Original Article

Caries status and risk factors among urban and rural primary students in Thua Thien Hue Province, Vietnam

Tran Tan Tai ,¹ Hoang Thi Ngoc-Anh ,² Hoang Dinh Tuyen ,³ Luu Ngoc Hoat ⁴

¹Faculty of Odonto - Stomatology, Hue University of Medicine and Pharmacy, Hue University, Thua Thien Hue, Vietnam

²Center of Population Health Sciences, Hanoi University of Public Health, Hanoi, Vietnam

³Faculty of Public Health, Hue University of Medicine and Pharmacy, Hue University, Thua Thien Hue, Vietnam

⁴Department of Biostatistics and Medical Informatics, Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam

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Correspondence to

Hoang Thi Ngoc-Anh

Center of Population Health Sciences, Hanoi University of Public Health, Hanoi 100000, Vietnam.

E-mail: htan@huph.edu.vn

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ORCID iDs

Tran Tan Tai

<https://orcid.org/0000-0002-4743-512X>

Hoang Thi Ngoc-Anh

<https://orcid.org/0000-0002-5675-9396>

Hoang Dinh Tuyen

<https://orcid.org/0000-0002-9725-4212>

Luu Ngoc Hoat

<https://orcid.org/0000-0001-6911-5410>

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Authors Contributions

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Tran TT, Hoang DT, Luu NH; Methodology: Tran

TT, Hoang DT, Luu NH; Software: Hoang TNA,

Hoang DT; Validation: Hoang TNA, Hoang DT;

Writing - original draft: Hoang TNA, Tran TT;

ABSTRACT

Background: Dental caries is an essential public health problem in most developing countries including Vietnam. This study's aims were to discover the dental caries prevalence in selected areas of Thua Thien Hue province, Vietnam, and to detect the association of sweet food consumption and oral hygiene practices with caries among Vietnamese primary school students.

Methods: A cross-sectional study was conducted in Hue City and in Nam Dong District as one urban and one rural areas of Thua Thien Hue province, Vietnam that identifies the dental caries prevalence and to find participants for the matched case-control study. Each child in the dental caries group was matched to a student in the non-caries group using multivariate matched sampling methods that incorporated the propensity score. Practices related to dental hygiene and sweet food consumption were obtained using an interviewer-administered questionnaire for the matched case-control study.

Results: Prevalence of dental caries in Hue City was 77.9% and in Nam Dong District was 77.3%, giving no statistically significant difference between two areas. Brushing teeth and replacing toothbrush frequently were related to the presence of dental caries in both urban and rural areas. Children who brushed teeth at least twice a day were less likely to have dental caries compared to those who did not (adjusted odds ratio [aOR], 0.42; 95% CI, 0.29–0.62; $P < 0.001$). The odds of having dental caries were significantly higher among children who replaced their toothbrush after at least each nine months than among those who replaced toothbrushes less than every three months (aOR, 2.66; 95% CI, 1.77–4.01; $P < 0.001$).

Conclusion: The prevalence of dental caries was equally high among primary students in Hue City and Nam Dong District. Using toothbrush correctly more than twice per day and replacing the toothbrush every three months can reduce dental caries among primary school students.

Keywords: Dental caries; Cross-sectional study; Case-control study; Vietnam

INTRODUCTION

Dental caries (DC) results when a microbial biofilm (plaque) that has formed on the tooth surface converts the free sugars contained in food and drinks into acids that dissolve tooth enamel and dentine over time.¹ The global epidemiological transition has led to a pandemic

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of childhood DC, affecting 60%–90% of children.² This high prevalence leads to a decrease in the quality of life of the affected children and high economic costs for their parents and for society, with disparities related to well-known issues of socioeconomics, immigration, lack of preventive efforts, and dietary changes.³ Besides, the pain from DC can affect school attendance as well as eating and speaking, which can impair growth and development.⁴

Even though the overall prevalence of DC has decreased in developed countries, caries continue to be an essential public health problem in most developing countries.⁴ Previous studies in developing countries showed a varied prevalence of DC, up to 78.3% in Lithuania, 30.5% in Sudan, and 37.5% in Kenya.^{5,7} This prevalence is a result of increasing utilization of sweet foods, poor tooth-brushing habits, poor oral hygiene, and a low level of awareness, among other factors.⁸ Caries can be prevented by decreasing sugar intake and brushing teeth after every meal, using the appropriate techniques, and by regular check-ups.

