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Caries increment in the permanent dentition of Mexican children in relation to prior caries experience on permanent and primary dentitions

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ABSTRACT

Objective: To evaluate the likelihood of caries increment in schoolchildren, based on their prior caries experience.

Material and methods: We undertook a longitudinal study in 452 six-to-nine year olds between 1999 and 2001 in Mexico, with dental exams conducted by two standardized examiners (kappa > 0.85). The dependent variable was the DMFT increment, dichotomized as without increment, and at least one unit of increment. Independent variables estimated caries experience at baseline. Data were analyzed using non-parametric tests and generalized linear models (*log-binomial*) to calculate relative risk (RR) adjusted for age and sex.

Results: The percentage of caries-free children diminished by 20.5% from 1999 to 2001. DMFT index increased two-fold, from 0.25 ± 0.70 in 1999 to 0.77 ± 1.30 in 2001 ($p < 0.001$). The overall risk for this sample was 24%. The DMFT increment was higher ($p < 0.001$) in children with DMFT > 0 and dmft > 0 in 1999 (RR = 1.89, 95% CI = 1.37–2.62; RR = 2.71, 95% CI = 1.94–3.76, respectively). The likelihood for DMFT increment from the 1999 levels was: (1) 2.78 times higher (95% CI = 2.06–3.76) if schoolchildren had caries in any of the first permanent molars and (2) 1.62 times higher (95% CI = 1.20–2.19) if schoolchildren were affected by high severity caries at baseline.

Conclusions: Both caries prevalence and mean DMFT had significant increments in 18 months. Dental caries in the primary (dmft) and permanent (DMFT) dentitions at baseline are goods indicators of subsequent caries development in this group of children in a medium income country. This relationship became stronger when the occurrence of caries in the first permanent molars was included.

1. Introduction

Dental caries is a process involving an imbalance in the interactions between the tooth surface/subsurface and the adjacent microbial biofilm. Active caries is a process whereby an overly acidic environment, caused by the presence of cariogenic organisms and fuelled by fermentable carbohydrate intake, leads to the destruction of hard tooth structures.[1,2]

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This imbalance is manifested as cumulative demineralization of the tooth. Such an imbalance, if unchecked, has the potential to produce cavitation of the enamel. The social cost of dental caries in preschool children and schoolchildren is considerable – numerous authors have indicated that caries is a dental public health problem due to its elevated prevalence and incidence. Furthermore, it is concentrated primarily among people in the lower socio-economic groups in Mexico, and the world.[3–10] For example; dental caries has been reported as the most common chronic infant disease in the United States – five times more common than asthma and seven times more common than fever.[11]

Several factors, such as high counts of *mutans streptococci*, teeth and host susceptibility, availability of fermentable carbohydrates in the diet, as well as diverse sociodemographic, socioeconomic, and behavioral factors have been associated with dental caries.[2,4–12] Dental literature on caries risk assessment, however, has shown that caries experience is the best predictor for future caries increment.[13–15] Studies have confirmed that caries experience in the primary dentition is a predictor of caries in the permanent dentition,[12,16–19] and that caries experience in the permanent and primary dentitions is a predictor of subsequent caries in the same dentition.[16,20,21] These trends have not been confirmed in the Mexican environment primarily due to the scarce longitudinal data that are available for dental caries in the child population in Mexico.[22,23] The objective of the present study was to quantify the likelihood for caries increase in the permanent dentition in a cohort of schoolchildren of Campeche, Mexico, based on their prior caries experience.

2. Materials and methods

The study's design and undertaking followed ethical guidelines for studies at the Universidad Autónoma de Campeche.

2.1. *Population, sample and study design*

Data were collected in Campeche, Mexico. Campeche is a town without artificially fluoridated water supplies, with a warm-humid climate, located in Southeastern Mexico on the Gulf of Mexico coast. The population under 15 years of age represents 30.5% of 216,897 inhabitants. Campeche is a seaport with tourism, fishing, lumber, and agricultural industries. Campeche is included in the domestic salt fluoridation program in the country. The present analyses were undertaken with data generated from a longitudinal study beginning in 1999 on the caries experience of 580 children (6–9 year olds, mean age 7.53 ± 1.08 years) attending four public elementary schools in the urban area of Campeche. A second and final examination took place in 2001, with dental examiners being blind to baseline examination data.

