DOI: 10.1111/j.1365-263X.2011.01146.x

INTERNATIONAL JOURNAL OF PAEDIATRIC DENTISTRY

Caries prevalence and its association with brushing habits, water availability, and the intake of sugared beverages

JOSEPH A. GUIDO[1], ESPERANZA A. MARTINEZ MIER[2], ARMANDO SOTO[3], HAFSTEINN EGGERTSSON[4], BRIAN J. SANDERS[5], JAMES E. JONES[6], JAMES A. WEDDELL[6], IRMA VILLANUEVA CRUZ[7] & JOSE LUIS ANTON DE LA CONCHA[7]

[1]Private Practice, Ft Collins, CO, USA, [2]Preventive and Community Dentistry, Bi-National/Cross-Cultural Health Enhancement Center, Oral Health Research Institute, Indiana University School of Dentistry, Indianapolis, IN, USA, [3]Department of Preventive & Community Dentistry, Indiana University School of Dentistry, Indianapolis, IN, USA, [4]Private Practice, Eugene, OR, USA, [5]Advanced Education Program in Pediatric Dentistry, Riley Dental Clinic, Indiana University School of Dentistry, Indianapolis, IN, USA, [6]Division of Pediatric Dentistry, Indiana University School of Dentistry, Indianapolis, IN, USA, and [7]Instituto de Ciencias de la Salud, Universidad Autónoma del Estado de Hidalgo, Pachuca, Hidalgo, Mexico

International Journal of Paediatric Dentistry 2011; 21: 432–440

Background. With Dental Caries being the most common disease amongst children in the world today, there is a need to fully understand risk factors that may be related to caries prevalence and how they could be best addressed.

Aim. The aim of this study was to evaluate soda, juice, sugared-beverage intake, brushing habits, and community water source availability as they relate to the prevalence of both noncavitated and cavitated caries lesions in small rural villages in Mexico.

Design. The International Caries Detection and Assessment System (ICDAS) was used in children from small, isolated, villages in Mexico. Risk factors were assessed via questionnaires.

Results. Caries prevalence in the villages was very high, ranging from 94.7% to 100% of the children studied. The mean number of surfaces with lesions per child (D1MFS + d1mfs) having scores ≥1 (noncavitated and cavitated) ranged from 15.4 ± 11.1 to 26.6 ± 15.2. Many of the children reported drinking beverages containing sugar.

Conclusions. Drinking sugared beverages, poor oral hygiene habits, and lack of access to tap water were identified as risk factor for caries in this sample of residents of rural Mexico.

Introduction

Dental caries remains the most common disease of childhood worldwide[1,2]. In the United States (US), the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2002 reported that 41% of children aged 2–11 years had dental caries in the primary dentition, and that 42% of children and adolescents aged 6–19 years had caries in the permanent dentition[1]. Dental caries in the US is no longer a population-wide problem, but it is endemic to specific population subsets[3].

In middle and low-income economy countries, dental caries is also a highly prevalent disease often characterized by marked differences within the same country[2]. In Mexico, caries has been and remains to be a severe problem[4–8]. To date, there is not a detailed nationwide assessment of the oral health status, but there is little doubt that caries experience is high in every age group[6]. Previous epidemiologic studies have shown that specific subgroups of the Mexican population are also disparately affected, with higher dental caries scores found in rural areas when compared with urban centres[4].

Upon analysis of the results of studies characterizing dental caries prevalence, it becomes clear that although dental caries can affect any child, the majority is found in low income and minority children[1,2]. The challenge to dental health professionals is to identify these population subsets and deliver proper preventive and restorative programs[1,9].

Different factors have been studied for their potential to be indicators that may aid in the identification of populations or individuals

Correspondence to:
J. A. Guido, Private Practice, 2016 Orchard Pl, Ft Collins, CO 80521, USA. E-mail: josephanthonyguido@gmail.com

at risk[10]. These include sugar consumption, tooth brushing, and socioeconomic status. In many areas of the world, sugared-beverage intake is a primary component of a child's total sugar consumption[11]. The amount and frequency of sugar consumption between meals are significantly associated with mean decayed, missing, and filled teeth (DMFT)[12,13]. It has been proposed that soda consumption leads to the rapid initiation and progression of caries[11–14]. Numerous studies have shown an association between mean DMFT scores and sugared soda consumption[3,11–14]. Results of studies conducted in rural Mexico have shown that the patterns of beverages' intake are complex, oftentimes associated to caries presence and warrant further study[15].

