SCIENTIFIC RESEARCH REPORT

International Dental Journal 2020; 70: 167–175

doi: 10.1111/idj.12537

Risk indicators of dental caries and gingivitis among 10–11-year-old students in Yangon, Myanmar

Zar Chi Kyaw Myint[1,2], Takashi Zaitsu[1], Akiko Oshiro[1], Masayuki Ueno[1], Ko Ko Soe[2] and Yoko Kawaguchi[1]

[1]*Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan;* [2]*Department of Preventive and Community Dentistry, University of Dental Medicine, Yangon, Myanmar.*

Objectives: To obtain basic data on dental caries and gingival status of students in Myanmar, and to identify related risk indicators, including socioeconomic conditions and oral health behaviours and habits. **Study design:** This cross-sectional study enrolled 537 fifth-grade students in Myanmar. Oral health behaviours and dietary patterns of students were assessed using questionnaires. Oral examinations were conducted to identify dental caries and gingivitis, and the oral samples were obtained to determine the bacteria levels in dental plaque. **Results:** The dental caries prevalence was 68.5%, with a mean number of decayed teeth of 2.07 ± 2.15. The prevalence of gingivitis was 98.9%, and the mean number of inflamed gingival areas in the anterior region was 16.2 ± 5.4. No significant differences were found between the sexes in terms of dental caries and gingivitis. Oral hygiene was significantly poorer, and levels of bacteria in dental plaque were significantly higher in boys than in girls. Multiple linear regression tests were used to analyse the association between risk indicators and dental caries and gingivitis. Tooth brushing frequency, a daily habit of mouth rinsing, dental visit experience, consumption of sugary snacks and oral hygiene status were significantly associated with dental caries. Mother's occupation, tooth brushing frequency, consumption of sweet drinks, oral hygiene status and bacterial levels in dental plaque were significant predictors of gingivitis. **Conclusions:** Myanmar students had a high prevalence of dental caries and gingivitis. Socioeconomic condition, oral hygiene status and oral health behaviours were all determined to be significant risk indicators.

Key words: *Dental caries, gingivitis, Myanmar, risk indicators, student*

INTRODUCTION

Oral health is an integral component of general health, and a major determinant of the quality of life. One of the most common oral diseases is dental caries, which affects 60%–90% of children globally[1]. In some Asian countries, dental caries is widespread and has become a major public health problem[2,3]. The high prevalence of dental caries may be associated with the frequent consumption of sweet foods, lack of adequate oral hygiene and accumulation of dental plaque, past experience of dental caries in the primary dentition, female sex, low socioeconomic status[4], and inadequate utilisation of dental services[5,6]. Dental caries and its associated pain can interfere greatly with a child's daily life by causing a lack of sleep, affecting academic performance and resulting in missed school days, and posing an economic burden[3].

Children also have various degrees of gingivitis, which may progress to periodontitis if not treated properly[7]. The aetiology of gingivitis is multifactorial and has been shown to be significantly associated with oral bacterial biofilms, as well as genetic, socioeconomic, demographic, iatrogenic and behavioural factors[8]. Gingivitis is a more innocuous condition compared with dental caries, and is rarely associated with obvious clinical signs and symptoms other than mild and intermittent gingival bleeding[9]. Microorganisms in dental plaque biofilms are the main aetiological factors for the initiation of gingival inflammation, but the host response also plays a major role[10].

Several studies have been conducted to investigate sex-based differences in oral diseases across various age groups. The greater burden of dental caries experience in girls has been associated with earlier tooth eruption,

more frequent snacking, hormonal or physiological differences, low concentration of IgA immunoglobulin and low salivary flow rate[11]. Oral hygiene care, and hormonal, physiological and behavioural differences between the sexes may all contribute to the higher risk for periodontal diseases[12]. Considering sex-based differences in the oral health status of students may improve prevention programmes and therapeutic approaches against oral diseases[13].

While culturing on agar plates has served as the conventional method for enumeration of bacterial colony-forming units (CFU), the disadvantage in that a few days are required before the results can be obtained. Recently, a dielectrophoretic impedance measurement system has been developed for the rapid quantification of bacterial concentrations within 1 minute (Panasonic, Tokyo, Japan)[14]. Prior studies have also demonstrated a strong correlation with conventional culture methods[15]. The compact size of the apparatus and its portability also make it highly suitable for surveying large samples in field conditions.

Schools are a place of learning and present a unique opportunity for promoting the importance of oral health to students[16]. The lack of an adequate level of oral hygiene care results in dental caries and gingivitis, which can lead not only to the early loss of deciduous teeth and damage to the permanent successors, but can also have a significant adverse effect on psychological well-being and general health[17]. Prior studies have demonstrated the effectiveness of implementing school oral healthcare programmes that are aimed at promoting healthy oral care practices[18].

Oral health promotion and oral health education are integral components of existing national health strategies in Myanmar[19]. Nevertheless, current efforts in dental public health-related activities remain insufficient. Moreover, there is a lack of annually collected data on oral health in schools in Myanmar. In particular, very limited data are available on the oral health status of school students during the mixed dentition stage. This is pertinent, as the early identification of risk indicators of oral diseases would allow dental professionals to formulate and enact appropriate preventive measures. Therefore, the objectives of the present study were to collect basic data on the clinical oral health status of school students in Myanmar, and to investigate associated risk indicators, including sex-based differences, socioeconomic condition of the parents, as well as the oral health behaviours and dietary patterns of students.

