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ORIGINAL ARTICLE

Correlates of childhood caries: A study in Qatar

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Abstract

Background: The prevalance of dental caries in children in Qatar is high, which necessitates preventive efforts.

Aim: To identify the sociodemographic and behavioural correlates of dental caries in the primary dentition of children 4- to 8-year-olds in Qatar.

Design: Weighted data from the Qatar Child Oral Health Survey 2017 were analysed for caries prevalence (dmft>0) and experience (dmft). Sociodemographic and behavioural variables were also drawn from the survey.

Results and Conclusion: Among the 1154 children, caries prevalence was 69.3% (95%CI [63.4, 74.5]) and experience at 3.8 dmft (95%CI [3.3, 4.2]). The prevalence ratio (PR) 0.82 (0.72, 0.94) was lower among younger than in older children; those for non-Qatari nationality Arabic PR 0.91 (0.82, 1.00) and Other PR 0.75 (0.57, 0.99) than for Qatari nationality; those attending international kindergartens/schools PR 0.89 (0.80, 0.99) than independent schools; and whose parents had university-level education PR 0.85 (0.75,0.95) than did not. Caries prevalence was lower among those toothbrushing by age 3 years PR 0.88 (0.80,0.99) than later; children with low/intermediate sugar exposures PR 0.85 (0.74,0.97) and 0.89 (0.79,1.00) than those with high exposures; children with a dental check-up PR 0.68 (0.53,0.87) than those without; and children who drank bottled water with some fluoride PR 0.89 (0.80,0.99) than those who did not. Findings were similar for dmft.

In conclusion caries prevalence varied but was high across sociodemographic correlates indicating vulnerablity. Interventions focusing on behaviours – such as toothbrushing, reducing sugar intake, check-up and encouraging intake of water with fluoride – are needed.

KEYWORDS
caries, child, indicators

1 | INTRODUCTION

Childhood is a critical period in health and development. This applies to oral health where dental caries is one of the most prevalent childhood diseases. Dental caries in the primary dentition has important consequences for children, their families and the communities. Discomfort, pain, and the need for invasive dental treatments are common sequalae. There are also links with general health and the broader health system. Many children with severe dental caries are treated under general anaesthesia in hospital settings. Whilst the immediate consequences are important, dental caries in the primary dentition is also one of the strongest predictors of dental caries in adult teeth.[1,2] Understanding how to prevent dental caries is important for improving oral health and is a benefit for both individuals and the community.

The prevalence and the extent of dental caries among children have been reported to be very high in Qatar. The National Oral Health Survey 2011 estimated the prevalence of dental caries in the primary dentition for 6-year-olds to be 72%, and the sum of the decayed, missing due to caries (extracted) or filled primary teeth (dmft) was 4.2 teeth.[3] This was considerably higher than targets set by the World Health Organization for the year 2000.[4] A smaller study by AlKhtib et al., in 2011 reported an 89% prevalence and 7.6 dmft in children aged 4–5 years.[5] The substantial difference between these reports prompted a further study of child oral health in 2017. The Qatar Child Oral Health Survey 2017 focussed on the oral health of 4–8-year-old children. The Survey followed a complex sampling strategy that resulted in findings that are representative of the Qatar child population. Only descriptive findings of the Survey have been previously reported.[6]

The reasons some children have higher levels of dental caries are complex. It is postulated that early in life, the interaction between the socio-environmental and individual behavioural factors leads to variations in oral health. The social determinant model for oral health emphasizes socio-environmental factors, which shape and constrain behaviours linked to oral health outcomes.[7] Socio-environmental and demographic factors operate at the individual level, socio-economic and cultural factors at the family level and broader social, cultural and physical factors at a community level. Individual behaviours include aspects of toothbrushing with fluoridated toothpaste, exposure to other fluorides, exposure to dietary sugars and dental visits.

Understanding early-life factors and their influence on child dental caries is of utmost importance for developing appropriate policies and interventions to ensure that all children have a good start to life. Although the aetiology of dental caries does not substantially vary, the distribution of dental caries and its risk behaviours may vary in different populations.

Why this paper is important to paediatric dentists

- Although childhood dental caries is among the most prevalent NCDs and creates a substantial burden of disease in children, the situation in Qatar is less well known.
- Childhood dental caries varies by sociodemographic characteristics. Qatari nationality children have more dental caries than non-Qatari children living in Qatar, but the prevalence of dental caries is high in all sociodemographic groups.
- Understanding variation especially by a set of mutable behavioural risk factors is crucial to successful interventions to improve children's experience of dental caries.