Not only sugared-beverages intake, but the overall diet of children today seems to contribute to the oral health and general health problems seen in our younger population. Diseases in which diet is clearly identified as a risk factor, childhood obesity, youth and adolescent diabetes, and dental caries, are on the rise in subsets of the population[12–21]. The intake of wholesome foods, like milk, has fallen, whereas soda and other sugared-beverage consumption have risen dramatically over the past 30 years[16,20,22,23]. This pattern of increased sugared-beverage consumption has been described in both rural and urban populations in high-, middle-, and low-income economy countries[12–23].

Considering that differences in risk factors have been recognized for different populations and individuals at risk, it seemed appropriate to design a study to evaluate those factors in a specific population. The aim of this study was to evaluate soda, juice, and sugared-beverages intake, toothbrushing habits and community water source availability as they relate to the prevalence of caries in small, isolated, rural villages in Mexico.

Material and methods

Approval from the institutional review board (IRB) at Indiana University was obtained. The villages selected for this study are located in the municipality of Calnali, in the state of Hidalgo, Mexico. The municipality of Calnali includes 18 villages or towns. The study was conducted in Calnali because of the availability of small isolated communities that were suitable to our study design and previous collaborations with these communities. Five isolated rural villages in the municipality of Calnali were chosen as study sites. The study was conducted in conjunction with a community service project, where children of all ages in the municipalities were offered dental examination and treatment.

Participant selection

All children of the villages were examined on a first come, first served basis. If the parent/legal guardian denied consent for the study, the child was not denied examination or treatment, but that child's information is not included in the study. The child had to meet the following inclusion criteria: be between the ages of 2–18 years of age, have no medical conditions that would contraindicate their receiving a dental examination, and be a lifetime resident of the village.

Juice and sugared-beverage consumption questionnaires

A questionnaire was developed to assess the consumption of different sodas, juices, and fruit drinks. Prior to development of the questionnaire, a complete list was compiled of all beverages sold in local stores of the villages selected for the study. A draft questionnaire was developed and pilot tested utilizing focus groups. The focus groups were administered the questionnaire and asked to identify problems with questions or potential difficulties understanding questions. From their input, a final version of the questionnaire was developed. Questions regarding water source and tooth brushing habits, which were found to be significant in previous studies, were also included in the final questionnaire[15]. A poster was available for the parents to reference with pictures of the different beverages included in the questionnaire. The questionnaire was administered to the parent and child participants by a trained researcher familiar with the

language and local customs, and who participated with the development of the questions.

Dental examination

The examiner in this study was a paediatric dental resident with 4 years of clinical experience. Prior to the initiation of the study, the examiner involved in data gathering was trained to diagnose caries using a novel detection system, the International Caries Detection and Assessment System (ICDAS)[24,25]. ICDAS classifies the severity of dental lesions from the earliest stages of visual demineralization to frank cavitations. An ICDAS score 0 is used for a sound surface, whereas a score 1 describes the first visual changes in enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure), and a score 2 is used for distinct visual changes in enamel. Scores 3–6 describe different degrees of cavitation; with score 3 describing localized enamel breakdown (without clinical visual signs of dentinal involvement), score 4 being lesions with an underlying dark shadow from dentin and score 5 describing distinct cavitation with visible dentin. Score 6 is used for the most severe lesions with extensive distinct cavitation with visible dentin.

The single examiner in this study was trained by a senior examiner with extensive experience in both using the ICDAS system and in training and calibrating other examiners. Training was provided by a 2-day *in vitro* exercise using extracted teeth mounted in dentoform models. *In vivo* training consisted of 2-day examination of 33 subjects. Scores were compared with those of the senior examiner, and kappa values were calculated for inter- and intra-examiner agreement. This single calibrated examiner performed dental examinations, and standard infection control procedures were used for each examination. Furthermore, each individual designated to record the data for the examiner underwent training provided on the method of recording the data for the ICDAS examination.

