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Early childhood caries among 3- to 5-year-old children in Hong Kong

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Objective: The aim of this study was to describe the prevalence of dental caries among 3- to 5-year-old children in Hong Kong and to investigate the factors associated with their dental caries status. **Methods:** Seven kindergartens in Hong Kong were selected using stratified random sampling. The 3- to 5-year-old kindergarten children were invited to join the study. The participants' parents were asked to complete a questionnaire regarding their children's demographic and socio-economic backgrounds, their dental habits and their own dental knowledge. Dental caries experience was measured using the decayed, missing and filled primary teeth (dmft) index. The visible plaque index was adopted for recording oral hygiene. The relationships between caries experience and children's demographic backgrounds, dental habits, oral hygiene and parental dental knowledge were studied using a zero-inflated negative binomial (ZINB) regression analysis. **Results:** Among the 1,204 participating preschool children, the overall prevalence of dental caries (dmft > 0) was 46%. The mean dmft score was 2.1 ± 3.4. The prevalences of dental caries among the 3-, 4- and 5-year-old children were 38%, 43% and 55%, respectively. ZINB regression analysis revealed that the study children who were boys, came from families with lower incomes, had dental visit experiences, had higher plaque scores and had parents with lower levels of dental knowledge, had higher dmft scores ($P < 0.05$). **Conclusions:** Dental caries is prevalent among preschool children in Hong Kong. The caries experiences of the study children are associated with gender, family income, parental dental knowledge, dental visit experience and oral hygiene.

Key words: *Dental caries, oral health, epidemiology, children, dental public health*

INTRODUCTION

Early childhood caries (ECC) is one of the most common chronic diseases in children. According to the report of the 2016 Global Burden of Disease Study, dental caries in primary teeth was ranked as the 12th most prevalent condition, affecting around 560 million children globally[1]. ECC is defined as the presence of one or more decayed (non-cavitated or cavitated) lesions, teeth missing from caries or filled tooth surfaces in any primary tooth among children younger than 6 years of age[2]. If it is left untreated, it will progress into the pulp tissue, possibly leading to toothache and dental abscess. Subsequently, it causes difficulty in chewing, thus reducing the quality of life of affected children[3].

The prevalence and severity of ECC vary among different regions and countries. In South-East Asia, the overall situation of caries in preschool children is unsatisfactory. In Cambodia, Lao and the Philippines, the caries prevalence of such children is approximately 90%[4]. In China, the latest national oral health survey revealed that 70.1% of 5-year-old children have dental caries experiences[5]. Hong Kong is a special administrative region of China with an estimated population of 7.4 million in 2017[6]. Several dental public health measures have been implemented to promote oral health in Hong Kong. Water fluoridation was established in 1961. The School Dental Care Service (SDCS) was developed in 1979 with the aim of providing free dental treatment for schoolchildren in Hong Kong[7]. As a result of these initiatives, caries prevalence and severity have declined significantly among schoolchildren and adolescents during the past few decades[8]. However, preschool children are not eligible to participate in the SDCS. Dental treatment for

preschool children is given by private dentists and paid for by parents. Previous studies indicate that ECC remains a major dental problem in Hong Kong[9]. No improvement has been made in the oral health statuses of 5-year-old children during the past two decades. According to the results of the territory-wide oral health surveys, caries prevalence was 50.7% among 5-year-old children in 2011, similar to that in 2001 (51.0%), but the extent of caries experience (mean dmft score) had slightly increased, from 2.3 in 2001 to 2.5 in 2011[10].