An invitation to participate in the study was made to parents/tutors and their consent obtained. Children with pit and fissure sealants in the first permanent molars were excluded from the study, as this preventive treatment would bias the caries increment in the permanent dentition. For the second examination in 2001, the sample was reduced to 452 children (77.9% of original sample) because some children were absent during the day of the second examination, or they had moved to a different school or residence address.

2.2. *Data collection and variables included in the analyses*

All subjects were clinically evaluated with natural daylight using a dental mirror to visualize teeth by one of three previously standardized examiners (kappa > 0.85). The examiners were previously trained in the criteria during a pilot test.

The examinations were carried out in schools utilizing two sets of criteria: WHO's criteria,[24] to determine the presence or absence of caries, and a recording of the size of lesion to assign a severity score.[25] We classified subjects in one of four caries severity groups, according to the number and size of clinically observable carious lesions – low and high severity. This criterion has been used in previous studies in Latin American populations[10,26–30] and validated in a longitudinal study.[25] The D component included decay at the dentinal level as well as secondary caries, and the M component included only teeth missing through caries. No radiographs were used and no white spot lesions were recorded. Children did not brush their teeth prior to the clinic exam but teeth were dried with gauze. We recorded the results of the exam on paper forms and summaries of the findings were shared with guardians/children.

The dependent variable was the caries increment from 1999 to 2001. This variable was dichotomized as (0) when there was no DMFT increment, and (1) when there was at least one unit of DMFT increase. The independent variables were age and sex, and diverse dental variables connoting caries experience, namely caries in any first permanent molar (0 = none, 1 = at least one tooth affected); caries in any permanent upper molars (0 = none, 1 = at least one tooth affected); caries in any permanent lower molars (0 = none, 1 = at least one tooth affected); caries severity[25] (0 = low caries severity, 1 = high caries severity); DMFT score at baseline examination (0 = DMFT equal to 0, 1 = DMFT > 0); and dmft score at baseline examination (0 = dmft equal to 0, 1 = dmft > 0).

2.3. *Statistical analyses*

Statistical analyses were carried out in STATA 8.2®. We first conducted an exploratory analysis to evaluate the quality of the data and describe the study population. We calculated measures of central tendency and dispersion for continuous variables. We obtained the frequencies and percentages for categorical variables. At the bivariate analysis stage, we used the χ^2, Mann–Whitney, Kruskall–Wallis, Pearson's partial correlation tests, and the non-parametric test for trends, according to the variables involved and contrasts across years – for this latter analysis, we used the Wilcoxon test. Binary outcomes in cohort studies are commonly analyzed through logistic regression models to obtain odds ratios for comparing groups with different characteristics. Although this is often appropriate, there may be situations when estimating a relative risk or risk ratio (RR) instead of an odds ratio (OR) is more desirable. Articles in recent literature illustrate that when the outcome event is common (incidence of 10% or more), it is often more desirable to estimate an RR since there is an increasing differential between the RR and OR with increasing incidence rates.[31,32]

We generated nine multivariate models for generalized linear models (*log-binomial* regression), one model for each variable of caries, and in these models we indicated (1) increment of DMFT and (0) no increment. The strength of the relationship in our models is expressed as RR with 95% confidence intervals (95% CI). All final models were adjusted for age and sex.

3. Results

Data from 452 children (mean age 7.53 ± 1.08 years in 1999; 51.3% were girls) that completed the study were incorporated to analyses. Tables 1 and 2 show the characteristics of the study population in terms of variables depicting caries experience.

3.1. Results in 1999

Of the 452 children that accrued data at baseline and follow-up, the mean DMFT and dmft scores were 0.25 ± 0.70 and 1.90 ± 2.64, respectively. Children aged 9 years were affected by caries more frequently in both primary (Kruskal–Wallis, $p < 0.01$) and permanent dentitions (Kruskal–Wallis, $p < 0.001$), compared with younger children. The prevalence of caries in the permanent dentition was 14.2% and in the primary dentition was 42.9%. Age and DMFT as well as age and dmft increased simultaneously (Pearson's correlation and non-parametric tests, $p < 0.001$). Caries prevalences in both permanent and primary dentitions were similar in boys and girls (χ^2-test, $p > 0.05$), as was DMFT index (Mann–Whitney test, $p > 0.05$). However, dmft was higher in girls than in boys (Mann–Whitney test, $p < 0.05$).