The examiner or an assistant brushed the child's teeth with a toothbrush and water prior to the examination. Teeth were dried using a dental air syringe tip, and the dental examination was performed using a non-LED headlamp and a dental mirror. A dental explorer was available, but its use was restricted to cleaning debris and feeling the surface of the tooth for assessment of lesion activity as described by the ICDAS criteria. The examiner observed the buccal, lingual, mesial, distal, and occlusal aspects of each tooth. Changes on tooth surfaces related to dental caries were given scores and recorded based on ICDAS criteria for lesion severity, lesion activity, and filling status.

Statistical methods

Information from the examinations and surveys was gathered, analysed, and tested for statistical significance. ICDAS severity scores were converted to DMFT scores at the cavitated and noncavitated level for statistical analysis purposes and to better compare our study to older studies that have used the DMFT system. DMFT scores were calculated at the cavitated and noncavitated level. Decayed, missing, and filled surfaces (D1MFS) counts included both cavitated and noncavitated lesions detected using the ICDAS criteria and were defined as the count of surfaces in permanent teeth per subject with either a lesion score >0, a lesion score indicating a tooth was missing because of caries, or a filling code ≥3; d1mfs was defined similarly for primary teeth. Separate analyses were conducted for these three outcomes. For each dentition type, caries was identified by a count >0. Caries prevalence was compared between villages by use of Fisher's exact test.

Survey questions were organized around collecting information related to consumption of particular types of beverages. The following drink categories were included in the questionnaire: fruit drinks, juice, soft drinks, milk, coffee, water, and other. Response categories for questions concerning frequency of daily consumption were 1 time per day, 1–3 times per day, 4–6 times per day, and >6 times per day. Counts in the last three response categories were sparse, so these categories were combined to be 'more than once per day'. Results for questions about frequency of consumption between meals and at night were combined in a similar manner.

Survey responses were summarized for two age groups: ages 2–6 and 7–13. Risk indicators that were considered for modelling were age, gender, and survey questions about consumption of particular beverages, frequency and timing of daily consumption and sources of drinking water. Univariate tests of association between DFMS and risk indicators were conducted using ANOVA models. Similar models were used to analyse d1fms. Risk indicators with *P*-values of 0.3 or smaller were eligible for inclusion in a multiple regression model for the respective outcome. Backwards selection was used until all variables were significant at the 0.05 levels. Two-way interactions of main effects were examined for statistical significance at the 0.05 levels. Residual plots were examined to assess whether the final model selected upheld model assumptions of normality of error terms and constant variance.

Results

Out of 188 possible subjects, 162 subjects completed the questionnaire, provided demographic data, and received a dental examination; however, only four of these subjects were older than 13, so only data on subjects aged 2–13 were analysed.

Caries prevalence

Demographic and caries data are presented in Table 1. Prevalence of caries was very high, ranging from 94.7% to 100% of children in each village having at least one carious lesion in either the primary or permanent teeth (Table 1). Prevalence of caries calculated using scores 4–6 (cavitated lesions) of the ICDAS criteria ranged from 58% to 75%. The mean number of surfaces with lesions per child (D1MFS + d1mfs) having scores ≥1 (noncavitated and cavitated) ranged from 15.4 ± 11.1 to 26.6 ± 15.2 (Table 1). Figures 1 and 2 present the distribution of the number of surfaces with lesions per child (information given separately for D1MFS and d1mfs) by age group. The mean number of teeth with obvious cavitated carious lesions into the dentin (lesion score ≥4) per child ranged from 2.42 to 3.27, whereas the number of filled teeth (filling score ≥3) ranged from 0.23 to 0.67. Repeatability of the ICDAS examination scores was strong with 90.7% agreement between