Previous research in Qatar has focussed on sociodemographic correlates and oral health. AlKhtib described dental caries prevalence and experience of 4–5-year-olds in Qatar. Only differences by age and sex were reported.[5] The National Oral Health Survey 2011 described dental caries experience in the primary dentition of 6-year-old children by nationality, school type attended and whether the school was a single sex or mixed school.[3] Other studies have included a more extensive suite of extensive sociodemographic and behavioural indicators but have been focussed on the permanent dentition in older children.[8,9]

The aim of this study was to explore dental caries prevalence and experience of the primary dentition among children aged 4–8 years, by sociodemographic background and individual behavioural correlates.

2 | MATERIALS AND METHODS

This study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[10]

2.1 | Participating children

The target population for the Qatar Child Oral Health Survey 2017[6] was children living in Qatar aged 4–8 years. The survey involved a stratified two-stage sample design. In the first stage of selection, a sampling frame of

all schools was compiled from the Supreme Council on Education listing kindergartens/schools located within Qatar. Kindergartens and schools represented all three regions of Qatar (Northern, Central and Western). Twenty kindergartens and 40 primary schools were selected using systematic sampling with probability of selection proportional to a school's in-scope enrolment size, producing a total of 60 clusters of children. For kindergartens, enrolment size was defined as the number of children aged 4–5 years and for primary schools, the number of 6–8-year-olds.

In the second stage of selection, children were sampled from selected kindergartens/schools based on age in years at a reference date in early 2017. For each age cohort, 15 children were selected using systematic sampling with equal probability. In total, 30 children were sampled from each selected kindergarten and 45 children from each selected primary school. The sample size calculation was based on previous data on 6-year-old children from a pathfinder survey, the Qatar National Child Oral Health Survey (NCOHS) 2011[3] and an expected response rate of 60%. Using this expected sample size, it would be possible to detect 15% difference in mean dmft score at age six years given statistical power of 80% and p value of .05.

The study was conducted in accordance with relevant institutional policies and protocols for studies on human subjects. Ethics approval was obtained from the Institutional Review Board at Primary Health Corporation. The selected kindergartens and schools were approached for participation and to gain local cooperation. Informed consent from parents for their child to participate was obtained.

2.2 | Data collection

A parental questionnaire was used to collect both self-reported oral health measures and other data on sociodemographics, dental preventive and risk behaviours, residential history, diet and use of dental services. These measures were tailored for use in Qatar from the NCOHS 2012–2014 parental questionnaire used in Australia,[11] then translated into Arabic and a dual-language Arabic and English version used in Qatar.

Standardised oral epidemiological examinations were conducted by a team of 10 trained examiners. Examinations took place in kindergartens/schools using portable dental equipment. Information was recorded onto laptop computers using a customised MS Access database.

The examinations involved visual assessment only, using mirror, blunt probe and compressed air. Cavitated carious lesions were observed and recorded, along with restorations at the surface-level and teeth missing due to caries. The examination protocol was based on that for the NCOHS of Australia 2012–2014.[11] Surface-level observations were aggregated at the tooth-level for the analysis. The examinations did not involve radiographs, and no dental treatment was provided.

Training and calibration of the examination team took place prior to commencement of the fieldwork, through a series of didactic and clinical sessions. The examiners were tested for compliance with the examination protocol during training and later for reliability during the fieldwork. A total of 37 children were re-examined to test for reliability during the fieldwork against two local 'gold' examiners.

Questionnaire data were prepared following detailed coding and data entry instructions and were combined with oral epidemiological data into one data set. Records with both the parental questionnaire and oral examination were included in the final data set.

2.3 | Data weighting

The probability of selection and participation rates varied by kindergarten and school. Therefore, an initial weight was derived to adjust for these differential rates. The weight was defined as the number of children selected of a specific age divided by the number of children who participated from that age. The initial weights were then adjusted to ensure that the weighted gender by age sample distribution reflected the 2015 Qatar Census distribution for children aged 4–8 years.[12] Children were assigned to a weighting cell based on their gender and age. Each weighting cell was then linked to the corresponding Census population count to derive the child's final weight. Hence, estimates were representative of Qatar's child population aged 4–8 years.