MATERIALS AND METHODS

Participants

The required sample size for this study was determined to be 362 students, after accounting for 80% power, a confidence level of 95%, and compensation for a 10% non-response rate. A previous study[20] that was conducted in Japan, and also part of a school oral health promotion programme, was used to inform the sample size calculation. Two townships were randomly sampled from 34 townships in Yangon Region, Myanmar, using a computer-generated random sampling method. Similarly, four schools within these two townships were randomly sampled. After obtaining permission from the education authorities of the schools, written informed consent forms were obtained from the students and their parents or guardians.

All eligible fifth-grade students in these four schools (n = 569) participated in the study. The exclusion criteria were students who: (1) had systemic disease or neuromuscular dysfunction; (2) lacked parents' permission; and (3) were not willing to participate in the study. A total of 537 participants (251 boys and 286 girls) completed the questionnaire survey and underwent a clinical oral examination. The overall response rate was 94.4%. This cross-sectional study was conducted from December 2017 to January 2018 as part of a school oral health promotion programme.

This study was approved by the ethical committee of the Department of Medical Research in Myanmar (approval no. Ethics/DMR/2017/064), University of Dental Medicine, Yangon and Tokyo Medical and Dental University (approval no. D2017-018). This study was conducted in full accordance with the Helsinki Declaration of the World Medical Association.

Questionnaire survey

The parents provided information on their occupational status. Questions regarding their occupational status were open-ended and categorised into five groups, such as government worker, professional, unskilled worker, merchant/seller, farmer, and dependent/unemployed. The students were asked to answer questions on their oral health behaviours, such as frequency of tooth brushing ('less than once a day', 'once a day', 'twice a day', and 'more than twice a day')[21], daily mouth-rinsing habit ('once a day', 'twice a day', 'thrice a day', and 'never')[22], dental visit over the last 12 months ('once', 'twice', 'three times', 'four times', 'more than four times', 'no visit to dental clinic during the last 12 months', and 'never visited a dentist'), and reasons for a dental visit (pain or trouble with teeth, gums or mouth, follow-up treatment, routine dental check-up, don't know)[23]. These standardised questionnaires had been previously validated[21–23].

Self-administered questionnaires assessed the dietary habits of students with regards to the availability of various types of sugary snacks and sweet drinks in their school canteen or snack shop. The children were asked to answer questions on their daily consumption

of at least one or more sweet snacks ('eat' or 'don't eat'), and sweet drinks ('drink' or 'don't drink'). Questionnaires were translated into Myanmar language, and the translated versions were assessed and revised by expert panels. The Myanmar versions were pretested on a convenience sample of 25% of the students in a pilot study. Test–retest reliability was performed 2 weeks later for reliability testing. Based on the feedback received, the final questionnaire was developed after minor revisions.

Clinical oral examination

A trained dentist evaluated the oral status of all students who were present on the day of examination. An artificial light, a mirror, and a community periodontal index probe [World Health Organisation (WHO)] were used in the oral examination. Dental caries were recorded using the decayed, filled teeth (dft), and decayed, missing and filled teeth (DMFT) indices, in accordance with WHO guidelines[23].

The gingival status of 12 anterior teeth was evaluated using the papillary, marginal and attached gingiva (PMA) index[24]: 10 interdental papilla, 12 marginal gingivae and 12 attached gingivae were assessed. Only the gingivae of erupted teeth were examined; therefore, the total PMA index score was based on 34 gingival sites.

Oral hygiene status was evaluated using the simplified oral hygiene index (OHI-S). The simplified debris index (DI-S) and simplified calculus index (CI-S) were used for the assessment. The OHI-S score was calculated by adding the DI-S (0–3) and CI-S (0–3) scores[25]. Cronbach's alpha coefficient was calculated to check the intra-examiner reliability of dental caries, OHI-S and PMA index. The values were excellent for dental caries (0.90), and good for OHI-S (0.76) and PMA (0.77).

Oral bacteria

Plaque samples were collected by the same investigator who performed the clinical examination. Using a sterilised cotton swab, a plaque sample was obtained from the cervical portion of the buccal surface of the maxillary left permanent first molar. The swab was moved three times from the mesial to the distal direction, and the same procedure was repeated after the swab was reversed. If the maxillary left permanent first molar was extracted or severely damaged by caries, the maxillary right permanent first molar was used as a substitute.

Bacteria within the plaque samples were quantified with a bacteria counter (Panasonic, Tokyo, Japan) over a duration of approximately 1 minute[14]. This bacteria inspection apparatus utilises dielectrophoretic impedance measurement (DEPIM), and quantitatively evaluates clinical samples from the oral cavity using high electrical conductivity and selective detection of biological cells based on their variability[26] or species, combined with an antigen–antibody reaction[27]. The results were expressed as face icons representing the seven-level ranking system, and the numerical value was displayed on an LCD screen. The first permanent molar was selected as the index tooth for dental plaque sampling, due to the longer period of exposure in the oral cavity compared with the other permanent teeth[28]. Additionally, it has been widely documented that dental plaque deposits are heavier in the posterior regions[29]. The first permanent molar has also been previously established as an index tooth for the determination of OHI-S index scores[25].