Although the trend is not yet clear in developing countries, including Vietnam, DC has a growing impact on the health and well-being of people in the region. The 2009 publication of the 1999 Vietnam National Oral Health Survey found that 85% of children aged 6 to 17 years had DC, a significantly higher prevalence and severity than that observed ten years earlier.^{9,10} Another study of children aged 2 to 6 years in Vietnam from 2015 to 2018 found a DC prevalence of around 90%.¹¹

To our knowledge, matched case-control studies of DC in primary students have seldom been done in Vietnam. The majority of the studies examining associations between risk factors such as oral care habits or diet and DC employed a cross-sectional design, which does not allow inference of causality.¹² Conversely, the matched case-control study allows estimation the strength of the association between an event (DC) and risk factors from a smaller sample size than a cross-sectional study with high precision since the power of causal inference does not completely depend on sample sizes.¹³ Understanding the determinants of DC in primary students, with a range of sweet food consumption and practices of oral hygiene variables, could provide evidence for formulating new policies designed to reduce DC in primary school students in Vietnam.

We hypothesized that urban children can be considered as a warning group of DC due to high exposure with many risk factor such as urbanized diet pattern¹⁴ and bottled water.¹⁵ In this study, we organized a cross-sectional study to discover the DC prevalence in one urban and one rural areas in a central province in Vietnam. A matched case-control study aims to detect the association of sweet food consumption and oral hygiene practices with DC among Vietnamese primary school students.

METHODS

Setting and participants

Thua Thien Hue is a province in the North Central Coast region of Vietnam, which consists of a mixture of urban, rural, and mountainous areas and a socio-economically mixed population. In Thua Thien Hue province, based on the experts' opinions and experiences, we selected Hue city (the provincial capital) for the urban area and Nam Dong district for the rural mountainous site with poor social economic status and several ethnic minority groups.

Children were invited to participate the study if they 1) did not suffer from any systematic diseases (based on the parent/caregiver's report) and 2) were accompanied by a parent/caregiver who spoke Vietnamese.

Sample size and sampling procedures

We used the sample size for case-control study¹⁶ as follow:

$$n = \frac{\{Z_{1-\frac{\alpha}{2}}\sqrt{2P_2(1 - P_2)} + Z_{1-\beta}\sqrt{P_1(1 - P_1) + P_2(1 - P_2)}\}}{(P_1 - P_2)^2}$$

With an expected exposure (frequently consumed added sugar) of 90% and 80% for case and control groups ($P_1 = 0.9$ and $P_2 = 0.8$),¹⁷ type I error (alpha) of 0.05, and power of statistical test (1-beta) of 0.9, at least 307 participants were needed for each case and control groups in matched case-control study. Since participants of this each group were selected from a cross-sectional study, the sample size of the cross-sectional study had to be enough for the matched case-control study. The ratio of DC and non-DC among primary students is approximately 3:1 in Vietnam.¹⁸ According to this ratio, at least 1,228 students (four times the anticipated non-carries participants in the matched case-control study) were needed to have a sufficient sample (307 participants) for the control group (non-carries students). Therefore, the minimum sample size for the cross-sectional study is 1,228.

In the first stage of sampling, which involved selection of schools in each stratum, we created two separate lists of schools for the two areas based on the online information published on the official website of the Vietnam Ministry of Education and Training. Generally, the numbers of students in rural schools were half of those in urban schools. We, therefore, used a simple random sampling technique to select two schools for the urban stratum and four schools for the rural one.

In the second stage of sampling that involved selection of students within the schools, we selected all students in the selected school.

From February 2014 to July 2014, we invited 1,480 children to participate in the cross-sectional study; 95% agreed, while of the 760 children invited for the matched case-control study, 100% agreed and completed the study. The 5% who did not participate in the first study were 1) unable to attend school on the day of the oral check-up; 2) absent at the time of check-up or 3) not permitted by the parents to participate in the study. The final samples for cross-sectional study and matched case-control study were 1,406 and 760, respectively.

The outcome variable “dental caries” was used to define cases and controls. Examinations results in classification of 1,091 children as cases and 315 children as controls. Each child in the DC group was then matched by age, gender, location, mother's education, family use of processed water, and family's economic status to a student in the non-carries group (1:1 ratio). The matched case-control study was performed using multivariate matched sampling methods that incorporate the propensity score.