Efforts have been made to improve the oral health statuses of Hong Kong preschool children. The Department of Health set up the oral health education unit, aiming to promote oral health and to provide free oral health education materials to schools and parents. The oral health programme 'Brighter Smiles for the New Generation' was launched to help children establish good oral health-related habits[11]. Another programme, called 'Brighter Smiles Playland', was developed to help kindergarten staff members teach children about toothbrushing, tooth-friendly diets and dental visits through interactive games and activities. Besides the provision of oral health-education programmes, changes in immigration guidelines and economic growth may affect the general and oral health of the Hong Kong population. Following the World Health Organization (WHO) recommendation, periodic surveys should be conducted at 5-year intervals to assess the oral health status of a community and to evaluate the effectiveness of the preventive population-based measures taken in the community[12]. As the last population-wide oral health survey among 3- to 5-year-old children was conducted in 2009[9], an updated child oral health status is required for dental practitioners and policy makers in planning and monitoring target-oriented preventive measures for kindergarten children in Hong Kong.

The aim of this study was to describe caries prevalence and the extent of caries experience among 3- to 5-year-old kindergarten children in Hong Kong and to investigate the risk factors associated with their dental caries statuses.

MATERIALS AND METHODS

The Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (IRB UW 16-180) approved the current study. Written consent was sought from the parent of each participating child. The study was conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki. This oral health survey was conducted in 2016.

Sample selection

Almost 95% of preschool children attend kindergarten in Hong Kong. The unit of sampling was a kindergarten. A stratified cluster random sample proportionate to the size of the subpopulations among the three geographical areas in Hong Kong – the new territories (NT), Kowloon (KL) and Hong Kong Island (HK)[6]– was adopted. The number of preschool children residing in three main geographical areas in Hong Kong was as follows: 89,000 children in NT; 50,000 in KL; and 29,000 on HK. The ratio of invited schools in NT, KL and HK was 4:2:1, following the ratio of the populations of NT, KL and HT[6]. Registered kindergartens in each area were numbered sequentially. Four kindergartens in NT, two in KL and one in HK were selected through a simple random sampling method using a list of computer-generated random numbers. All seven selected kindergartens agreed to participate in the survey. All children in the selected kindergartens were invited to take part. The inclusion criteria were children aged 3–5 years with written parental consent. Children with special needs or severe chronic diseases were excluded.

Sample size estimation

Based on the Hong Kong Census in 2016, the population of Hong Kong preschool children was approximately 168,000[6]. The sample size estimation was based on previous caries prevalence (approximately 50%)[9]. The confidence interval was set at 5% (CI: 45%–55%) with a 95% confidence level. The sample size of each age group (3-, 4- and 5-year-old children) was 383, or 1,149 children in total were required. With an estimated response rate of 80%, the total number of children invited to take part the study would be at least 1,436.

Questionnaire survey

A self-completed questionnaire and parental consent form were sent to all parents of children in the selected schools. The questionnaire featured four sections[13]: (i) demographic background: sex, age, place of birth, parenthood status and main caregiver; (ii) socio-economic status: parents' education levels and family income; (iii) oral health–related habits: bottle-feeding habits, snacking habits, toothbrushing habits and dental visit experience; and (iv) parental dental knowledge. Twenty-one questions about the aetiology of dental caries and caries prevention were modified from the previous study[9]. One mark was given for each correct answer, whereas no mark was given for each incorrect answer. Thus, the marks (0–21) were

categorised into one of three levels, as follows: high (15–21 marks); moderate (8–14 marks); or low (0–8 marks). Missing and inappropriate answers on the returned questionnaire were checked and followed up by telephone.