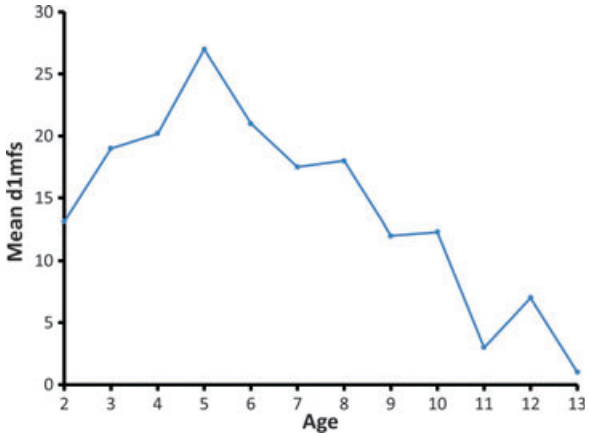

Fig. 1. Mean d1mfs by age group.

Table 1. Demographics, caries prevalence, and mean outcomes.

Village	1	2	3	4	5	*P*-value
Children						
N	39	28	39	33	19	**0.03****
Age (Mean ± SD)	7.5 ± 2.8	7.4 ± 2.7	8.7 ± 2.8	6.6 ± 2.7	8.1 ± 3.1	
Caries prevalence *n* (%)	39 (100)	28 (100)	37 (94.9)	33 (100)	18 (94.7)	0.17*
Primary dentition caries prevalence *n/N* (%)	33/34 (97.1)	22/23 (95.7)	26/30 (86.7)	30/30 (100)	14/17 (82.4)	**0.05***
Permanent dentition caries prevalence *n/N* (%)	33/34 (97.1)	22/24 (91.7)	31/35 (88.6)	18/18 (100)	15/15(100)	0.39*
D1MFS + d1mfs (mean ± SD)	23.2 ± 17.6	20.4 ± 10.9	15.4 ± 11.1	26.6 ± 15.2	16.8 ± 17.0	**0.01****
D1MFS (mean ± SD)	18.6 ± 15.7	16.0 ± 10.6	12.6 ± 10.6	23.0 ± 16.0	13.6 ± 16.9	**0.05****
d1mfs (mean ± SD)	7.9 ± 8.4	8.5 ± 7.3	6.4 ± 6.9	10.5 ± 9.4	5.9 ± 5.6	0.35**

*Fisher's exact test.
**ANOVA.
Bold values indicate statistically significant $P \leq 0.05$.

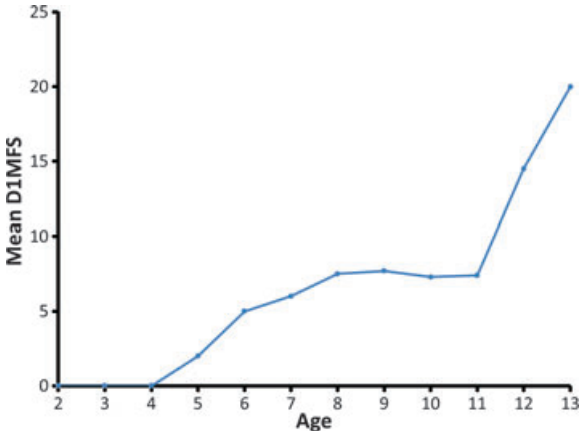

Fig. 2. Mean D1MFS by age group.

original and repeated scores. Weighted kappa was 0.75, indicating substantial agreement.

Beverage intake

The percentage of children who consumed different types of beverages is reported in Table 2. In each village, the majority of children reported drinking fruit drinks and juice at least once a day. Consumption of soda was reported even more frequently. In contrast, smaller numbers of children were reported to drink milk with no sugar added. Large numbers of children also reported drinking coffee even at an early age, and almost all children reported drinking water. Of those children who reported drinking juice or fruit drinks, the majority reported drinking it between meals, whereas those children who reported drinking soda, milk, or coffee reported doing it during meals. Water consumption was reported to occur between and during meals. Most children had access to water (96.8%) either through tap water at home or through a community water source; however, a small number of parents/legal guardians (3.2%) indicated their water source as something other than a community or home source (i.e., a water truck that visits the village once a week).

Table 2. Beverage consumption by age group.