Parents/caregivers of primary students signed a consent form before we carried out the oral examinations of the students in cross-sectional study and interviewed questionnaire for the matched case-control study.

Variables

The dependent variable was the DC status detected by the presence of tooth decay, missing, and filled teeth at the time of the oral examination. We calculated the DMFT (permanent teeth) and dmft (primary teeth) indices, defined as the total number of teeth or surfaces that are decayed (D), missing (M), or filled (F) in an individual, ranging from 0 to 28 or 32. The independent variables were the frequency of consumption of sweet foods and oral hygiene practice. Frequency of consumption of sweet foods was the average number of days in a week that children consumed sweet foods (foods having a high sugar content, such as candy or preserves) in the previous 30 days. Information related to oral hygiene practice included brushing the teeth after meals (yes/no), average time of brushing (in minutes), the number of times brushing per day, the way of cleaning teeth (using toothpick, toothpaste with fluoride, and/or using mouth rinse with fluoride), time of using a brush before changing to a new one (in months), and time periods between oral health checkups (in months).

Training and data collection

Oral examination in the cross-sectional study

The training and calibration exercise consisted of two steps, one theoretical and one practical. The theoretical step involved a discussion of the criteria for the diagnosis of DC. A specialist in pediatric dentistry (the gold standard) coordinated this step, instructing two data collectors (two general dentists) on how to perform the examination. The practical step was presented at a randomly selected primary school that was not part of the main sample. Data collectors also took one week of practical lessons in a chosen school, where they examined students and categorized the status of DC under the direct supervision of a general dentist. At the end of the training session, 20 students were examined by the data collectors independently for DC under the supervision of a certified dentist. Interobserver agreement was then calculated using Cohen's Kappa statistic, resulting in a score of 0.75, which indicates "acceptable agreement."

We trained two research assistants to interview the mothers or caregivers about children's age, sex, location, mother's education, family use of processed water, and family's economic status, for the matching step in the matched case-control study.

Interviewing with structured questionnaire in the matched case-control study

The structured questionnaire was designed to evaluate the association of oral health conditions with sweet food consumption and oral hygiene practices. The questionnaire consisted of ten items distributed over the two domains: sweet food consumption and oral hygiene care.

Data collectors from Hue University of Medicine and Pharmacy were given and intensive two-day training on how to interview children and complete the questionnaire.

Data analysis

We checked and entered data using Epidata version 3.0 software. We then cleaned and exported the data to STATA version 16.0 for analysis. Frequencies and percentages were used to describe categorical variables. In bivariate analysis, odds ratio (OR) and 95% confidence interval (CI) generated from logistic regression were used to evaluate the relationship between DC and each participant's characteristics. To identify factors related to DC, multiple logistic regression was carried out using the stepwise backward selection procedure with a cutoff of $P \leq 0.2$.

Ethical considerations

Ethical approval for this study was obtained from research evaluation by the Ethical Review Committee of Hue University of Medicine and Pharmacy on 15 January 2014. After researchers provided complete information about the purpose and procedures of the study, and all students' mothers/caregivers provided informed consent for their children to participate in the study. We referred all students having any oral disorders to certified dentists for treatment and consultation.

RESULTS

Of the 1,406 children who participated in the cross-sectional study, the prevalence of age was equally distributed from seven to 11 years, however significantly different between rural and urban areas ($P < 0.001$). Approximately half of the participants were boys (53.2%) and had mothers/caregivers graduated from high school and/or upper level of education (50.9%). The majority of participants were Kinh ethnicity (majority) (92.3%). Relatively few students (10.9%) were from low-income families. Nearly one quarter (22.0%) of the children used non-processed water sources for daily hygiene activities, while more than one third (38.7%) consumed sugary foods on more than four days per week. Apart from sex, other variables were significantly different between rural and urban students (Table 1).