In the present study, bacteria were quantified as CFU/mL, and categorised as follows: Level 1 = under 10^5 CFU/mL; Level 2 = $10^{5–6}$ CFU/mL; Level 3 = $10^{6–6.5}$ CFU/mL; Level 4 = $10^{6.5–7}$ CFU/mL; Level 5 = $10^{7–7.5}$ CFU/mL; Level 6 = $10^{7.5–8}$ CFU/mL; and Level 7 = over 10^8 CFU/mL. For statistical analysis, these categories were regrouped into two levels: low (Levels 1–6) and high (Level 7) based on the median value.

Data analysis

Descriptive statistics of the study variables were calculated according to sex. Distributional differences in categorical variables were described and analysed with the chi-square test, and the mean differences of the continuous variables were analysed with the independent *t*-test. Questionnaires regarding the parent's occupation, oral health behaviours, dietary habits and clinical oral health status were categorised into two groups for analysis. Multiple linear regression analyses were used to predict the association of the outcome variables [decayed permanent and deciduous teeth (DT + dt) and gingivitis (PMA index)] with the following independent variables: sex; parents' occupation (e.g. government worker, professional, or other); tooth brushing frequency ('more than once daily' or '≤ once daily'); mouth-rinsing habit ('yes' or 'no'); dental visit ('yes' or 'no'); daily consumption of sweet snacks ('eat' or 'don't eat'); daily consumption of sweet drinks ('drink' or 'don't drink'); OHI-S score (low score of < 1.5 or high score of ≥ 1.5); and bacteria level [low (Levels 1–6) or high (Level 7)]. All statistical analyses were conducted using SPSS software, version 21.0 (IBM, Tokyo, Japan). The level of significance was $P < 0.05$.

RESULTS

Sociodemographic and health behaviours

Among the 537 students, 46.7% were boys and 53.3% were girls. Their mean age was 10.6 ± 0.7 years. The most common occupation of the fathers was an

unskilled worker (74.3%), and most (59.6%) mothers were dependents/housewives. There were no significant distributional differences in the occupations of fathers and mothers, between boys and girls.

All (100.0%) students brushed their teeth at least once daily, with 36.9% brushing more than once daily. There were no significant distributional differences between boys and girls regarding tooth brushing frequency. Less than a third (28.7%) of students reported a mouth-rinsing habit after meals, with girls rinsing their mouths significantly more than boys ($P = 0.004$). Most (86.6%) students ate sweet snacks, but there was no significant proportional difference between sexes. The percentage of students who consumed sugary drinks was significantly higher among boys (90.0%) than girls (80.1%; $P = 0.001$; *Table 1*). More than half (55.9%) the students had either not visited a dentist within the previous 12 months, or had never visited a dentist. Moreover, the main reason for visiting a dentist was pain associated with the teeth and gums (82.7%). Only 5.5% of the students had visited a dentist for a routine oral examination. There were no significant sex-based differences with regards to history of dental visits or reasons for dental visits (*Table 1*).

Oral health status

Table 2 shows the students' dental caries status and gingival status. The mean number ± standard deviation (SD) of permanent teeth of all students was 21.2 ± 4.6 (20.5 ± 4.7 for boys and 21.7 ± 4.4 for girls). The number of permanent teeth was significantly higher in girls than in boys ($P = 0.002$). The DMFT was 0.68 ± 1.05 in boys and 0.62 ± 1.00 in girls. The numbers of decayed teeth (DT), missing teeth (MT) and filled teeth (FT) in boys were 0.66 ± 1.04, 0.01 ± 0.09 and 0.01 ± 0.14, respectively, while in girls they were 0.60 ± 0.98, 0.01 ± 0.13 and 0.01 ± 0.10, respectively. No significant sex-based differences were noted in the dental caries experience of the permanent teeth.

No significant difference in the mean number of primary teeth was found between boys (3.52 ± 3.59) and girls (2.96 ± 3.17). The mean dft of the primary teeth was 1.51 ± 1.95 in boys and 1.41 ± 1.94 in girls. The mean numbers of decayed deciduous teeth

Table 1 Sociodemographic and oral health behavioural characteristics

Variables	Total (n = 537)	Boys (n = 251)	Girls (n = 286)	P-value
Age (years), mean (SD)	10.6 (0.7)	10.7 (0.7)	10.6 (0.6)	0.922
Father's occupation, n (%)				
Government worker	44 (8.2)	17 (6.8)	27 (9.4)	0.563
Professional	34 (6.3)	18 (7.2)	16 (5.6)	
Unskilled worker	399 (74.3)	193 (76.9)	206 (72.0)	
Merchant/seller	40 (7.4)	13 (5.2)	27 (9.4)	
Farmer	12 (2.2)	6 (2.4)	6 (2.1)	
Dependent/unemployed	8 (1.5)	4 (1.6)	4 (1.4)	
Mother's occupation, n (%)				
Government worker	27 (5.0)	11 (4.4)	16 (5.6)	0.309
Professional	5 (0.9)	1 (0.4)	4 (1.4)	
Unskilled worker	178 (33.1)	91 (36.3)	87 (30.4)	
Merchant/seller	2 (0.4)	1 (0.4)	1 (0.3)	
Farmer	5 (0.9)	4 (1.6)	1 (0.3)	
Dependent/housewife	320 (59.6)	143 (57.0)	177 (61.9)	
Tooth brushing frequency, n (%)				
Twice or more daily	198 (36.9)	84 (33.5)	114 (39.9)	0.125
≤ Once daily	339 (63.1)	167 (66.5)	172 (60.1)	
Habit of mouth rinsing, n (%)				
Yes	154 (28.7)	57 (22.7)	97 (33.9)	**0.004**
No	383 (71.3)	194 (77.3)	189 (66.1)	
Sweet snacks, n (%)				
Eat	465 (86.6)	224 (89.2)	241 (84.3)	0.091
Don't eat	72 (13.4)	27 (10.8)	45 (15.7)	
Sweet drink, n (%)				
Drink	455 (84.7)	226 (90.0)	229 (80.1)	**0.001**
Don't drink	82 (15.3)	25 (10.0)	57 (19.9)	
Dental visit in previous 12 months, n (%)				
Yes	237 (44.1)	110 (43.8)	127 (44.4)	0.892
No	300 (55.9)	141 (56.2)	159 (55.6)	
Reasons for dental visit, n (%)	(n = 237)	(n = 110)	(n = 127)	
Pain or trouble with teeth, gums or mouth	196 (82.7)	92 (83.6)	104 (81.9)	0.375
Treatment/follow-up treatment	23 (9.7)	9 (8.2)	14 (11.0)	
Routine check-up of teeth/treatment	13 (5.5)	5 (4.5)	8 (6.3)	
I don't know/don't remember	5 (2.1)	4 (3.6)	1 (0.8)	