2.4 | Outcome variables

We used dental caries experience in the primary dentition expressed as the mean number of decayed (d), missing due to dental caries (m) and filled(f) teeth (dmft) due to dental caries, which allowed us to estimate dmft and the prevalence of dental caries, dmft>0. Estimates for derived outcome variables were calculated with 95% confidence intervals (95% CI). The intraclass correlation coefficient (ICC) for dental caries experience scores against retests conducted by gold examiners for dmft for 4- to 8-year-olds was 0.98, indicating good-to-excellent reliability.

2.5 | Potential correlates

Age was recoded into two groups: 4/5- and 6/7/8-years-old, corresponding with the split from kindergarten to school. Sex was male or female. Nationality was coded into four groups: Qatari, non-Qatari Arabic, non-Qatari Indian subcontinent and Other (mostly European). Allocation was based on one or more parent's place of birth, with a hierarchy that moved from Qatari to Arabic, to Indian, to Other. Region was coded as Northern, Central or Western. School type was coded as three groups: Community related to Embassy; Independent/Arabic private Qatar curriculum; and International curriculum. Household income was collected; however, there was a higher level of missingness and it was highly correlated with nationality and therefore omitted from analyses. Parental educational level was coded as School/Diploma or University. Mothers work status was coded as Full/Part-time, or None.

A set of behavioural correlates covered four areas. Toothbrushing behaviour included two measures: whether the child reportedly brushed before age 3 years and frequency of brushing with fluoridated toothpaste coded as <1/day, 1/day and 2+ times/day. Dietary sugar exposure was collected in a food frequency approach, and the actual number of exposures was dependent on the definition of servings. Dietary sugar exposure was coded as the summed number of servings of sugary food or sugar-sweetened beverage on a usual day. Dental visiting was captured by a check-up visit in the last 12 months. The usual source of drinking water was requested, either bottled water or tap water. In Qatar, almost all tap water is desalinated water with no fluoride. If bottled water was usually consumed, the individual usual brand was identified. Information on the fluoride content of individual brands was available from the Ministry of Health based on assays in 2015. The fluoride level of brands listed and was coded as no or negligible fluoride (<0.05 mg F/L) or low levels of fluoride (>0.05 mg F/L). Most of the six brands with low levels of fluoride were < 0.3 mg F/L with only three brands to tested on multiple occasions to have >0.3 mg F/L.

Missingness was present in about 12%–14% of children. Missing responses, including do not know, were excluded.

2.6 | Analysis

Statistical Analysis System (SAS) callable procedures from Statistical Software for Analysing Correlated Data (SUDAAN) v11.0.3 were used. The SUDAAN procedures used weights to generate population estimates that adjust for the complex sample design used. Analysis was conducted progressively from descriptive to bivariate then multivariable analyses. It was assumed that missingness was random, and complete-case analysis (also known as listwise deletion analysis) was conducted.

Bi- and multivariable models were generated for the dental caries outcomes, the prevalence of dental caries and dental caries experience, against sociodemographic correlates and against a separate set of behavioural correlates. Analysis was conducted using multivariable log-Poisson regression models with robust standard error estimation using PROC LOGLINK. Adjusted prevalence ratios (PRs) and its 95% confidence intervals (95%CI) were calculated for prevalence of dental caries, whereas adjusted mean ratios (MRs) and its 95%CI were calculated for dental caries experience, mean dmft.

3 | RESULTS

A total of 1154 children completed questionnaires and examinations, with a response rate of 48.1%. Children had slightly varying probabilities of selection and participation rates necessitating weighting of the data to represent the population of children in Qatar. A comparison between the unweighted and weighted data is presented in Table 1. The background characteristics that showed most change from the sample to population estimates due to the weighting of the data were age at selection, region and children attending International curriculum kindergarten/schools. Qatari nationality children made up just over one-quarter of children (26.3%), whereas non-Qatari Arabic nationality children were the largest group (44.2%). There were smaller percentages of non-Qatari Indian subcontinent and Other nationality children. The distribution by kindergarten and school type showed the largest group being International curriculum kindergartens/schools (61.8%) with the smallest group being community related to Embassy kindergarten/schools (7.9%). Nearly three-quarters of parents had a university-level education and just over one-half of mothers were not working.

Table 2 presents the bivariate associations of dental caries prevalence and experience with the sociodemographic correlates. Overall, the prevalence (and 95% CI) of dental caries was 69.3% (63.4, 74.5), and the mean dental caries experience was 3.8 teeth (3.3, 4.2). Kindergarten-aged children (4–5-year-olds) had a lower prevalence and experience of dental caries than school-aged children (6–8-year-olds). All three non-Qatari nationality groups (Arabic, Indian subcontinent and Other) had a lower prevalence and experience of dental caries than Qatari children. Children attending community related to Embassy and International curriculum schools also had lower dental caries prevalence and experience as compared with Independent and National curriculum schools. Children whose parents had a

TABLE 1 Unweighted and weighted data by a set of background variables (age, sex, nationality, region, kindergarten/school type, parent highest level of education and mother's work status).