More than three quarters of the children (77.6%) were diagnosed with DC, of which 34.8% had decay in both primary and permanent teeth. Relatively few students had missing teeth

Table 1. Characteristics of primary school children, 7–11 years by location^a (n = 1,406)

Participants' characteristics	All	Location		P-value ^b
		Rural	Urban	
Total	1,406 (100)	661 (47)	745 (53)	
Age (yr)				< 0.001
7	315 (22.4)	167 (53)	148 (47)	
8	297 (21.1)	123 (41.4)	174 (58.6)	
9	308 (21.9)	141 (45.8)	167 (54.2)	
10	309 (22)	122 (39.5)	187 (60.5)	
11	177 (12.6)	108 (61)	69 (39)	
Sex				0.210
Boy	748 (53.2)	340 (45.5)	408 (54.5)	
Girl	658 (46.8)	321 (48.8)	337 (51.2)	
Ethnicity				< 0.001
Kinh (majority)	1,298 (92.3)	554 (42.7)	744 (57.3)	
Minority	108 (7.7)	107 (99.1)	1 (0.9)	
Economic status				< 0.001
Poor	153 (10.9)	117 (76.5)	36 (23.5)	
Non-poor	1,253 (89.1)	544 (43.4)	709 (56.6)	
Mother/caregivers' education				< 0.001
≤ Primary school	345 (24.5)	303 (87.8)	42 (12.2)	
Secondary school	346 (24.6)	196 (56.6)	150 (43.4)	
≥ High school	715 (50.9)	162 (22.7)	553 (77.3)	
Water sources in family				< 0.001
Processed water	1,097 (78)	353 (32.2)	744 (67.8)	
Non-processed water	309 (22)	308 (99.7)	1 (0.3)	
Frequency of sugar intake per week				0.020
Up to 4 days	862 (61.3)	384 (44.5)	478 (55.5)	
More than 4 days	544 (38.7)	277 (50.9)	267 (49.1)	

^aNam Dong district as rural area and Hue city as urban area; ^bgroups compared using Pearson's chi-squared for age, sex, mother/caregivers' education, frequency of sugar intake per week and Fisher's exact test for ethnicity, economic status, and water sources in family.

Table 2. Dental issues found among primary school children, 7–11 years by locations^a (n = 1,406)

Variables	All	Location		P-value
		Rural	Urban	
Total	1,406 (100)	661 (47)	745 (53)	
Dental caries (any type)				0.810
Yes	1,091 (77.6)	511 (46.8)	580 (53.2)	
No	315 (22.4)	150 (47.6)	165 (52.4)	
Missing teeth (any type)				< 0.001
Yes	131 (9.3)	92 (70.2)	39 (29.8)	
No	1,275 (90.7)	569 (44.6)	706 (55.4)	
Filled teeth (any type)				< 0.001
Yes	138 (9.8)	24 (17.4)	114 (82.6)	
No	1,268 (90.2)	637 (50.2)	631 (49.8)	
Type of dental caries				0.550
Primary	456 (32.4)	203 (44.5)	253 (55.5)	
Permanent	146 (10.4)	74 (50.7)	72 (49.3)	
Both primary and permanent	489 (34.8)	234 (47.9)	255 (52.1)	
No caries	315 (22.4)	150 (47.6)	165 (52.4)	
Type of missing teeth				< 0.001
Primary	126 (9)	90 (71.4)	36 (28.6)	
Permanent	5 (0.4)	2 (40)	3 (60)	
No missing teeth	1,275 (90.7)	569 (44.6)	706 (55.4)	
Type of filled teeth				< 0.001
Primary	85 (6)	11 (12.9)	74 (87.1)	
Permanent	53 (3.8)	13 (24.5)	40 (75.5)	
No filled teeth	1,268 (90.2)	637 (50.2)	631 (49.8)	
Gingivitis				< 0.001
Yes	467 (33.2)	151 (32.3)	316 (67.7)	
No	939 (66.8)	510 (54.3)	429 (45.7)	
Tartar				0.380
Yes	439 (31.2)	214 (48.7)	225 (51.3)	
No	967 (68.8)	447 (46.2)	520 (53.8)	
Plaque accumulation				0.011
Yes	780 (55.5)	343 (44)	437 (56)	
No	626 (44.5)	318 (50.8)	308 (49.2)	

^aNam Dong district as rural area and Hue city as urban area.

(9.3%) or filled teeth (9.8%). Of the 131 students with missing teeth, 126 (96.2%) were missing primary teeth. Of the 138 students who had filled teeth, 85 (61.6%) were in primary teeth. The percentages of children with gingivitis, tartar, and plaque accumulation were 33.2%, 31.2%, and 55.5%, respectively (**Table 2**). The prevalence of caries, type of caries and tartar was relatively equal between rural and urban students ($P < 0.05$).

