentition. Caries experience by age is given in Table II. The dmft index ($n = 1{,}309$) was 2.85 ± 2.73 for the entire sample, with higher figures for 9-year-olds (3.37 ± 2.68). Mean DMFT ($n = 1{,}640$) was 1.44 ± 2.05, ranging from 0.18 ± 0.56 in 6-year-olds to 3.79 ± 2.96 in 13-year-olds. The DMFT + dmft index was 3.71 ± 3.29. The SiC was 3.76 when all age groups were included, and 6.05 when only 12-year-olds were considered.

No significant gender differences were observed ($p > 0.05$) for caries indices. The median DMFT and dmft scores by age group showed a statistical difference ($p < 0.001$) in the Kruskal-Wallis test. In a non-parametric test for trends, DMFT showed an increase by age ($p < 0.01$), but dmft ($p = 0.71$) did not. Table III gives the bivariate logistic regression analysis for dmft and DMFT across clinical, socio-economic, and socio-behavioral variables.

Table I. Children's and parents' characteristics in the study sample

Variable	Mean (SD)	IL-UL
Age (years)	9.06 (2.02)	6–13
Family size (number of children)	3.65 (1.83)	1–12
Father's schooling (years of study)	7.00 (4.10)	0–18
Mother's schooling (years of study)	6.46 (3.67)	0–17
	n	%
Sex		
Boys	836	50.9
Girls	808	49.2
Enamel defect (primary dentition)		
Without defect	1,177	90.0
With defect	130	10.0
Enamel defect (permanent dentition)		
Without defect	1,518	92.6
With defect	122	7.4
Hygiene		
Adequate	373	22.7
Regular	753	45.8
Inadequate	518	31.5
Mother's occupation		
Homemaker	1,012	61.6
Work out of home	632	38.4
Socio-economic level		
High	393	25.8
Medium	719	47.1
Low	414	27.1

IL = inferior limit, UP = upper limit.

The results of the multivariate analysis are given in Table IV for primary teeth. Caries experience was associated with presence of enamel defects (OR = 4.92; 95% CI = 2.45–9.88); subjects with enamel defects were almost five times more likely to have dental caries than subjects without defects. Having inadequate oral hygiene increased caries probability by 55% (OR = 1.55; 95% CI = 1.14–2.10) compared with the subjects with regular or adequate hygiene. Low SES had a modest influence—children from low SES had an OR 1.38 times higher likelihood of having caries than children from medium and high SES (95% CI = 1.00–1.90). Girls were 1.29 times more likely (95% CI = 1.00–1.69) to have caries. Children from families with three or more children were more likely to have caries (OR = 1.50; 95% CI = 1.09–1.27). Finally, the mother's highest level of schooling was negatively associated with caries experience (OR = 0.96; 95% CI = 0.92–0.99).

The results of the multivariate analysis for permanent teeth are given in Table V. Children with caries in their primary teeth had a strong association (OR = 6.04; 95% CI = 4.20–8.69) with caries experience. The presence of enamel defects (OR = 4.17; 95% CI = 2.36–7.39) was also positively associated with caries, as was the age of children—by each increment of one year in age, the likelihood of having caries

Table II. Mean ($\bar{\chi}$) and standard deviation ($\pm$) of caries indices in primary teeth ($n=1{,}309$) and permanent teeth ($n=1{,}640$), and the Significant Index for Caries (SiC), by age group

Age	$\bar{\chi}\pm$dmft (n)*†	$\bar{\chi}\pm$DMFT (n)*‡	% dmft = 0 (n)	% DMFT = 0 (n)	SiC
6	2.62 ± 3.18 (216)	0.19 ± 0.57 (212)	38.4 (83)	87.3 (185)	0.56
7	3.07 ± 3.10 (237)	0.55 ± 1.10 (237)	31.2 (74)	73.0 (173)	1.65
8	3.15 ± 2.72 (212)	0.75 ± 1.23 (213)	23.1 (49)	65.3 (139)	2.21
9	3.37 ± 2.68 (260)	1.36 ± 1.50 (269)	20.8 (54)	43.1 (116)	3.15
10	2.57 ± 2.29 (221)	1.65 ± 1.80 (268)	23.5 (52)	39.9 (107)	3.79
11	2.06 ± 1.71 (112)	2.28 ± 2.64 (235)	19.6 (22)	29.8 (70)	4.97
12	1.92 ± 1.81 (38)	3.11 ± 2.62 (128)	18.4 (7)	19.5 (25)	6.05
13	2.00 ± 2.80 (13)	3.79 ± 2.97 (78)	30.8 (4)	18.0 (14)	7.19
Total	2.85 ± 2.73 (1309)	1.44 ± 2.05 (1640)	26.7 (345)	50.6 (829)	3.76

* Kruskal-Wallis test $p<0.001$.
† Non-parametric for trend test $= -0.73$, $p=0.71$.
‡ Non-parametric for trend test $=19.66$, $p=0.00$.