Table 2 – Dental caries in primary dentition at baseline (1999)

	Mean dmft	% dmft > 0
Age (in 1999)		
6 years ($n = 105$)	0.93 ± 1.64	31.4
7 years ($n = 104$)	2.00 ± 2.85	40.4
8 years ($n = 140$)	2.29 ± 2.91	49.3
9 years ($n = 103$)	2.26 ± 2.65	48.5
All	1.90 ± 2.64	42.9
	$p = 0.0011^{*}$	$p = 0.023^{\ddagger}$
	$p < 0.001^{\dagger}$	$p < 0.01^{\dagger}$
Sex		
Boys	1.58 ± 2.37	40.5
Girls	2.21 ± 2.85	45.3
	$p = 0.0417^{\P}$	$p = 0.302^{\ddagger}$

* Kruskal–Wallis.
† Mann–Whitney.
¶ Non-parametric test for trend.
‡ Chi squared.

3.2. Results in 2001

The mean DMFT index was 0.77 ± 1.30. Older children were more affected by caries (Kruskal–Wallis, $p < 0.001$) than younger children. The caries prevalence in the permanent dentition was 34.7%. Age and DMFT increased in a similar manner (Pearson's correlation and non-parametric tests, $p < 0.001$). Caries prevalence was about the same among boys (33.6%) and girls (35.8%) ($\chi^2 = 0.2280$; $p = 0.633$), as was DMFT index (Mann–Whitney test, $p > 0.05$).

Table 1 – Description of variables in relation to dental caries in permanent dentition in 452 Mexican children

	1999	2001	Difference	P-value
Mean DMFT	0.25 ± 0.70	0.77 ± 1.30	0.52 ± 1.01	0.0000[a]
Age (in 1999)				
6 years ($n = 105$)	0.01 ± 0.10	0.45 ± 1.02	0.44 ± 1.01	0.0000[a]
7 years ($n = 104$)	0.13 ± 0.50	0.55 ± 1.10	0.41 ± 0.91	0.0000[a]
8 years ($n = 140$)	0.22 ± 0.64	0.80 ± 1.19	0.58 ± 0.98	0.0000[a]
9 years ($n = 103$)	0.64 ± 1.07	1.27 ± 1.70	0.63 ± 1.15	0.0000[a]
	n (%)	*n* (%)	%	
DMFT = 0	388 (85.8%)	295 (65.3%)	20.5%	
DMFT > 0	64 (14.2%)	157 (34.7%)	20.5%	
Caries in permanent molars				
No	354 (78.3%)			
At least one	98 (21.7%)			
Severity of caries				
Low	266 (58.9%)			
High	186 (41.2%)			
Sex				
Boys	220 (48.7%)			
Girls	232 (51.3%)			

a Wilcoxon's test.

Table 3 – Bivariate relationships between caries increment (1 = increment by at least one DMFT unit vs. 0 = no increment) and selected variables in permanent dentition

	Increment = 0	Increment > 0	RR (95% CI)
Caries in permanent molars			
No	284	70	1[a]
At least one	43	55	2.84 (2.16–3.73)[†]
Caries in permanent upper molars			
No	312	103	1[a]
At least one	15	22	2.40 (1.75–3.28)[†]
Caries in permanent lower molars			
No	288	75	1[a]
At least one	39	50	2.72 (2.07–3.57)[†]
Caries severity (in 1999)			
Low severity caries	209	57	1[a]
High severity caries	118	68	1.71 (1.27–2.30)[‡]
DMFT (in 1999)			
DMFT = 0	295	93	1[a]
DMFT > 0	32	32	2.07 (1.54–2.82)[†]
Age (in 1999)			
6–7 years	164	45	1[a]
8–9 years	163	80	1.53 (1.12–2.10)[‡]
Sex			
Boys	163	57	1[a]
Girls	164	68	1.13 (0.84–1.53)[n/s]

n/s: no significant.
[a] Reference category.
[†] $p < 0.001$.
[‡] $p < 0.01$.