P-value numbers marked in bold indicate numbers that are significant.

Table 2 Oral health status and oral bacteria level

Variables	Total (n = 537)	Boys (n = 251)	Girls (n = 286)	P-value
Permanent teeth				
Number of teeth, mean (SD)	21.2 (4.6)	20.5 (4.7)	21.7 (4.4)	**0.002**
DT mean (SD)	0.63 (1.00)	0.66 (1.04)	0.60 (0.98)	0.494
MT mean (SD)	0.01 (0.11)	0.01 (0.09)	0.01 (0.13)	0.798
FT mean (SD)	0.01 (0.12)	0.01 (0.14)	0.01 (0.10)	0.890
DMFT mean (SD)	0.65 (1.02)	0.68 (1.05)	0.62 (1.00)	0.510
Prevalence of dental caries, n (%)	196 (36.5)	97 (38.6)	99 (34.6)	0.333
Primary teeth				
Number of teeth, mean (SD)	3.22 (3.38)	3.52 (3.59)	2.96 (3.17)	0.057
dt mean (SD)	1.44 (1.93)	1.50 (1.94)	1.40 (1.93)	0.539
ft mean (SD)	0.01 (0.16)	0.01 (0.13)	0.01 (0.18)	0.851
dft mean (SD)	1.45 (1.94)	1.51 (1.95)	1.41 (1.94)	0.551
Prevalence of dental caries, n (%)	278 (51.8)	139 (55.4)	139 (48.6)	0.117
Untreated caries (DT + dt), mean (SD)	2.07 (2.15)	2.16 (2.13)	1.99 (2.18)	0.384
Prevalence of dental caries in primary and permanent teeth, n (%)	368 (68.5)	179 (71.3)	189 (66.1)	0.193
PMA index, mean (SD)	16.2 (5.4)	17.1 (5.1)	15.5 (5.6)	**< 0.001**
Prevalence of gingivitis, n (%)	531 (98.9)	248 (98.8)	283 (99.0)	0.872
DI-S score, mean (SD)	1.30 (0.42)	1.42 (0.42)	1.19 (0.39)	**< 0.001**
CI-S score, mean (SD)	0.14 (0.27)	0.17 (0.31)	0.11 (0.23)	**0.014**
OHI-S (DI-S + CI-S), mean (SD)	1.44 (0.59)	1.59 (0.62)	1.31 (0.54)	**< 0.001**
Bacteria level, high (Level 7), n (%)	287 (53.4)	156 (62.2)	131 (45.8)	**< 0.001**

P-value numbers marked in bold indicate numbers that are significant.
CI-S, simplified calculus index; dft, decayed and filled primary teeth; DI-S, simplified debris index; DMFT, decayed, missing and filled permanent teeth; dt, deciduous teeth; DT, decayed permanent teeth; FT, filled teeth; MT, missing teeth; OHI-S, simplified oral hygiene index; PMA, papillary, marginal and attached gingiva; SD, standard deviation.

(dt) and filled teeth (ft) were 1.50 ± 1.94 and 0.01 ± 0.13, respectively, in boys; and 1.40 ± 1.93 and 0.01 ± 0.18, respectively, in girls. There were no significant sex-based differences in the dental caries status of primary teeth.

The prevalence of caries in the permanent and primary teeth were 36.5% and 51.8%, respectively. No significant difference in dental caries prevalence was detected between boys and girls.

The mean number of sites with gingival inflammation was significantly higher among boys compared with girls (17.1 ± 5.1 *vs.* 15.5 ± 5.6; $P < 0.001$). Boys had significantly higher scores for DI-S (1.42 ± 0.42), CI-S (0.17 ± 0.31) and OHI-S (1.59 ± 0.62) compared with girls [1.19 ± 0.39 ($P < 0.001$), 0.11 ± 0.23 ($P = 0.014$) and 1.31 ± 0.54 ($P < 0.001$), respectively]. The prevalence of gingivitis was 98.8% in boys and 99.0% in girls; however, no sex-based difference was observed. The percentage of boys (62.2%) with high levels of bacteria (Level 7) was significantly higher than in girls (45.8%; $P < 0.001$).