Table 3 represents the dmft and DMFT indices by age groups and residential location. Decayed teeth were the principal component in both dmft and DMFT indices in the 10–11-year age group. Means of both dmft and DMFT indexes were significantly higher in the urban 10–11-year-old group compared to rural 10–11-year-age group.

In the results of bivariate analyses shown in **Table 4**, it can be seen that DC were likely to occur in children using toothpicks (OR, 1.39; 95% CI, 1.01–1.91), or replacing the toothbrush after nine months or more (OR, 3.12; 95% CI, 2.10–4.64). In contrast, children were less likely to have DC if they brushed their teeth at least twice a day (OR, 0.35; 95% CI, 0.24–0.51). Children eating sweets four times per week had a higher likelihood of caries than those consuming less than four times, however, the difference was not statistically significant (OR, 1.34; 95% CI, 0.97–1.87).

Dental caries among Vietnamese primary students

Table 3. Distribution of decayed, missing, and filled primary (dmft) and permanent (DMFT) teeth by age and location^a (n = 1,406)

Indices	7–9 years, mean (SD)				10–11 years, mean (SD)			
	Total (n = 920)	Rural (n = 431)	Urban (n = 489)	P-value ^a	Total (n = 486)	Rural (n = 230)	Urban (n = 256)	P-value ^b
d	6.4 (3.3)	6.3 (3.2)	6.4 (3.4)	0.67	4.7 (2.6)	4.1 (2.2)	5.1 (2.8)	0.001^c
m	1.7 (0.9)	1.8 (1.0)	1.6 (0.8)	0.35	1.4 (0.9)	1.3 (0.7)	1.6 (1.5)	0.59
f	2.3 (1.5)	2.1 (1.0)	2.5 (1.5)	0.51	2.1 (1.4)	1.0 (0.0)	2.2 (1.4)	0.26
dmft	6.6 (3.4)	6.6 (3.3)	6.6 (3.5)	0.83	4.8 (2.7)	4.2 (2.4)	5.3 (2.9)	< 0.001^d
D	3.0 (2.1)	2.9 (2.0)	3.0 (2.3)	0.68	3.5 (2.9)	3.0 (2.2)	3.9 (3.3)	0.014^c
M	3.0 (1.4)	-	3.0 (1.4)	-	1.7 (0.6)	2.0 (0.0)	1.0 (0.0)	-
F	1.8 (1.0)	1.1 (0.4)	2.0 (1.0)	0.031^c	2.0 (1.0)	1.5 (0.8)	2.1 (1.0)	0.18
DMFT	3.0 (2.1)	2.9 (2.0)	3.1 (2.2)	0.48	3.5 (2.9)	3.1 (2.2)	3.9 (3.4)	0.019^c

Bold-face values indicate numbers with *P*-value < 0.05.

dmft = decay-missing-filled index in primary teeth; DMFT = decay-missing-filled index in permanent teeth; SD = standard deviation.

^admft and DMFT is the sum of the number of decayed, missing due to caries, and filled teeth in the primary teeth and permanent teeth, respectively; ^bMann-Whitney U test; ^c*P* < 0.05; ^d*P* < 0.001.

Table 4. Sweet food consumption and oral hygiene practices among primary school children in the case-control study (n = 630)