Table III. Logistic regression bivariate analysis for caries on primary and permanent dentitions. The dependent variables—dmft and DMFT—were dichotomized (dmft = 0 versus dmft > 0 and DMFT = 0 versus DMFT > 0)

Variable	Primary dentition OR (CI 95%)*	Permanent dentition OR (CI 95%)*
Age (years)	1.18 (1.09–1.27)	1.64 (1.55–1.74)
Sex		
Boys	1†	1†
Girls	1.20 (0.94–1.54)	1.19 (0.98–1.44)
Enamel defect		
Without defect	1†	1†
With defect	4.73 (2.45–9.14)	4.61 (2.92–7.29)
CBOHI		
Adequate	1†	1†
Regular	1.54 (1.14–2.10)	1.30 (1.01–1.66)
Inadequate	1.81 (1.30–2.52)	1.59 (1.21–2.07
Caries on primary teeth		
dmft = 0	n/a	1†
dmft > 0		6.31 (4.57–8.72)
Family size (number of children)	1.15 (1.06–1.25)	1.19 (1.13–1.26)
Father's schooling (years of study)	0.94 (0.91–0.97)	0.94 (0.92–0.96)
Mother's schooling (years of study)	0.94 (0.90–0.97)	0.94 (0.92–0.97)
Mother's occupation		
Homemaker	1†	1†
Work out of home	1.03 (0.87–1.33)	0.84 (0.69–1.03)
Socio-economic level		
Medium and high	1†	1†
Low	1.65 (1.22–2.23)	1.38 (1.11–1.73)

* Crude odds ratio (CI 95%), † Category of reference, n/a = not applicable.

increased by 72% (OR = 1.72; 95% CI = 1.57–1.87). Children with inadequate hygiene were more likely (OR = 1.54; 95% CI = 1.10–2.17) than children with regular and adequate hygiene of having caries, just as female sex (OR = 1.34; 95% CI = 1.03–1.76) or belonging to a low SES family (OR = 1.31; 95% CI = 0.97–1.76) increased such probability.

The model adjustments in Tables III and IV were tested with the Hosmer-Lemeshow goodness-of-fit test and were not found to be significant in either model ($p>0.10$), suggesting that the observed probabilities were similar to predicted probabilities. We obtained satisfactory results in the specification error test (Tables IV and V).

Discussion

The present research led to two principal findings. First, further information was found on the young population in Mexico's caries experience profile. The available studies on dental caries indicate that caries is a public health problem because of its high prevalence and incidence [1–5]. While the prevalence of caries in our study was slightly lower than figures commonly reported in other epidemiological studies in Mexico (both caries prevalence and dmft and DMFT scores), neither WHO/FDI goals for the year 2000 [34] or 2015 [25] were reached. All dental indices used to measure children's dental health in this study were substantially higher than those reported in selected oral health studies from industrialized and less-developed countries with approximately the same level of urbanization, industrialization, and economic development. For example, caries prevalence in the permanent dentition was 61.6%, with mean DMFT = 2.4, for 12-year-old Italian children [12]. Caries prevalence in the permanent dentition was 61.6%, with mean DMFT = 2.4 for 12-year-old Slovenian children [35]. Such morbidity levels are lower than those observed in our study. Studies in Brazil suggest that DMFT are either below the levels found in the present study (e.g. DMFT = 2.06 at 12 years of age) [36] or higher (DMFT ranging from 4.59 to 6.25) [8,14]. Our dmft values were usually lower. At a local level, the caries experience in the present study population was better than population groups in other regions of Mexico [1–5], bringing our findings closer to the WHO/FDI goals for 2000 in children ages 6 and 12 years [34].

The second finding offered an objective description of some of the first variable arrays demonstrated to modify caries experience in primary and permanent

Table IV. Logistic regression multivariate model for caries on primary dentition ($n=1{,}218$). Dependent variable, dmft, was dichotomized as dmft = 0 versus dmft > 0

Variable	AOR	CI 95%	*p*
Sex			
Boys	1		
Girls	1.30	1.00–1.69	0.052
Enamel defect			
With defect	1*		
Without defect	4.92	2.45–9.88	0.000
CBOHI			
Adequate	1*		
Regular and inadequate	1.55	1.14–2.10	0.005
Family size (number of children)			
≤2	1*		
>3	1.50	1.13–1.99	0.005
Mother's schooling (years of study)†	0.96	0.92–0.99	0.020
Socio-economic status			
Medium and high	1*		
Low	1.38	1.00–1.90	0.050

AOR = Adjusted odds ratio by the variable content in the table.
* Reference category.
Adjustment: Goodness-of-fit Hosmer-Lemeshow test χ^2 (8) = 5.71, $p=0.6799$.
Specification error test: predictor $p=0.000$, predictor square $p=0.205$.
Box-Tidwell test for mother's schooling $p=0.400$.