Out of a total of 537 students, low (Levels 1–6) and high (Level 7) levels of bacteria were observed in 250 and 287 students, respectively (*Table 3*). Students with high levels of bacteria (Level 7) also had a significantly higher mean number of DI-S ($P < 0.001$), CI-S ($P = 0.016$), OHI-S ($P < 0.001$) and PMA ($P < 0.001$). No association was found between bacteria levels and mean decayed teeth (DT + dt; $P = 0.372$).

Risk indicators of dental caries and gingivitis

Table 4 shows the results of multiple linear regression analyses investigating the relationship between decayed teeth (DT + dt) and gingivitis (PMA), with potential explanatory variables. Significant risk predictors for decayed teeth (DT + dt) included brushing only once daily; no mouth-rinsing habit after meals; dental visits within the last 12 months; daily consumption of sweet snacks; and high OHI-S scores.

Gingivitis scores (based on the PMA index) were significantly associated with the mother's occupation (government workers or professionals, as opposed to other job types); brushing only once daily; drinking sweet drinks daily; high OHI-S scores; and high levels of bacteria.

Table 3 Association of levels of bacteria with oral health status

Bacteria level	n (%)	DI-S mean (SD)	CI-S mean (SD)	OHI-S (DI-S + CI-S) mean (SD)	PMA mean (SD)	DT + dt mean (SD)
Low (Levels 1–6)	250 (46.6)	1.10 (0.36)	0.11(0.24)	1.21 (0.52)	14.52 (5.96)	1.98 (1.85)
High (Level 7)	287 (53.4)	1.48 (0.38)	0.16 (0.29)	1.64 (0.57)	17.71 (4.49)	2.15 (2.39)
P-value		**< 0.001**	**0.016**	**< 0.001**	**< 0.001**	0.372

P-value numbers marked in bold indicate numbers that are significant.
CI-S, simplified calculus index; DI-S, simplified debris index; dt, deciduous teeth; DT, decayed permanent teeth; OHI-S, simplified oral hygiene index; PMA, papillary, marginal and attached gingiva.

Table 4 Multiple linear regression analysis for the association between dental caries (DT + dt) and gingivitis with their related factors

Independent variables	Dental caries (DT + dt)			Gingivitis (PMA)		
	B	SE	*P*-value	*B*	SE	*P*-value
Sex	0.119	0.186	0.522	−0.057	0.963	0.890
Father's occupation	−0.243	0.255	0.341	−0.252	0.565	0.656
Mother's occupation	0.694	0.381	0.069	1.943	0.843	**0.022**
Tooth brushing frequency	0.735	0.190	**<0. 001**	1.604	0.421	**< 0.001**
Daily mouth rinsing habit	0.647	0.203	**0.001**	0.713	0.449	0.113
Dental visit	0.550	0.181	**0.002**	−0.445	0.401	0.267
Sweet snacks consumption	0.656	0.268	**0.015**	−0.122	0.593	0.837
Sweet drinks consumption	0.188	0.256	0.463	1.647	0.567	**0.004**
OHI−S	0.531	0.168	**< 0.002**	4.021	0.373	**< 0.001**
Bacteria level	−0.166	0.194	0.391	0.986	0.429	**0.022**

P-value numbers marked in bold indicate numbers that are significant.
B = regression coefficient; Sex: boy = 0, girl = 1; Father's occupation: Others (unskilled workers, farmer, merchant/seller, dependent/unemployed) = 0, Professional or government worker = 1; Mother's occupation: Others (unskilled workers, farmer, merchant/seller, dependent/unemployed) = 0, Professional or government worker = 1; Tooth brushing frequency: ≥ 2 times daily = 0, once a day = 1; Daily mouth-rinsing habit: Yes = 0, No = 1; Dental visit: No = 0, Yes = 1; Sweet snacks: No = 0, Yes = 1; Sweet drinks: No = 0, Yes = 1; OHI-S: low score (< 1.5) = 0, high score (≥ 1.5) = 1; Bacteria level: low (Levels 1−6) = 0, high (Level 7) = 1.
dt, deciduous teeth; DT, decayed permanent teeth; OHI-S, simplified oral hygiene index; PMA, papillary, marginal and attached gingiva.

DISCUSSION

The present study examined the oral health status and related risk indicators among students who were in the late mixed dentition period. While many studies have reported on the oral health status of preschool children,[30,31] studies targeting students with mixed dentition are very scarce, especially in Myanmar. Therefore, the findings in this study may potentially inform the development of oral health promotion strategies for students in this age group.

The dentition status of Myanmar students was poor overall in that nearly 70% of students had dental caries in the permanent or primary teeth. Compared with the findings of studies conducted in other developing countries, the mean DMFT and dental caries prevalence in the permanent dentition in the present study were lower[32–34]; however, the mean dft and prevalence of dental caries in the primary dentition were the same or higher than those of previous reports[30,32,35].

A previous overview paper[36] reported that nearly 60% of 12-year-old Myanmar children had gingival inflammation. In the current study, nearly all students had inflammation in at least one area of the anterior region. The index used in the aforementioned study was different from the indices used in the current study. However, the gingival condition was much poorer in the current study. A possible reason for poor oral health status among students in this study may be the lack of regular dental visits and school oral health promotion programmes. Therefore, they had fewer opportunities to receive adequate oral health education.