Clinical examination

A single examiner (KJC) was trained and supervised by experienced dental epidemiologists (LECM and CHC). The study children were positioned supine on small tables in the kindergartens. The clinical examinations were conducted using a ball-ended WHO Community Periodontal Index (CPI) probe and a disposable dental mirror with an intra-oral light-emitting diode (LED) light attached. Dental caries was diagnosed at the tooth level. Caries status was assessed according to the diagnostic criteria of the WHO[12]. A tooth was recorded as decayed (dt) when a dentine lesion had an unmistakable cavity or when both a dentine carious lesion and a restoration were present. A tooth was recorded as missing (mt) when it was extracted as a result of caries. A tooth was recorded as filled (ft) when a permanent filling without caries was present. No radiographs were taken. Approximately 10% of the study children were re-examined on the same day. The duplicate examinations were conducted after at least 30 children had been examined, so that the examiner could not remember the first scoring. The intra-examiner kappa value was 0.98. Oral hygiene status was recorded using the visible plaque index (VPI)[14]. The visible plaque of the buccal and lingual surfaces of six index teeth (55, 51, 63, 71, 75 and 83) was recorded as the presence of visible plaque (score 1) or the absence of visible plaque (score 0). The VPI score was then calculated as the percentage of the number of surfaces with visible plaque relative to the total number of surfaces examined.

Approximately 10% of the participating children were randomly re-examined on the same day as their examinations to assess intra-reliability reproducibility. Following a child's oral examination, his or her oral health report was sent to his or her parent. No intervention was provided. Parents were advised to seek further treatment at their own expense if necessary.

Statistical analysis

Data analysis was performed using IBM SPSS Statistics for Windows, version 24.0 (SPSS Inc., Chicago, IL, USA) and Stata version 13.1 (StataCorp, College Station, TX, USA). The study children with missing data were excluded from the data analysis. Statistical sample weights were performed. The intra-examiner agreement was assessed using Cohen's kappa statistics. A chi-square test was used to test the association of caries prevalence (yes/no) with various variables. The Mann–Whitney *U*-test or Kruskal–Wallis *H*-test was adopted to study the distribution of decayed, missing or filled primary teeth (dmft) scores according to the variables studied. All independent variables were studied as covariates in the regression model. The negative binomial model, Poisson model and zero-inflated models were taken into consideration to investigate the association between the dmft scores and independent variables. Vuong's test was adopted to indicate an appropriate statistical model. A backward stepwise procedure was used to remove insignificant variables ($P > 0.05$) from the regression model. The final model contained only the remaining variables that were statistically significant. The level of statistical significance for all tests was set at 0.05.

RESULTS

A total of 1,700 kindergarten children in seven kindergartens were invited to participate in this survey. The response rate was 89% (1,514/1,700). The Cohen's kappa value for the assessment of caries status was 0.97. Of the 1,514 children with parental consent, the following were excluded: 181 because they were younger than 3 or older than 5 years of age; 102 because they failed to complete the questionnaire; 31 because they were absent from school on the day of the examination; and two because they were uncooperative (more than one reason could be indicated). Thus, 1,204 children with completed questionnaires were included in the study. Among these, 522 were from NT, 453 from KL and 229 from HK. The ratio of participating children in NT, KL and HK was 5:4:2, whereas the ratio of the Hong Kong population in 2016 was approximately 4:2:1[6]. Therefore, proportional sample weights were performed. The following descriptive data and further statistical analysis were weighted.

Among the study children, 650 (54.6%) were girls, and the mean age (±SD) was 4.6 (±0.8) years. The numbers of the children aged 3, 4 and 5 years who were included in the study were 307 (25.8%), 427 (35.8%) and 457 (38.4%), respectively. Most (90.8%) were born in Hong Kong. A total of 552 (46.3%) children had caries experiences (dmft > 0). Approximately 14.4% had five or more teeth with caries experiences. The mean dmft score (±SD) was 2.1 (± 3.4). Untreated dt (2.0 ± 3.3) constituted 95% of the dmft score (*Table 1*). The mean number of ft or mt was very small (ft = 0.1; mt = 0.01). A positively skewed distribution of the dmft score was found, with the skewness being 2.1. Maxillary incisors had the highest caries prevalence (29%), whereas mandibular incisors had the lowest (2%). However,

Table 1 Prevalence and severity of dental caries in the study children, according to age and gender