Table V. Logistic regression multivariate analysis for caries on permanent dentition ($n=1{,}215$). Dependent variable, DMFT, was dichotomized as DMFT = 0 versus DMFT > 0

Variable	AOR	CI 95%	*p*
Age (years)	1.72	1.57–1.87	0.000
Sex			
Boys	1*		
Girls	1.36	1.04–1.78	0.027
CBOHI			
Adequate	1*		
Regular and inadequate	1.54	1.10–2.17	0.012
Enamel defect			
Without defect	1*		
With defect	4.17	2.36–7.39	0.000
Caries on primary teeth			
dmft = 0	1*		
dmft > 0	6.04	4.20–8.69	0.000
Socio-economic status			
Medium and high			
Low	1.31	0.97–1.76	0.081

AOR Adjusted odds ratio by the variables contents in the table.
* Reference category.
Adjustment: Goodness-of-fit Hosmer-Lemeshow test χ^2 (8) = 12.45, $p=0.1322$.
Specification error test: predictor $p=0.000$, predictor square $p=0.170$.
Box-Tidwell test for age of children $p=0.071$.

dentitions in young age groups in Mexico. In the present investigation, enamel defects were a strong predictor for dental caries on the primary and permanent dentitions, after adjusting for other variables. Other authors [18–21] have observed this association between hypomineralized enamel (presumably it can help bacterial colonization) and dental caries. Differences across the sexes were in line with previous findings [1,17], just as the significant relationship between oral hygiene and dental caries in permanent and primary dentitions had been reported previously [10,20,22]. In this study, we measured oral hygiene using an index that comprises toothbrushing frequency and the presence of plaque. This combined approach may have led to a better approximation of oral hygiene. After adjusting the two variables, the index attempts to minimize the misclassification that may have occurred from the findings accrued by the clinical examination through independent reports of the frequency of toothbrushing.

In the bivariate analysis, there was a significant relation between parent's schooling and caries prevalence (Table II). In the multivariate analysis, however, no relationships could be demonstrated. Mother's level of schooling supported this relation only in the model for primary dentition, as observed by other authors [10]. It would appear that the strength of such a relation is lost when more complex arrays of factors become operational as the child grows older. In general, the consistent association between more disadvantaged socio-economic background and increased caries experience in Mexico and other countries was confirmed [3,4,11–13]. The most important aspect of such confirmatory association between DMFT and dmft indices and SES is that this link remained even after controlling for other variables.

Our findings suggest that the caries experience in primary teeth is a major predictor for caries in permanent dentition, thus substantiating longitudinal reports from other countries [15,16,37]. This variable, as well as others evaluated in the present analysis, could be useful in identifying subjects with a high caries risk [38–41] following today's standards of care. Despite being almost universal, dental caries has a wide range of severity in terms of the number of tooth surfaces that are decayed or filled [42,43]. This uneven distribution of lesions has prompted calls for managing and preventing caries using procedures appropriate to each individual's disease burden, the development stage of the individual carious lesion, and the perceived risk for development of future lesions, even though some of the underlying assumptions concerning the risk assessment approach still need to be objectively evaluated as far as the management implications (e.g. current caries risk is predictive of future new carious lesions) or treatment implications are concerned (e.g. preventive measures indeed reduce future caries).

This study had certain limitations that call for a cautious interpretation of the results. A cross-sectional study measures cause and effect at the same point in time, introducing the problem of temporal ambiguity and an inability to establish causal relationships.

Furthermore, the fact that questionnaires were used directed at mothers/guardians to collect information could be introducing some degree of recall bias.

In conclusion, dental caries status for this sample of Mexican children was favorable compared with previous studies, i.e. it being closer to the goals proposed by the WHO/FDI for 2000. The study has identified clinical, socio-economic and behavioral determinants for dental caries in both dentitions on Mexican schoolchildren. Such positive trends may be emphasized through preventive programs that meet population treatment needs by targeting resources through objective risk assessment, and by ameliorating dissimilar disease experiences between social classes. Epidemiological data can thus be used for designing programs aimed at improving oral health services in this community.

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