Variables		Unweighted n	Unweighted %	Unweighted 95%CI	Weighted %	95%CI
Total	**Categories**	**1154**				
Age						
	4–5	264	22.9	14.1,34.8	40.9	27.8,55.3
	6–8	890	77.1	65.2,85.9	59.1	44.7,72.2
Sex						
	Male	602	52.2	42.7,61.5	51.08	43.2,58.9
	Female	552	47.8	38.5,57.3	48.92	41.1,56.8
Nationality						
	Qatari	246	25.4	18.4,34	26.3	18.9,35.3
	Non-Qatari Arabic	431	44.5	36.1,53.3	44.2	35.2,53.6
	Indian subcont.	196	20.2	12,32.1	16.4	9.2,27.5
	Other	95	9.8	5.2,17.8	13.1	7.3,22.5
	Missing	186				
Region						
	Northern	213	18.5	9.8,31.9	24.37	13.8,39.3
	Central	397	34.4	22.6,48.5	43.46	30.4,57.6
	Western	544	47.1	33.5,61.2	32.17	21.6,45.0
Kindergarten/School type						
	Community related to Embassy	122	10.6	4.6,22.5	7.95	3.3,17.8
	Independent + National curriculum	414	35.9	23.3,50.8	30.21	19.2,44.1
	International curriculum	618	53.6	39.4,67.2	61.84	48.0,74.0
Parents' highest level of education						
	School/Diploma	302	30	24.3,36.5	26.93	21.2,33.6
	University	704	70	63.5,75.7	73.07	66.4,78.8
	Missing	148				
Mother's work status						
	Full-time/part-time	431	43.8	38.4,49.5	45.81	40.1,51.6
	Not working	552	56.2	50.5,61.6	54.19	48.4,59.9
	Missing	171				

Note: Age at time of children's selection in the sample.

Region: Northern (Al Shamal, Al Khor, Umm Salal, Al Daayen); Central (Doha, Al Wakrah); Western (Al Shahaniya, Al Rayyan).

Arabic Private Qatar Curriculum = National Curriculum.

university-level education had lower dental caries than those whose parents had a school or Diploma education. Dental caries prevalence and experience were not associated with sex of the child, region or with mother's work status.

The distribution of the dental children across the categories of behavioural factors and the association of dental caries prevalence and experience with the behavioural factors are presented in Table 3. Just under 60% of children had not commenced toothbrushing by 3 years. Although a little more than one-half of the children were currently brushing 2+/day, a small percentage were brushing <1/day. The exposure to sugary foods was high with 8.5 servings consumed on a usual day. Exposure to particular foods with a cultural relevance to Qatar such as dates did not explain the high number of sugary foods serves per day. Children in Qatar consumed on average 2.9 serves (a cup or 250 mL) of sweetened

TABLE 2 Caries in the primary dentition by sociodemographic variables—bivariate associations (sex, nationality, kindergarten/school type, region, parent's highest level of education and mother's work status).