Beverages	2–6 years *N* = 63 Number of children who reported drinking beverage at least 1 time per day (%)	7–13 years *N* = 95 Number of children who reported drinking beverage at least 1 time per day (%)
Fruit drinks	43 (68.3)	68 (71.6)
Juice	35 (55.6)	62 (65.3)
Soft drinks	45 (71.4)	79 (83.2)
Milk	59 (93.7)	80 (84.2)
Plain	18 (28.6)	34 (35.8)
Chocolate	9 (14.3)	12 (12.6)
With raw brown sugar	1 (1.6)	3 (3.2)
With white sugar	11 (17.5)	8 (8.4)
Coffee	49 (77.8)	80 (84.2)
Black	2 (3.2)	5 (5.3)
With raw brown sugar	15 (23.8)	30 (31.6)
With white sugar	13 (20.6)	19 (20.0)
Other	16 (25.4)	32 (33.7)
Water	63 (100)	91 (95.8)

Hygiene habits

Oral hygiene habits are presented in Table 3. Parents/legal guardians reported that most children brush their teeth at least sometime, with the percentage of children who brushed their own teeth increasing as the age of the child increased.

Statistical results

Results of univariate tests are presented in Table 4. Univariate tests showed that age had a significant association with ranked D1FMS. Age, drinking soda or milk with sugar, the child brushing his own teeth, and using drinking water from a source classified as bottled water, filtered water, or some other type of special drinking water was univariately significantly associated with ranked d1mfs score.

Table 3. Oral hygiene by age group.

	2–6 years *N* = 63	7–13 years *N* = 95
Oral hygiene *n* (%)		
Parent brushes child's teeth		
Yes	25 (39.7)	16 (16.8)
Sometimes	5 (7.9)	10 (10.5)
No	26 (41.3)	52 (54.7)
Child brushes' own teeth		
Yes	31 (49.2)	54 (56.8)
Sometimes	16 (25.4)	23 (24.2)
No	8 (12.7)	8 (8.4)

Table 4. Results of univariate tests of association of risk factors with D1MFS and d1mfs.

	D1FMS	d1fms
	P-value	*P*-value
Age	<0.0001	<0.0001
Gender	0.82	0.36
Drink fruit drinks	0.54	0.47
Drink juice	0.92	0.21
Drink soda	0.71	0.04
Drink milk with sugar	0.99	0.02
Drink coffee	0.66	0.11
Drinking water from house faucet	0.55	0.07
Drinking water from outside faucet	0.19	0.21
Drinking water from town faucet/well	0.33	0.49
Drinking water from large container of bottled water	0.14	0.77
Drinking water from other source	0.64	0.01
Parent brushes childs teeth	0.16	0.14
Child brushes own teeth	0.95	0.006
Frequency of drinking fruit drinks	0.61	0.51
Frequency of drinking juice	0.70	0.24
Frequency of drinking soda	0.83	0.43
Time of day drinking fruit drinks	0.82	0.24
Time of day drinking juice	0.90	0.16
Time of day drinking soda	0.92	0.80
Time of day drinking milk	0.97	0.15
Time of day drinking coffee	0.92	0.19
Time of day drinking water	0.55	0.22

For d1mfs, if the child drank milk with sugar, then the number of surfaces with caries increased. There was a difference in the number of surfaces with caries between children who did and did not brush their own teeth; the children who brushed their own teeth having higher caries rates. However, the children whose parents said that they less frequently (sometimes) brushed their own teeth did not have significantly higher numbers of surfaces with caries in their primary teeth than did the children whose parents responded that their children frequently brushed their own teeth. If the child obtained their drinking water from a source classified as bottled drinking water and filtered drinking water, then the number of surfaces in their primary teeth with caries was significantly fewer.

Results for the multiple regression models are presented in Table 5. The multiple regression model for ranked D1MFS score showed that as age increased, mean rank D1MFS score increased. Although not statistically significant, children in villages 3 and 5 had the oldest mean age. In other words, the number of surfaces with caries in permanent teeth significantly increased as the children's ages increased (older children had more surfaces with caries than younger children). The multiple regression model for ranked d1mfs score showed that mean ranked d1mfs score significantly decreased as the ages of the children increased.