Participants' characteristics	Group		Unadjusted		Adjusted	
	Control (n = 315)	Case (n = 315)	OR (95% CI)	P-value	aOR (95% CI)	P-value
Daily frequency of sugar intake						
Up to 4 times	217 (68.9)	196 (62.2)	1		-	-
More than 4 times	98 (31.1)	119 (37.8)	1.34 (0.97–1.87)	0.343	-	-
Brush teeth at least twice a day						
No	53 (16.8)	115 (36.5)	1		1	
Yes	262 (83.2)	200 (63.5)	0.35 (0.24–0.51)	< 0.001	0.42 (0.29–0.62)	< 0.001
Brush teeth after meal						
No	121 (38.4)	131 (41.6)	1		-	-
Yes	194 (61.6)	184 (58.4)	0.88 (0.64–1.21)	0.079	-	-
Brush teeth at least 2 min per time						
No	47 (14.9)	51 (16.2)	1		-	-
Yes	268 (85.1)	264 (83.8)	0.91 (0.59–1.40)	0.115	-	-
Use flour toothpaste when brushing						
No	33 (10.5)	38 (12.1)	1		-	-
Yes	282 (89.5)	277 (87.9)	0.85 (0.52–1.40)	0.182	-	-
Use fluoride mouth rinse						
No	251 (79.7)	253 (80.3)	1		-	-
Yes	64 (20.3)	62 (19.7)	0.96 (0.65–1.42)	0.201	-	-
Use tooth stick						
No	196 (62.2)	171 (54.3)	1		1	
Yes	119 (37.8)	144 (45.7)	1.39 (1.01–1.91)	0.036	1.32 (0.95–1.85)	0.100
Holding food in mouth						
No	281 (89.2)	270 (85.7)	1		-	-
Yes	34 (10.8)	45 (14.3)	1.38 (0.86–2.22)	0.123	-	-
Replace toothbrushes						
≤ 3 mon	173 (54.9)	122 (38.7)	1		1	
6 mon	88 (27.9)	74 (23.5)	1.19 (0.81–1.75)	0.405	1.10 (0.74–1.64)	0.637
≥ 9 mon	54 (17.1)	119 (37.8)	3.12 (2.10–4.64)	< 0.001	2.66 (1.77–4.01)	< 0.001
Regular dental visit at least every 6 mon						
No	92 (29.2)	85 (27.0)	1		1	
Yes	223 (70.8)	230 (73.0)	1.12 (0.79–1.58)	0.343	1.23 (0.85–1.77)	0.273

Values are presented as number (%). Bold-face values indicate numbers with *P*-value < 0.05.

OR = odds ratio; CI = confidence interval.

In multivariable regression, there was a significant association between DC and brushing teeth at least twice a day, in that children who did that were less likely to have DC compared to those who did not (aOR, 0.42; 95% CI, 0.29–0.62; *P* < 0.001). Also, the odds of having DC were significantly higher among children who only replaced their toothbrush once in nine months or more than among those who did that within three months (aOR, 2.66; 95% CI, 1.77–4.01; *P* < 0.001) (Table 4).

Table 5. Sweet food consumption and oral hygiene practices among primary school children between urban (Hue city) and rural (Nam Dong District) areas

Participants' characteristics	Location			
	Rural (n = 329)		Urban (n = 301)	
	aOR (95% CI)	P-value	aOR (95% CI)	P-value
Brush teeth at least twice a day				
No	1		1	
Yes	0.33 (0.18–0.61)	< 0.001	0.38 (0.22–0.64)	< 0.001
Use tooth stick				
No	1		1	
Yes	1.5 (0.93–2.44)	0.098	1.16 (0.71–1.9)	0.544
Replace toothbrushes				
≤ 3 mon	1		1	
6 mon	1.28 (0.72–2.26)	0.401	0.83 (0.5–1.51)	0.544
≥ 9 mon	3.73 (2.05–6.81)	< 0.001	2.15 (1.21–3.83)	0.009
Regular dental visit at least every 6 mon				
No	1		1	
Yes	0.63 (0.37–1.06)	0.080	1.10 (0.66–1.84)	0.702

Bold-face values indicate numbers with P -value < 0.05 .

aOR = adjusted odds ratio; CI = confidence interval.

In both urban and rural areas, brushing teeth at least twice a day and replacing toothbrush once in three months were significantly associated with DC (Table 5). These associated factors were also confirmed when stratified by mother's education and family economic status (Supplementary Table 1).

DISCUSSION

In Vietnam, data on dental caries in primary school children is scarce. In this study, dental caries is a common health problem among primary school children in both urban and rural areas. Brushing teeth and replacing toothbrushes frequently were likely to alleviate the presence of DC in both areas. Our study is the first in-depth assessment of factors related to DC to focus on two separate socio-cultural environments: rural and urban sites in Vietnam. Such evidence is crucial to improve the management of DC among primary students in these areas.