			All children aged 4–8 years			
Variables	**Categories**	**Distribution %**	**Prevalence % dmft>0 (95%CI)**	**PR (95%CI)**	**Experience mean dmft (95%CI)**	**MR (95%CI)**
Total			69.3 (63.4,74.5)		3.8 (3.3,4.2)	
Age						
	4–5	40.9 (27.8,55.3)	60.1 (50.8,68.6)	**0.79 (0.67,0.94)**	3.6 (2.8,4.4)	0.93 (0.71,1.20)
	6–8	59.1 (44.7,72.2)	75.6 (69.1,81.2)	Ref.	3.9 (3.5,4.3)	Ref.
Sex						
	Male (Ref)	51.1 (43.2,58.9)	67.5 (61,73.4)	Ref.	3.8 (3.3,4.3)	Ref.
	Female	48.9 (41.1,56.8)	71.1 (62.4,78.5)	1.05 (0.92,1.20)	3.7 (3.1,4.4)	0.98 (0.80,1.19)
Nationality						
	Qatari (Ref)	26.3(18.9,35.3)	83.5(76.7,88.6)	Ref.	4.7(4.3,5.2)	Ref.
	Arabic	44.2(35.2,53.6)	68.9(61.1,75.7)	**0.82(0.74,0.92)**	3.7(3.0,4.3)	**0.78(0.65,0.94)**
	Indian subcontinent	16.4(9.2,27.5)	57.0(46.8,66.7)	**0.68(0.56,0.83)**	2.7(2.2,3.3)	**0.58(0.46,0.72)**
	Other	13.1(7.3,22.5)	54.2(41.1,66.8)	**0.65(0.51,0.83)**	2.9(1.8,4.0)	**0.61(0.42,0.88)**
Region						
	Northern (Ref)	24.4 (13.8,39.3)	71.1 (57.7,81.6)	Ref.	3.9 (3.0,4.7)	Ref.
	Central	43.5 (30.4,57.6)	67.8 (58.5,75.9)	0.95 (0.77,1.18)	3.5 (2.9,4.1)	0.90 (0.68,1.18)
	Western	32.2 (21.6,45)	69.8 (60.4,77.8)	0.98 (0.79,1.21)	4.1 (3.2,4.9)	1.04 (0.77,1.41)
Kindergarten/School type						
	Independent+ National curriculum (Ref)	30.2 (19.2,44.1)	85.4 (79.3,89.9)	Ref.	5.1 (4.6,5.5)	Ref.
	Community related to Embassy	7.9 (3.3,17.7)	58.6 (46.1,70.0)	**0.69 (0.55,0.85)**	3.1 (2.4,3.8)	**0.61 (0.47,0.78)**
	International Curriculum	61.8 (47.9,74)	62.7 (55.5,69.4)	**0.73 (0.65,0.83)**	3.2 (2.7,3.8)	**0.64 (0.53,0.77)**
Parent's highest level of education						
	School/Diploma (Ref)	26.9 (21.2,33.6)	83.0 (75.0,88.9)	Ref.	5.0 (4.3,5.7)	Ref.
	University	73.1 (66.4,78.8)	63.3 (57.1,69.2)	**0.76 (0.68,0.86)**	3.2 (2.7,3.6)	**0.64 (0.52,0.77)**
Mother's work status						
	Full-time/part-time (Ref)	45.8 (40.1,51.6)	65.8 (58.2,72.8)	0.94 (0.83,1.06)	3.4 (2.8,3.9)	0.86 (0.73,1.02)
	Not working	54.2 (48.4,59.9)	70.3 (63.4,76.4)	Ref.	3.9 (3.4,4.4)	Ref.

Note: Age at time of children's selection in the sample.Region: Northern (Al Shamal, Al Khor, Umm Salal, Al Daayen); Central (Doha, Al Wakrah); Western (Al Shahaniya, Al Rayyan).

Arabic Private Qatar Curriculum = National Curriculum.

Estimates in bold indicate statistically significant associations.

Abbreviations: MR, mean ratio; PR, prevalence ratio.

beverage each day. The sugar exposure was categorised into tertiles (low, intermediate and high). The cut points applied were 8 and 13 serves of sugary food and/or sugar-sweetened beverage. Only 15.2% of children had made a check-up visit in the last 12 months. Most children usually drank bottled water, evenly split between those bottle waters with no fluoride and those with a low fluoride level. Only a small percentage reported usually drinking tap water.

Dental caries prevalence and experience were lower among those children who began brushing by 3 years of age compared with those who commenced later, and those who brushed 2+/day at the time of the data collection compared with those who brushed less than once

TABLE 3 Dental caries in the primary dentition by behavioural variables—bivariate associations (tooth brushing, other fluorides, dietary sugars, dental visiting and drinking fluoridated bottled water).