Table 5. Results of multiple regression model for d1fms and D1MFS.

	d1fms (r^2 = 0.24)		D1FMS (r^2 = 0.12)	
	Std error	*P*-value	Std error	*P*-value
Age*	1.39	0.0010	1.21	<0.0001
Drinks milk	10.25	0.04		
Water source is other	13.84	0.04		
Child brush teeth				
No	10.38	0.27		
Sometimes	7.44	0.007		

*Centred at 7.2 years for d1mfs and at 8.5 years for D1MFS.

Discussion

Caries prevalence was extremely high in our study, at a mean 97.0% and ranging from 94.7% in village 5–100%. In villages 1, 2, and 4, almost every child we saw presented with caries. The prevalence results of our study are very similar to those of another study using ICDAS methods and conducted in the same rural areas in Mexico[15].

Previous studies conducted in rural areas of Mexico have noted caries prevalence between 43% and 91%[4,6,7]; however, comparisons of prevalence should be made with caution because of utilization of different indices. Other studies recording noncavitated lesions have shown a greater number of lesions detected than would be expected by traditional DMF examination[26,27]. Therefore, it is not surprising that caries prevalence found in this study was higher than previously reported.

ICDAS includes incipient lesions; therefore, it can give a more accurate picture of a patient's caries status. Previous methods of recording caries only at the level of cavitation have been deemed outmoded[24,25]. The importance of including initial caries lesions in the total caries score has been stressed in a num-

ber of recent studies[28,29]. Also, the recommendation has been made to perform examinations on dry, clean teeth, which for this study implied that the dental examiner brushed each child's teeth prior to examination. Cotton roll isolation was used along with air drying to achieve optimal examination conditions, which allowed accurate estimation of caries even at the early noncavitated stages. Data on repeatability for ICDAS have shown substantial to very good repeatability (weighted kappa 0.7–0.9)[25,30]. The repeatability in this study was good.

As noted earlier, ICDAS scores were converted to DMFT for the specific purpose of comparing our study to older prevalence studies. The estimation of prevalence calculated only using scores 4–6 (cavitated lesions) of the ICDAS criteria ranged from 58% to 75% and is closer to that reported by previous studies conducted in Mexico, where prevalence ranged from 43% to 91%[4,6,7]. In this study, the mean number of teeth with cavitated lesions (lesion score ≥4) or filled (filling score ≥3) per children ranged from 2.65 to 3.94 and is comparable to previous studies in Mexico which have shown the DMFT to be 4.39[4]. The very low percentage of restored teeth per subject indicates a lack of access to oral health care among all five villages.

Our analysis evaluated specific risk indicators to correlate the caries prevalence with these risk indicators reported by the participants. Indicators that had a significant effect on the mean D1MFS or d1mfs scores were used to provide some insight on the aetiological factors associated with the high caries prevalence observed in this population.

These results showed that drinking soda, milk with sugar, drinking water from a source classified as bottled water, filtered water or some other type of special drinking water, and the child brushing his own teeth were univariately significant with caries in the primary dentition (d1mfs scores). Previous studies have shown significant associations between soda consumption and increased caries risk[12–23]. It is worth noting that no significant associations were established between our D1MFS scores and soda intake. The vast majority of our children ages 7–13 reported drinking soda, fruit drinks, or juice, and those results along with the high prevalence of caries complicated establishing statistical significance. This study does support the results of those studies that have shown that the majority of children nowadays drink some sort of beverage containing sugar. Furthermore, in this study, we found that even when the children reported drinking milk, approximately half of those added sugar or a sugar-containing chocolate powder to their milk. The significance of this finding is indicated by the fact that those children who drank milk with sugar in our study had a larger number of surfaces with caries.

In this study, obtaining water from a source classified as bottled water, filtered water, or some other type of special drinking water was associated with decreased caries prevalence. This is in agreement with previous results from our group in these communities[15]. In our study, we did not collect water samples to analyse them for fluoride. Previous studies in this community have indicated that the fluoride content of bottled water varies widely from negligible to above optimal, whereas tap water in this community contains negligible amounts of fluoride[15,31].