3.3. *Differences between the participants that completed and did not complete the follow-up*

The ages of the children that had both baseline and follow-up measurements ($n = 452$, mean age = 7.53) and those that were not included at follow-up ($n = 128$, mean age = 7.44) were similar ($p > 0.05$). An analysis of dental caries levels at baseline revealed that there were no differences between those that had both baseline and follow-up measurements, compared to those that had only the baseline measurement – in terms of dmft, 1.90 ± 2.64 versus 1.48 ± 1.89 ($p = 0.9846$), and DMFT, 0.25 ± 0.70 versus 0.34 ± 0.08 ($p = 0.3809$) (Mann–Whitney test). Schoolchildren that were followed from 1999 to 2001 were not significantly different from those that could not/did not participate in 2001.

3.4. *Bivariate analysis of the combined 1999–2001 results*

The total increment in the DMFT index from 1999 to 2001 was 0.52 ± 1.01. The percentage of children caries-free in the permanent dentition diminished 20.5% from 1999 to 2001. The caries risk in the entire sample was 24%. When analyzing data by age groups, we observed that the greatest increment was among children that were 9 years old in 1999 (Table 1). The increment in the DMFT index over the whole sample (0.25 ± 0.70 in 1999, to 0.77 ± 1.30 in 2001) was statistically significant (Wilcoxon test, $p < 0.0001$). When we compared age groups, the results were statistically significant ($p < 0.0001$) for every group (Table 1). With regard to the sex of the participants, both the DMFT increments in boys (0.26 ± 0.64 in 1999, 0.72 ± 1.26 in 2001) and girls (0.24 ± 0.76 in 1999, to 0.81 ± 1.34 in 2001) were statistically significant. Although females showed a larger increment in dental caries than males (0.46 ± 0.93 versus 0.58 ± 1.09), the differential increment by sex was not significant (Mann–Whitney test, $p > 0.05$).

The bivariate analyses that calculated the relative risk (Tables 3 and 4) revealed that all variables were statistically significant when the dependent variable was the increment in dental caries (0 = DMFT increment = 0 versus 1 = DMFT increment > 0) and the independent variables offered diverse estimates of dental caries in 1999 – with the exception of sex.

Table 4 – Bivariate and multivariate relationships using generalized linear models between caries increment (1 = increment by at least one DMFT unit vs. 0 = no increment) and caries in primary dentition

	RR (95% CI)	P-value
Bivariate		
dmft (in 1999)		
dmft = 0	1[a]	
dmft > 0	2.83 (2.04–3.92)[b]	0.000
Multivariate[b]		
dmft (in 1999)		
dmft = 0	1[a]	
dmft > 0	2.71 (1.94–3.76)	0.000

[a] Reference category.
[b] Model adjusted by age and sex.

Table 5 – *Log-binomial* generalized linear models incorporating caries increment (1 = increment by at least one DMFT unit vs. 0 = no increment) and selected variables in permanent dentition

	GLM *log-binomial*	
	RR (95% CI)	P-value
Caries in permanent molars		
No	1[a]	
At least one	2.78 (2.06–3.76)	0.000
Caries in permanent lower molars		
No	1[a]	
At least one	2.61 (1.93–3.53)	0.000
Caries in permanent upper molars		
No	1[a]	
At least one	2.19 (1.59–3.02)	0.000
DMFT		
DMFT = 0	1[a]	
DMFT > 0	1.89 (1.37–2.62)	0.000
Caries severity (in 1999)		
Low severity caries	1[a]	
High severity caries	1.62 (1.20–2.19)	0.002

The models (five) included one variable of prior caries experience (in 1999) and age and sex.
[a] Reference category.

When we contrasted caries in permanent dentition across children who were 8 years old in 1999, and children who were 8 years old in 2001 (or 6 years old in 1999), the seemingly similar results (0.22 ± 0.63 versus 0.45 ± 1.02) turned out to be statistically different (Mann–Whitney, $p > 0.05$). Identical results were obtained when we compared caries prevalence figures (41.1 versus 51.2, $p > 0.05$, χ^2-test).