Variables			All children aged 4–8 years			
			Prevalence % dmft>0 (95%CI)		Experience mean dmft (95%CI)	
Total	***n***	**Distribution %**	**69.3 (63.4,74.5)**	**PR (95%CI)**	**3.8 (3.3,4.2)**	**MR (95%CI)**
Brush by 3 y.o.						
No	731	59.2 (53.7,64.6)	75.2(69.7,80.0)	Ref	4.3 (3.8,4.7)	Ref
Yes	423	40.8 (35.4,46.3)	60.6(53.1,67.7)	**0.81(0.72,0.90)**	3.1(2.5,3.6)	**0.72 (0.60,0.86)**
Brushing frequency						
<1/day	76	7.4 (5.0,10.9)	82.9 (68.2,91.6)	Ref	5.2 (3.8,6.6)	Ref
1/day	378	36.9 (32.1,41.9)	67.8 (60.7,74.2)	**0.82 (0.69,0.97)**	4.1 (3.5,4.6)	0.78 (0.57,1.08)
2+/day	556	55.7 (50.0,61.3)	65.4 (57.8,72.2)	**0.79 (0.66,0.94)**	3.1 (2.7,3.6)	**0.61 (0.45,0.82**)
Sugar exposures						
Low	422	35.1 (32.0,38.3)	65.3 (57.2,72.5)	**0.86 (0.76,0.97)**	3.3 (2.7,3.9)	**0.76 (0.62,0.94)**
Intermediate	343	32.3 (28.7,36.1)	66.5 (58.1,74.0)	**0.87 (0.77,0.99)**	3.7 (3.1,4.3)	0.85 (0.69,1.04)
High	389	32.6 (28.9,36.5)	76.3 (69.0,82.3)	Ref	4.3 (3.7,5.0)	Ref
Check-up last 12 months						
Check-up	147	15.2(11.5,19.8)	48.0 (36.0,60.2)	**0.66 (0.51,0.85)**	2.4 (1.5,3.2)	**0.59 (0.41,0.85)**
No	1007	84.8(80.2,88.5)	73.1 (67.6,77.9)	Ref.	4.0 (3.6,4.5)	Ref.
Drinking water						
Low F Bottled water	461	45.4(39.0,52.0)	63.7 (56.4,70.4)	**0.88 (0.79,0.99)**	3.2 (2.6,3.7)	**0.79 (0.66,0.94)**
No F Bottled water	510	50.3(43.6,57.0)	72.0 (65.1,77.9)	Ref.	4.1 (3.5,4.6)	Ref.
Tap water	48	4.2(2.9,6.1)	61.4 (39.4,79.5)	0.85 (0.61,1.20)	3.5 (2.1,5.0)	0.87 (0.57,1.34)

Note: Sugar exposure: Low <8 exposures/day, Intermediate 8–13 exposures/day exposures/day, High >13.Drinking water: No F < 0.05 mg F/L, Low F > 0.05 mg F/L, generally not >0.03 mg F/L.

Estimates in bold indicate statistically significant associations.

Abbreviations: R, mean ratio; PR, prevalence ratio.

a day. Children who reportedly had a low or intermediate summed number of serves of sugary food and sugar-sweetened beverages and those who had made a visit to a dentist for a check-up in the last 12 months had lower dental caries prevalence and experience. Across the three groups of children defined by drinking water, those children who drank bottled water on a usual day with even a low fluoride level had lower dental caries prevalence than those who drank bottled waters with no fluoride. Those who usually drank tap water were not significantly different from those who drank bottled waters with no fluoride.

Table 4 presents the multivariable associations of caries with the block of sociodemographic and behavioural factors, respectively. In the top section of Table 4 presenting the block of sociodemographic variables, age was associated with both dental caries prevalence and experience. Non-Qatari nationality (Arabic and Other—predominantly Western countries) had a significantly lower dental caries prevalence, whereas those children with a non-Qatari Indian subcontinent nationality had a significantly lower dental caries experience than Qatari nationality children. Children attending International curriculum schools had a significantly lower dental caries prevalence, and children whose parents had a university education had a significantly lower dental caries prevalence and experience than those with a school or Diploma education.

In the bottom section of Table 4 presenting the block of behavioural factors, brushing by the age of 3 years was associated with a lower dental caries prevalence, and brushing 2+/day was associated with a lower dental caries experience than brushing less than 1/day. Children who reported low or intermediate summed number of serves of sugary food/beverages had lower dental caries prevalence, and those children who reported a low number of servings had lower dental caries experience. Visiting a dentist for a check-up in the last 12 months was associated with both a lower prevalence and experience of dental caries

TABLE 4 Multivariable regression models of dental caries in the primary dentition by separate blocks of sociodemographic and behavioural variables.