Decayed teeth were the greatest contributors to the DMFT scores. Only a few students had filled teeth, and more than half of the students had not visited a dental clinic. These results implied that necessary dental treatments were not regularly provided for the students, and that their parents did not acknowledge the necessity of treatment. The presence of dental caries was significantly associated with dental visits within the preceding year. A previous study[37] reported that utilisation of dental services depended on two different types of health behaviours, that is preventive care and illness-related dental visits. In the present study, among students who had visited a dental clinic, 82.7% had done so because of pain or trouble in their teeth or gums. This may be attributed to the lack of oral health awareness by both students and parents. It is necessary to educate them about the importance of dental visits for the prevention of oral disease.

It has been reported across many countries that the oral health-related behaviours and habits of children are strongly influenced by the socioeconomic status of their parents.[38,39] The parents' (especially the mothers') level of education or knowledge has a great impact on the child's oral health.[5,40] In this study, students whose mothers were government workers or professionals were more likely to have gingivitis. In Myanmar, people who work as government workers and professionals are regarded as having a higher socioeconomic status compared with individuals in other occupations. Therefore, it seems plausible that parents of a higher socioeconomic status are more able to afford sugary snacks and drinks for their children. Furthermore, mothers who work as civil servants or professionals spend substantial time away from their home; therefore, they may not have sufficient time to oversee their children, compared with mothers working in other occupations.

In Myanmar, every school has a canteen, and such facilities potentially serve as a readily available

source of cariogenic foods and beverages. This study showed that the consumption of highly cariogenic foods, especially sweet snacks, was significantly associated with dental caries, a finding that has been firmly established in previous studies[6,41]. This study also found that the consumption of sweet drinks was a risk indicator for gingivitis. This supports previous studies[42,43] that have reported that ingredients in sugary soft drinks enhance inflammation, and contribute to a higher risk of periodontal disease.

In the present study, brushing teeth only once a day was a significant risk indicator for dental caries and gingivitis. Moreover, the lack of mouth rinsing after a meal was also associated with dental caries. These results corroborated the findings of other studies[6,44]. The modality of tooth brushing is an important determinant of dental caries and gingivitis. All students in this study brushed their teeth at least once daily, yet their oral health status was not necessarily good. At home, students should be taught to choose less cariogenic food, and should be guided to practice an adequate oral hygiene regimen to prevent dental caries and gingivitis. It has been widely established that the early implementation of mechanical plaque control methods such as tooth brushing and flossing is adequate to prevent plaque-induced gingivitis and dental caries in children[10,45,46].

In the present study, the OHI-S index was found to be a risk indicator for both dental caries and gingivitis, supporting the results of previous studies conducted in other countries[47,48]. This was not surprising, given that OHI-S is a direct measure of dental plaque, which is the prime aetiological agent of both caries and periodontal disease. This study found significant associations between levels of bacteria (as determined by DEPIM) and both oral hygiene and gingivitis, even after adjusting for other confounding variables in multiple linear regression analyses. This suggests that the bacterial counter machine could potentially be used to evaluate oral hygiene status, and serve as a tool to motivate students to clean their teeth. However, the study revealed that total bacteria levels in the dental plaque samples were not associated with dental caries. This may be explained by the specific plaque hypothesis, whereby only a few specific species, such as *Streptococcus mutans* and *Streptococcus sobrinus*, are actively involved in dental caries[49]. While the bacteria counter machine can quantitatively detect biological cells according to their variability, it cannot specifically detect cariogenic bacteria. Moreover, because this was a cross-sectional study, additional longitudinal studies are required to check the relationship.

No sex-based difference in caries experience was observed in this study, although girls had a significantly higher number of permanent teeth. Prior studies have reported that boys have a higher dental caries experience than girls[33,50]. Although the OHI-S score, gingivitis (PMA index), and the number of bacteria in dental plaque were significantly lower in girls by bivariate analysis, sex was not associated with dental caries or gingivitis in multiple linear regression analyses after adjusting for other independent variables. In the current study, boys tended to consume more sugary drinks, and experienced more gingivitis compared with girls. A similar finding has also been reported in a previous study[42]. Among the investigated oral hygiene behaviours, the only significant difference was mouth-rinsing habit, which was significantly higher in girls. These results suggest that poor oral hygiene, oral hygiene habits and dietary behaviours were the major determinants of dental caries and gingivitis, rather than sex per se.

Children who have dental caries in the primary dentition are more likely to develop dental caries in the permanent dentition[51]. Thus, during the mixed dentition period, appropriate measures should be taken to promote the oral health of Myanmar students. The risk indicators of dental caries and gingivitis determined in this study may make it possible to identify students at a higher risk for oral disease, and allow for the earlier implementation of preventive measures. Moreover, the students can easily recognise their oral hygiene status by checking the face icon in the bacteria counter machine, which can be used as one of the motivating materials for the improvement of oral health.

A limitation in the present study was the representativeness of the sample. A random sampling method was employed, but the sample was chosen only from one area in Myanmar. Therefore, the results of this study may have limited generalisability to other regions in the country. As the data pertaining to oral health behaviours and habits were obtained using a self-report survey, there was a possibility of information and response bias. Another limitation in this study came from using some questions with categorical responses to record dietary sugar intake. Furthermore, this was a cross-sectional study; therefore, a longitudinal study needs to be implemented to confirm the current findings.