3.5. *Multivariate analysis adjusting for age and sex*

The multivariate results are in Tables 4 and 5. We generated six models, one for each caries experience variable adjusted by age and sex. The likelihood of experiencing a DMFT increment in children that had caries in at least one first permanent molar in 1999 was almost three times (RR = 2.78; 95% CI 2.06–3.76) the likelihood of children who were caries free in their first permanent molars in 1999. With regard to dmft, we observed that children who had a dmft > 0 in 1999 had a likelihood of caries 2.71 times (RR = 2.71; 95% CI 1.94–3.76) greater than that of children who had dmft = 0. The likelihood of an increase in the DMFT in children that had caries in one of the first upper or first lower permanent molars at baseline in 1999 was 2.19 (95% CI 1.91–7.89), and 2.61 times greater (95% CI 2.76–7.72), respectively. Children that were assigned to the group with a high severity of caries in the first measurement had a greater likelihood (RR = 1.62; 95% CI 1.20–2.19) of presenting at the follow-up examination with a DMFT increment than those children with less severe caries conditions in 1999. Finally, children that had DMFT > 0 in the first examination had almost twice the likelihood (RR = 1.89; 95% CI 1.37–2.62) of having a higher DMFT, compared to those children with DMFT = 0 in 1999.

4. Discussion

In this longitudinal study conducted in Southeastern Mexico, there was a relatively lower level of dental caries than has been reported for comparable age groups in marginal urban and peri-urban populations in Mexico in the 1990s.[5–8] A more detailed evaluation afforded by the longitudinal perspective in the present study reveals a worrying scenario – in only a year and a half, the occurrence of caries tripled in permanent teeth. Given that a significant part of this effect could reasonably be expected to occur as permanent teeth were erupting in the mouth, it is a legitimate concern that those teeth may develop caries as soon as (or shortly after) they are exposed to the mouth's cariogenic environment.

In the Mexican context, Sánchez-Pérez and Sáenz-Martínez[22] conducted a follow-up study with a peri-urban population in Mexico City using a similar time interval and age groups. They observed that 21% of the children with dental caries developed new lesions – which was greater than the percentage of new lesions observed in children without caries. We obtained figures from 36.7% to 59.5%, according to the variable used (caries severity or caries in permanent upper molars) for children with dental caries. In contrast, in children without caries, our percentages were much lower. These differences are even more notable if we take into account that while the follow-up period was similar in both studies (18 months), the population used by Sánchez-Pérez and Sáenz-Martínez[22] was slightly older. According to the trends identified in the two studies, older children had more dental caries. The greater incidence of caries could not be accounted for by restricted access to public health fluoridation (as both study areas were involved in the salt fluoridation program enacted in Mexico in the early 1990s) or a biased study population that continued in our study due to greater perceived needs (because there were no differences in the baseline measurements between those participating only in the 1999 exams and those that took part in both 1999 and 2001 exams). Sánchez-Pérez and Sáenz-Martínez[22] did not estimate cohort attrition in their report.

Studies of dental caries incidence in non-Mexican school age populations provide results that are either similar to, or different from, our findings. Direct comparisons are problematic considering that the follow-up periods are not equal (ranging from a year and a half, to 8 years), or that diagnostic criteria may be different. Compounding this problem, there have been secular changes in patterns of caries over time. Therefore, contrasts between our findings and other reports cannot be detailed. The multivariate model component of the analysis, which examined the potential to predict the occurrence of dental caries, confirmed that there is a diversity of variables pertaining to caries occurrence that predict caries risk in the permanent dentition – even within a short follow-up period such as 18 months. The more salient of these variables was the occurrence of caries in first permanent molars, replicating the conclusions from studies from the Middle East, North America, and Europe.[2,12–18,20] The presence of caries in first permanent molars may afford a reasonably precise, simple, and economic clinical screening tool to identify children likely to develop new caries. The attributable relative risk offered by this indicator is strong, although Seppa et al.[16] observed that occurrence of caries in the primary dentition was a stronger predictor of the presence of caries in the permanent dentition than the experience of caries in the first permanent molars. It is evident that features of different populations make it necessary to locally evaluate the convenience, costs, and diagnostic value of indicators to obtain the best predictor possible – either looking at caries experience in permanent molars or in the primary dentition[12,16–19] or both.

5. Conclusions

These findings indicate that both the occurrence of dental caries in the permanent dentition and the DMFT index have significant increments in as short a time as 18 months. We confirmed that caries experience in both primary and permanent dentitions is a good predictor of subsequent caries increments in the permanent dentition. These results should be taken into account when designing preventive programs in Campeche, so that children likely to develop new caries can be timely identified, and thus health program priorities can be set from an informed perspective.

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