	Caries prevalence	Caries experience
	% dmft>0	Mean dmft
Variable	**PR (95%CI)**	**MR (95%CI)**
Socio-demographic		
Age		
4–5	**0.82 (0.72,0.94)**	0.94 (0.76,1.18)
6–8	Ref.	Ref.
Sex		
Male	Ref	Ref
Female	1.04 (0.93,1.16)	0.94 (0.80,1.11)
Nationality		
Qatari	Ref	Ref
Arabic	**0.91 (0.82,1.00)**	0.91 (0.74,1.11)
Indian subcontinent	0.80 (0.63,1.02)	**0.73 (0.54,0.99)**
Other	**0.75 (0.57,0.99)**	0.74 (0.49,1.11)
Kindergarten/School type		
Comm Related to Embassy	0.83 (0.64,1.07)	0.86 (0.60,1.24)
Independent+Nat curriculum	Ref	Ref
International Curriculum	**0.89 (0.80,0.99)**	0.85 (0.69,1.06)
Parent's highest level of education		
School/Diploma	Ref	Ref
University	**0.85 (0.75,0.95)**	**0.72 (0.58,0.89)**
Behavioural		
Brush by 3 y.o.		
No	Ref	Ref
Yes	**0.88 (0.79,0.99)**	0.83 (0.68,1.02)
Brushing frequency		
<1/day	Ref	Ref
1/day	0.89 (0.74,1.07)	0.85 (0.61,1.19)
2+/day	0.90 (0.76,1.08)	**0.72 (0.53,0.97**)
Sugar exposure		
Low	**0.85 (0.74,0.97)**	**0.75 (0.60,0.92)**
Intermediate	**0.89 (0.79,1.00)**	0.87 (0.72,1.05)
High	Ref.	Ref.
Check-up last 12 months		
Check-up	**0.68 (0.53,0.87)**	**0.63 (0.44,0.91)**
No	Ref	Ref
Drinking water		
Low F Bottled water	**0.89 (0.80,0.99)**	**0.79 (0.62,0.96)**
No F Bottled water	Ref.	Ref.
Tap water	0.85 (0.57,1.26)	0.85 (0.51,1.41)

Note: Sugar exposure: Low <8 exposures/day, Intermediate 8–13 exposures/day exposures/day, High >13.Drinking water: No F < 0.05 mg F/L, Low F > 0.05 mg F/L, generally not >0.03 mg F/L.

Estimates in bold indicate statistically significant associations.

Abbreviations: MR, mean ratio; PR, prevalence ratio.

compared with not making such a visit. Finally, drinking bottled water with even a low fluoride level was associated with a lower dental caries prevalence and experience than drinking bottled water with no fluoride. Dental caries prevalence and experience of children who usually drank tap water were no different from those drinking bottled water with no fluoride.

4 | DISCUSSION

Primary dentition dental caries prevalence and experience were high among children residing in Qatar. The dental caries prevalence of 69.3% and dental caries experience at 3.8 dmft were very similar to that observed in the National Oral Health Survey 2011.[2] The prevalence and/or experience was lower among younger children, those of non-Qatari nationality, attending International curriculum kindergartens and schools and whose parents had a university-level education. Dental caries accumulates with age and is generally higher among children from households with less formal education. The finding that non-Qatari nationality children had lower prevalence and experience of dental caries than Qatari nationality children was also consistent with the findings of the National Oral Health Survey 2011. It is suggested that the higher levels of dental caries among Qatari nationality children reflect dental caries as a disease of affluence in a country that has rapidly improved its economic circumstances. Non-Qatari children resident in Qatar were found to have lower dental caries prevalence and experience. This is counter to the frequent finding in Western countries that children of more recent immigrant groups have poorer child oral health.[11] The lower levels of dental caries among children in International curriculum kindergartens and schools reflected the partial stratification of the four nationalities identified across the schooling system.

The prevalence and experience of dental caries were also lower among those who began toothbrushing by 3 years of age, brushed more than 1/day, had a lower exposure to sugary foods and sugar-sweetened beverages, made a check-up visit in the last 12 months and usually drank bottled water with at least a low fluoride level. Each of these behaviours has been frequently identified in research as protective factors against dental caries among children.[13,14] The standout finding for toothbrushing was the modest percentage of children for whom brushing with a toothpaste commenced toothbrushing by 3 years of age (40.8%) and the relatively low percentage reportedly brushing 2+ times a day (55.7%).

The combined exposure to sugary foods and the drinking of sugar-sweetened beverages was a key indicator. Whilst these data should not be interpreted as sugar

intake, they were indicative of frequency of exposure to sugars.