CONCLUSION

Myanmar students with a mixed dentition had a high prevalence of dental caries and gingivitis, as well as poor oral hygiene, and inadequate oral healthcare habits. The socioeconomic condition, oral hygiene status and oral health habits were risk indicators for dental caries and gingivitis. Cooperative efforts by school authorities, teachers, health professionals and

parents in school oral health promotion programmes would be essential for the improvement of oral health status of Myanmar students.

Acknowledgements

The authors wish to express their appreciation to all school children who participated in the study.

Conflict of interest

All authors declare no potential conflicts of interest in this study.

Funding information

This study was supported by a dental hygiene research grant 2018 from the FUTOKU Foundation (Tokyo, Japan), and the Tokyo Medical and Dental University (Tokyo, Japan).

REFERENCES

1 Petersen PE. Priorities for research for oral health in the 21st Century – the approach of the WHO Global Oral Health Programme. *Community Dent Health* 2005 22: 71–74.

2 Lo EC, Duangthip D.Caries control throughout life in Asia. International Dental Conference. November, 20–22, 2013, Krabi, Thailand.

3 Bali Declaration-Good Oral Health as Investment in Children's Future. The 7th Asian Conference of Oral Health Promotion for School Children (ACOHPSC). September, 12–14, 2013, Bali, Indonesia.

4 Casanova-Rosado AJ, Medina-Solis CE, Casanova-Rosado JF *et al.* Dental caries and associated factors in Mexican schoolchildren aged 6–13 years. *Acta Odontol Scand* 2005 63: 245–251.

5 Ahmadzadeh J, Rezaeian S, Esmahili-Sani A *et al.* Oral health status and behaviors of children aged 6–12 years old: a crosssectional study. *Ann Public Health Res* 2015 2: 1017.

6 Thwin KM, Zaitsu T, Ueno M *et al.* Early childhood caries and related risk factors among Myanmar preschool children. *Int J Clin Prev Dent* 2016 12: 229–236.

7 Pari A, Ilango P, Subbareddy V *et al.* Gingival diseases in childhood – a review. *J Clin Diagn Res* 2014 8: ZE01–ZE04.

8 Chrysanthakopoulos N. Prevalence of gingivitis and associated factors in 13–16-year-old adolescents in Greece. *European J Gen Dent* 2016 5: 58.

9 Shizuma Y, Zaitsu T, Ueno M *et al.* Relationship between self-assessment and clinical evaluation of dental plaque and gingival condition in Japanese adolescents. *Int J Dent Hyg* 2018 16: 144–150.

10 Clerehugh V. *Guidelines for periodontal screening and management of children and adolescents under 18 years of age*. London: British Society of Periodontology and The British Society of Paediatric Dentistry; 2012. p. 1–25.

11 Martinez-Mier EA, Zandona AF. The impact of gender on caries prevalence and risk assessment. *Dent Clin North Am* 2013 57: 301–315.

12 Albandar JM. Global risk factors and risk indicators for periodontal diseases. *Periodontology* 2000 2002(29): 177–206.

13 Furuta M, Ekuni D, Irie K *et al.* Sex differences in gingivitis relate to interaction of oral health behaviors in young people. *J Periodontol* 2011 82: 558–565.

14 Hamada R, Suehiro J, Nakano M *et al.* Development of rapid oral bacteria detection apparatus based on dielectrophoretic impedance measurement method. *IET Nanobiotechnol* 2011 5: 25–31.

15 Hirota K, Inagaki S, Hamada R *et al.* Evaluation of a rapid oral bacteria quantification system using dielectrophoresis and the impedance measurement. *Biocontrol Science* 2014 19: 45–49.

16 Petersen PE. Improvement of global oral health – the leadership role of the World Health Organization. *Community Dent Health* 2010 27: 194–199.

17 WHO. *Oral health promotion: an essential element of a health-promoting school WHO information series on school health document eleven*. Geneva: World Health Organization; 2003, publication no. WHO/NMH/NPH/ORH/School/03.3.

18 Jürgensen N, Petersen PE. Promoting oral health of children through schools – Results from a WHO global survey 2012. *Community Dent Health* 2013 30: 204–218.

19 Ministry of Health. Health in Myanmar. Health services in Myanmar; 2006. p. 44–45. Available from: mohs.gov.mm/Main/content/publication/health-in-myanmar-2006. Accessed 23 February 2019.

20 Ueno M, Takayama A, Adiatman M *et al.* Application of visual oral health literacy instrument in health education for senior high school students. *Int J Health Promot Educ* 2013 52: 38–46.

21 Polk DE, Geng M, Levy S *et al.* Frequency of daily tooth brushing: predictors of change in 9- to 11-year old US children. *Community Dent Health* 2014 31: 136–140.

22 Sandhya A, Dhanaraj C, Sangaeeth S. A survey on mouth rinsing habits in young adult population. *Int J Sci Res* 2015 6: 1715–1717.

23 World Health Organization. *Oral Health Surveys: Basic-Methods*, 5th edn. Geneva: WHO; 2013.

24 Massler M, Schour I. Epidemiology of gingivitis in children. *J Am Dent Assoc* 1952 45: 319–324.

25 Greene JC, Vermillion JR. The simplified oral hygiene index. *J Am Dent Assoc* 1964 68: 7–13.

26 Suehiro J, Hamada R, Noutomi D *et al.* Selective detection of viable bacteria using dielectrophoretic impedance measurement method. *J Electrostat* 2003 57: 157–168.