The child brushing his/her own teeth was a third indicator that showed association to caries. In all five villages, many of children did not have help with tooth brushing (25/63 for 2–6 year olds), but those who did had a decreased number of carious lesions in their primary dentition.

Further studies are needed to evaluate the specific risk indicators identified in this study as significantly associated with dental caries. Such studies would include evaluating water for fluoride content longitudinally, as well as a diet survey that evaluated the consumption of fermentable carbohydrates over a 3- to 4-day period. Also, studies are needed to further investigate the relationship between drinking soda, fruit drinks, and juice and caries prevalence in the permanent dentition.

There are limitations inherent to our study design that warrants consideration, including the use of a cross-sectional study to evaluate caries risk indicators and the reliability of our beverage intake questionnaire. Another limitation is the small number of children

included in the study that reported not drinking some type of sugared beverages.

The task for public health care officials and dental practitioners is to identify the populations that are most at risk for dental decay. Understanding risk factors associated with caries is most important so that we can focus on our preventive and treatment methods to those populations at greatest risk. In doing this, we aim to minimize the morbidity associated with dental caries. It has been previously proposed that because dental caries no longer uniformly distributed throughout the population as it once was historically, risk assessment needs to be performed and preventive measures need to be aimed at those populations with the highest risk[3].

What this paper adds

- Our results indicated that caries prevalence was associated with some caries risk indicators, specifically drinking soda, and unsupervised brushing.
- Our results indicated that caries prevalence was very high in these rural villages in Mexico.
- Further studies are needed to investigate the relationship between drinking soda, fruit drinks, juice, and milk with sugar and caries prevalence in permanent teeth.

Why this paper is important to paediatric dentists

- Understanding general risk factors and how they are associated with caries prevalence will help the practitioner identify those patients that are most at risk.
- Questioning parents/legal guardians about their children's exposure to specific risk indicators associated with caries in this study, such as the specific sodas consumed in their community, may aid in identifying children who are at greatest risk for dental caries.
- The high caries prevalence noted in this population indicates that there still is a great need for comprehensive public health dental programs.

Acknowledgements

The authors would like to thank Ms. Susan Ofner and Ms. Harpreet Singh (Indianapolis, IN, USA) for their assistance with data management and statistical analysis.

References

1 Beltran-Aguilar ED, Barker L, Canto MT *et al.* Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis – United States, 1988–1994 and 1999–2002. *MMWR CDC Surveill Summ* 2005; **54**: 1–44.
2 Van Palenstein Helderman W. Priorities in oral health care in non-EME countries. *Int Dent J* 2002; **52**: 30–34.
3 Anderson M. Risk assessment and epidemiology of dental caries: review of the literature. *Pediatr Dent* 2002; **24**: 377–385.
4 Irigoyen ME, Luengas IF, Yashine A *et al.* Dental caries experience in Mexican schoolchildren from rural and urban communities. *Int Dent J* 2000; **50**: 41–45.
5 Maupome G. An introspective qualitative report on dietary patterns and elevated levels of dental decay in a deprived urban population in northern Mexico. *J Dent Child* 1998; **65**: 276–284.
6 Maupome G, Borges S, Ledesma C *et al.* Caries prevalence in self-selected populations from rural and urban deprived areas. *Salud Publica Mex* 1993; **35**: 357–367.
7 Dufoo S, Maupome G, Diez de Bonilla J *et al.* Caries experience in a selected patient population in Mexico City. *Community Dent Oral Epidemiol* 1996; **24**: 298–299.
8 Gonzalez J. Condiciones bucales dentro del Cerezo De Leon. *Rev ADM* 1994; **51**: 253–257.
9 Huntington NL, Kim IJ, Hughes CV. Caries risk factors for Hispanic children affected by early childhood caries. *Pediatr Dent* 2002; **24**: 536–542.
10 Zero D, Fontana M, Lennon AM. Clinical applications and outcomes of using indicators of risk in caries management. *J Dent Educ* 2001; **65**: 1126–1132.
11 Burt BA, Pai S. Sugar consumption and caries risk: a systematic review. *J Dent Educ* 2001; **65**: 1017–1023.
12 Ismail AI, Burt BA, Eklund SA. The cariogenicity of soft drinks in the United States. *J Am Dent Assoc* 1984; **109**: 241–245.
13 Ismail AI, Tanzer JM, Dingle JL. Current trends of sugar consumption in developing societies. *Community Dent Oral Epidemiol* 1997; **25**: 438–443.
14 Majewski RF. Dental caries in adolescents associated with caffeinated carbonated beverages. *Pediatr Dent* 2001; **23**: 198–203.
15 Cook SL, Martinez-Mier EA, Dean JA *et al.* Dental caries experience and association to risk indicators of remote rural populations. *Int J Paediatr Dent* 2008; **18**: 275–283.
16 Heller KE, Burt BA, Eklund SA. Sugared soda consumption and dental caries in the United States. *J Dent Res* 2001; **80**: 1949–1953.
17 Cavadini C, Siega-Riz AM, Popkin BM. US adolescent food intakes trends from 1965 to 1996. *Arch Dis Child* 2000; **83**: 18–24.
18 Szpunar SM, Eklund SA, Burt BA. Sugar consumption and caries risk in schoolchildren with low caries experience. *Community Dent Oral Epidemiol* 1995; **23**: 142–146.
19 Holbrook WP, Arnadottir IB, Takazoe I *et al.* Longitudinal study of caries, cariogenic bacteria and