Dental caries was prevalent among a population of primary school children in both urban and rural areas in Vietnam. Our findings were higher than what had been reported previously in China (41.15%) and Malaysia (61.6%).^{19,20} A recent meta-analysis of DC studies in different regions of Saudi Arabia determined this prevalence was 80%.²¹ The WHO/FDI (World Dental Federation) oral health goals to be achieved by the year 2000 proposed that prevalence of caries in 5–6-year-olds should be less than 50%, and the number of teeth affected by caries at the age of 12 should not be more than 3.²² Although no target was set for primary school children, the mean DMFT index was 3.5 for 10–11-year-olds in our study, which is above the desirable range set by the WHO. Our DMFT index was also higher than findings in Indonesia in 2019 (1.58) and Myanmar in 2012 (0.2).^{23,24} The findings from Saudi Arabia were similar to those from the present study with the prevalence of primary teeth caries reported during 1999–2008 at 5.38, and for permanent teeth at 3.34.²⁵ The collective evidence from our study and previous studies confirms the endemic nature of DC in primary students and signifies a burden on public health.

Brushing teeth twice a day played an important role in preventing DC. We found that primary school students who brushed teeth at least twice a day were less likely to have DC than those

who did not. Effective brushing will remove dental plaques, which is the first step in DC and using a toothpaste containing fluoride reduces decay by making enamel more resistant.²⁶ We also found that the frequency of DC was significantly higher among children who only replaced their toothbrush after at least nine months than those who replaced toothbrushes within three months. The World Dental Federation recommends that the toothbrush should be replaced with a new one every three months, because toothbrushes could become carriers of bacteria over time,²⁷ as germs collected from the mouth accumulate in the bristles of the toothbrush. When toothbrushes touch each other, the germs can spread easily from one toothbrush to another, contributing to DC in other family members.

In our knowledge, the relationship between using toothpicks and dental caries has not been well studied. While a finding among urban primary school children in Ethiopia reported that 67.6% of children cleaned their teeth using traditional toothpicks related to dental caries,⁸ another report did not show better or worse impact from using toothpicks for controlling gingivitis or plaque.²⁸ This study reported that in a multivariate regression model, children cleaning their teeth using the traditional toothpick were not more likely to have DC than those who did not use them. We recommend further studies to develop a clearer picture about this relationship.

Diet is one of three main factors in the development of DC, which were identified almost 100 years ago. The total consumption of sugar, as well as the frequency of its intake, contributes to the onset of DC.²⁹ However, in this study, we found no significant difference in caries prevalence between children eating sweets four times per week and those consuming less than four times. The importance of diet in caries incidence has, however, been demonstrated in other studies, with regard to the total amount consumed,³⁰ as well as the frequency of intake.^{31,32} There is a need for further study in our population, with more details on food consumed, such as dietary records, 24-hour recalls, and a semiquantitative assessment of food frequency, to obtain a more accurate picture of any possible association.

Our initial hypothesis is that the urban school children can be considered as a warning group. They may be exposed to an increasingly urbanized diet pattern with high added sugar and salt¹⁴ and bottled water with lacking of fluoride¹⁵ which plays a vital role in caries progression. However, our findings revealed similar prevalence of DC and factors were related to caries among both urban and rural mountainous groups. This may due to the expansive development of commercial advertisements of sweets, chocolates, or snacks in the media. An increased preference for urbanized food is an issue not only urban areas but also in rural ones, especially in this era of high technology and easy transportation.

One strength of this study was that we integrated a cross-sectional study to investigate the DC prevalence and a matched case-control study to investigate the relationship between potential caries-prevention factors. Matching for control and case groups improved study efficiency by improving precision in controlling for potential confounding factors in the analysis. Matching ensured that there were similar numbers of cases and controls in confounders.³³ To our knowledge, our project is the first one in Vietnam to study about factors related to DC prevalence using a matched case-control approach. Our findings contributed the evidence that will inform design of appropriate intervention programs for primary school students to prevent and treat caries.

This study is limited by its retrospective nature; normative bias and recall bias may have influenced responses from mothers/caregivers and students. Another limitation is that all

the participants in our study were from Thua Thien Hue province, which although it is a large province is located in Central Vietnam, so the results may not be generalizable to primary students in other areas of the country.

The prevalence of dental caries among primary school students in this population was very high. Student who delayed replacing their toothbrushes past three months increased the likelihood of dental caries. Children who brushed their teeth at least twice a day had fewer dental caries. More efforts are needed to encourage better health oral hygiene to reduce this high prevalence among school children.

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SUPPLEMENTARY MATERIAL

Supplementary Table 1

Sweet food consumption and oral hygiene practices among primary school children in the case-control study by mother's education and family economic status (n = 630)

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