27 Suehiro J, Shutou M, Hatano T *et al.* High sensitive detection of biological cells using dielectrophoretic impedance measurement method combined with electropermeabilization. *Sens Actuators B Chem* 2003 96: 144–151.

28 Oznurhan F, Ekci ES, Ozalp S *et al.* Time and sequence of eruption of permanent teeth in Ankara, Turkey. *Pediatric Dental Journal* 2016 26: 1–7.

29 Sreenivasan PK, Prasad KVV. Distribution of dental plaque and gingivitis within the dental arches. *J Int Med Res* 2017 45: 1585–1596.

30 Martins MT, Sardenberg F, Abreu MH *et al.* Factors associated with dental caries in Brazilian children: a multilevel approach. *Community Dent Oral Epidemiol* 2014 42: 289–299.

31 Oo MMT, Naing L, Mani SA *et al.* Dental caries experience and treatment needs in the mixed dentition in North East Malaysia. *Arch Orofac Sci* 2011 6: 41–48.

32 Bashirian S, Shirahmadi S, Seyedzadeh-Sabounchi S *et al.* Association of caries experience and dental plaque with sociodemographic characteristics in elementary school-aged children: a cross-sectional study. *BMC Oral Health* 2018 18: 2–12.

33 Shah AF, Tangade P, Ravishankar TL *et al.* Dental caries status of institutionalized orphan children from Jammu and Kashmir. *India. Int J Clin Pediatr Dent* 2016 9: 364–371.

34 Maharani DA, Adiatman M, Rahardjo A *et al*. An assessment of the impacts of child oral health in Indonesia and associations with self-esteem, school performance and perceived employability. *BMC Oral Health* 2017 17: 65.

35 Abuaisha A, Zainuddin H, Ismail S *et al*. Oral hygiene habits and its association with dental caries among children aged 8–12 years in Libyan schools, Klang Valley, Malaysia. *Int J Pub Health Clin Sci* 2016 3: 44–58.

36 Aung EE, Maung K, Zaitsu T *et al*. An overview of oral health situation and challenges in Myanmar. *Asian J Res Med Med Sci* 2018 1: 1–10.

37 Ohi T, Sai M, Kikuchi M *et al*. Determinants of the utilization of dental services in a community-dwelling elderly Japanese population. *Tohoku J Exp Med* 2009 218: 241–249.

38 Miura H, Araki Y, HaraguchI K *et al*. Socioeconomic factors and dental caries in developing countries: a cross-national study. *Soc Sci Med* 1997 44: 269–272.

39 Macigo FG, James RM, Ogunbodede E *et al*. Sugar consumption and dental caries experience in Kenya. *Int Dent J* 2016 66: 158–162.

40 Pinto GdS, Hartwig AD, Elias R *et al*. Maternal care influence on children' s caries prevalence in southern Brazil. *Braz Oral Res* 2016 30. e70.

41 Mafuvadze BT, Mahachi L, Mafuvadze B. Dental caries and oral health practice among 12 year old school children from low socio-economic status background in Zimbabwe. *Pan Afr Med J* 2013 14: 164.

42 Song IS, Han K, Ko Y *et al*. Associations between the consumption of carbonated beverages and periodontal disease: The 2008–2010 Korea national health and nutrition examination survey. *Medicine (Baltimore)* 2016 95: e4253.

43 Fann JC, Lai H, Chiu SY *et al*. A population-based study on the association between the intake of soft drinks and periodontal disease in Taiwanese adults aged 35–44 years (KCIS no. 33). *Public Health Nutr* 2016 19(8): 1471–1478.

44 Kumar S, Tadakamadla J, Johnson NW. Effect of toothbrushing frequency on incidence and increment of dental caries: a systematic review and meta-analysis. *J Dent Res* 2016 95: 1230–1236.

45 Siddharth M, Singla A, Kaur S. Periodontal diseases in children and adolescents – a review. *J Oral Health Res* 2013 4: 18–23.

46 Hujoel PP, Cunha-Cruz J, Banting DW *et al*. Dental flossing and interproximal caries: a systematic review. *J Dent Res* 2006 85: 298–305.

47 Shabani LF, Begzati A, Dragidella F *et al*. The correlation between DMFT and OHI-S Index among 10–15 years old children in Kosova. *J Dent Oral Health* 2015 1: 1–5.

48 Milciuviene S, Bendoraitiene E, Vaitkeviciene V *et al*. Dental caries and oral hygiene in 12 year-old Lithuanian schoolchildren. *OHDMBSC* 2004 III: 25–31.

49 Aas JA, Griffen AL, Dardis SR *et al*. Bacteria of dental caries in primary and permanent teeth in children and young adults. *J Clin Microbiol* 2008 46: 1407–1417.

50 Hiremath A, Murugaboopathy V, Ankola AV *et al*. Prevalence of dental caries among primary school children of India – a cross-sectional study. *J Clin Diagn Res* 2016 10: ZC47–ZC50.

51 Skeie MS, Raadal M, Strand GV *et al*. Caries in primary teeth at 5 and 10 years of age: a longitudinal study. *Eur J Paediatr Dent* 2004 5: 194–202.

Correspondence to:
Takashi Zaitsu,
Department of Oral Health Promotion,
Graduate School of Medical and Dental Sciences,
Tokyo Medical and Dental University,
1-5-45 Yushima,
Bunkyo-ku,
Tokyo 113-8549, Japan.
Email: zaitsu.ohp@tmd.ac.jp