diet in children just before and after starting school. *Eur J Oral Sci* 1995; **103**: 42–45.
20 Shenkin JD, Heller KE, Warren JJ *et al.* Soft drink consumption and caries risk in children and adolescents. *Gen Dent* 2003; **51**: 302–303.
21 Jones C, Woods K, Whittle G *et al.* Sugar, drinks, deprivation and dental caries in 14-year-old children in northwest England in 1995. *Community Dent Health* 1999; **16**: 68–71.
22 Schlosser E. *Fast Food Nation*. Boston: Houghton Mifflin Harcourt, 2001.
23 American Beverage Association. [Online]. 2007 April [cited 2007 April 21]; Available from: URL: http://www.ameribev.org/
24 Pitts NB, Stamm JW. International Consensus Workshop on caries clinical trials (ICW-CCT) – final consensus statements: agreeing where the evidence leads. *J Dent Res* 2004; **83**: C125–C128.
25 Ismail AI, Sohn W, Tellez M *et al.* The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. *Community Dent Oral Epidemiol* 2007; **35**: 170–178.
26 Autio-Gold J, Tomar S. Prevalence of noncavitated and cavitated carious lesions in 5-year-old head start schoolchildren in Alachua County, Florida. *Pediatr Dent* 2005; **27**: 54–60.
27 Fyffe HE, Deery C, Nugent ZJ *et al.* Effect of diagnostic threshold on the validity and reliability of epidemiological caries diagnosis using the Dundee selectable threshold method for caries diagnosis (DSTM). *Community Dent Oral Epidemiol* 2000; **28**: 42–51.
28 Kühnisch J, Goddon I, Berger S *et al.* Development, methodology and potential of the new Universal Visual Scoring System (UniViSS) for caries detection and diagnosis. *Int J Environ Res Public Health* 2009; **6**: 2500–2509.
29 Mendes FM, Braga MM, Oliveira LB, Antunes JL, Ardenghi TM, Bönecker M. Discriminant validity of the International Caries Detection and Assessment System (ICDAS) and comparability with World Health Organization criteria in a cross-sectional study. *Community Dent Oral Epidemiol* 2010; **38**: 398–407.
30 Braga MM, Ekstrand KR, Martignon S, Imparato JC, Ricketts DN, Mendes FM. Clinical performance of two visual scoring systems in detecting and assessing activity status of occlusal caries in primary teeth. *Caries Res* 2010; **44**: 300–308.
31 Martínez-Mier EA, Soto-Rojas AE, Buckley CM *et al.* Fluoride concentration of bottled water, tap water, and fluoridated salt from two communities in Mexico. *Int Dent J* 2005; **55**: 93–99.