The parental questionnaire included drinking water consumption by children on a usual day. Most children drank some bottled water on a usual day, the remainder reported drinking tap water on a usual day. We were able to construct a drinking bottled water variable that showed that even low levels of fluoride were associated with lower dental caries prevalence and experience. The relationship between fluoride concentration in drinking water and dental caries is curvilinear and quite sensitive at lower fluoride levels. An optimum fluoride level in drinking water that would achieve near-maximum dental caries prevention without causing unwanted dental fluorosis would be expected to be closer to the bottom end of the recommended range or 0.5 mg F/L in a location with a high ambient temperature whether in tap or bottled water.[15]

This study focused on child resident in Qatar aged 4–8 years. The 4- and 5-year-old age group was selected as those children are within kindergartens forming clusters for sampling, whereas the older 6–8-year-olds were at school. The age range excluded children less than 4 years old and therefore does not lend itself to estimating severe early childhood caries (S-ECC).The 4- and 5-year-old estimates (Table 2), however, are comparable with early childhood caries (ECC) with a threshold of cavitation for decay. The age range was extended to 8 years as this tends to be near the peak age of dental caries in the primary dentition.[11] Permanent dentition dental caries was also observed and recorded but is not reported. This means the total burden of dental caries and treatment needs could be greater in children 6 years old and above than that implied by the dental caries prevalence and experience in the primary dentition.

These findings came from a survey with considerable emphasis on drawing a probability sample from the resident child population and the detailed weighting of data to produce estimates representative of the population. The distribution of children by sex and age was closely aligned to the 2015 Qatar Census. The lower response rate than expected resulted in some loss of statistical power, but significant differences across groups were still detected. The dental examinations were conducted by calibrated examiners, and the parental questionnaire was detailed. Missingness, however, was a constant at a moderate level. It most likely arose from literacy concerns or proficiency in either Arabic or English. This increased the confidence interval around estimates for subgroups. The food frequency approach built around standard serving was only indicative of sugar intake, and the assaying of fluoride levels in brands of bottled water available in Qatar was sometimes quite varied leading to a coarse, but robust dichotomy around a low fluoride level. Despite these concerns about measurement, both sugar exposure and fluoride levels in bottled water proved valuable in the analysis.

There were a very high prevalence and extent of dental caries yet to be brought under control by a range of policies and programs with considerable reach through the child population. The association of dental caries in the primary dentition with sociodemographic factors leant only limited support for a targeted strategy. Associations describing the 'who' were significant, but weak. They comment on the relative differences between subgroups. The absolute prevalence and experience of dental caries, however, were high in all subcategories. The high overall prevalence of dental caries supported the need for population-level interventions in addition to the theoretical arguments for such an approach.[16,17]

The associations with behavioural factors tell the 'why'. They indicate that the focus should be on reducing sugar exposure,[18,19] the use of fluoridated toothpaste in toothbrushing[20] and possibly the wider availability of bottled or packaged drinking water with low levels of fluoride.[21] The late initiation of toothbrushing and only moderate frequency of toothbrushing, however, mean that the benefit of fluoridated toothpaste will be attenuated until toothbrushing practices greatly improve. The greater availability of bottled drinking water with some fluoride is a possible direction. It would achieve an automatic exposure because it provides a preventive benefit without any active compliance by children or parents.[22]

Interventions including oral health promotion[23] involving anticipatory guidance[24,25] in areas ranging from toothbrushing behaviour to dietary patterns (sugary foods and sugar-sweetened beverages) are needed. Clinical preventive interventions such as well-baby checks and periodic check-up visits also need to be considered under the umbrella of universal access to dental services.[26] A systematic approach is required to ensure early diagnosis and prompt treatment of dental caries. Outreach through kindergarten/school-based screening and provision of non-invasive procedures such as fissure sealants and use of fluoride varnish measures for active dental caries need to be backed up by referral to clinics for more definitive treatment in a primary care setting.

Dental caries in the primary dentition among children in Qatar was high. Dental caries prevalence varied but was high across all sociodemographic factors, suggesting a need for an all of population approach intervensions. Preventive interventions aimed at modifying behavioural factors associated with dental caries including toothbrushing practices, sugar intake, check-up visits and the drinking of water with fluoride are needed.

AUTHOR CONTRIBUTIONS

S.C. was involved in data capture, data curation, and formal analysis and writing—original draft. A.O.A. was a principal investigator and was involved in conceptualization, data capture, review and editing. M.S.A.D. was a co-investigator and was involved in conceptualization, data capture, review and editing. H.G.S.M. and T.M. were involved in data capture and statistical data management, review and editing. G.M.A. supported the research team and was involved in review, editing and approving. M.A.M. was the senior responsible officer for the research project and was involved in review, editing and approving. M.A.T. was a custodian of the research project and was involved in review, editing and approving. J.d.V. was involved in conceptualization, review and editing. L.G.D. was involved in conceptualization, data capture, data curation, and formal analysis and writing—review and editing. A.J.S. was involved in conceptualization, data capture, data curation, and writing—original draft.

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CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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