Independent factors	*n*	Caries prevalence (dmft > 0) (%)	*P*	Mean dmft (SD)	Mean d (SD)	Mean m (SD)	Mean f (SD)	*P*
All children	1,191	46.3		2.1 (3.4)	2.0 (3.3)	0.01 (0.2)	0.1 (0.6)	
Gender								
Female	650	42.4	<0.001*	1.8 (3.1)	1.7 (3.0)	0.02 (0.2)	0.1 (0.5)	<0.001†
Male	541	51.0		2.5 (3.7)	2.3 (3.6)	0.01 (0.1)	0.1 (0.6)	
Age								
3 years	307	37.5	<0.001*	1.4 (2.9)	1.3 (2.8)	0.01 (0.1)	0.02 (0.2)	<0.001‡
4 years	427	43.1		1.9 (3.2)	1.8 (3.1)	<0.01 (0.1)	0.1 (0.4)	
5 years	457	55.4		2.7 (3.8)	2.5 (3.7)	0.02 (0.3)	0.2 (0.8)	

*Chi-square test.
†Mann–Whitney *U*-test.
‡Kruskal–Wallis test. dmft, decayed (d), missing (m) and filled (f) teeth.

maxillary molars had a lower caries prevalence compared with mandibular molars. More than six (66%) out of 10 children brushed their teeth at least twice daily, and 70% began brushing before the age of 2. However, 24% of the children still engaged in bottle feeding at bedtime, and a large proportion (82%) had never visited a dentist.

In the bivariate analysis, statistically significant differences were found in the prevalence of caries between gender and age of children ($P < 0.001$) (*Table 1*). Caries prevalence increased with increasing age during the preschool years ($P < 0.001$). Children born in Hong Kong had a lower caries prevalences compared with those born in Mainland China or in other countries ($P = 0.01$) (*Table 2*). Children from families with high family incomes had a lower caries prevalences compared with those from families with low family incomes ($P < 0.001$). Children who had previously visited a dentist had a higher caries prevalences compared with those who had never visited a dentist ($P < 0.001$). Regarding parental dental knowledge, children whose parents had low levels of dental knowledge had a higher caries prevalences compared with those whose parents had high levels of dental knowledge ($P < 0.001$). In the Mann–Whitney *U*-test and Kruskal–Wallis *H*-test, a lower rank of the median dmft score was observed among the study children who were born in Hong Kong, whose main caregivers were domestic helpers, whose parents had tertiary-level (university) education or whose parents had high levels of dental knowledge. Regarding oral health-related behaviours, children who had sugary snacks once or less daily, had never visited a dentist, started toothbrushing before the age of 2 years or brushed their teeth twice daily, had significantly lower dmft scores (*Table 2*).

According to the results of Vuong's test, the ZINB model provided a better fit than the Poisson distribution ($P < 0.001$). The output of the final model comprised two parts: the zero-inflated part (in the logit model); and the negative binomial process (on the natural log scale) (*Table 3*). The results from the final model of the zero-inflated part (dmft = 0) indicated that seven variables, namely age, birthplace, parenthood, family income, frequency of snacking, dental visit experience and VPI score, were significantly associated with the chance of having a 'no caries experience' (dmft = 0). Younger children who were born in Hong Kong, came from single-parent families or high-income families, had sugary snacks once a day or fewer, never visited the dentist and had lower plaque scores, had an increasing probability of having 'no caries experience' ($P < 0.05$). In addition, the results of the final ZINB regression model (dmft > 0), with the five factors of gender, family income, dental visit experience, parental dental knowledge and VPI score, revealed statistically significant associations with the mean dmft score in the negative binomial part. Boys who had higher plaque scores, came from low-income families, had dental visit experiences and had parents with lower levels of dental knowledge, had significantly higher dmft scores ($P < 0.05$).

DISCUSSION

Various preventive measures have been implemented to reduce the burden of ECC in Hong Kong. As suggested by the WHO Global Consultation, subnational oral health surveillance, including the assessment of modifiable risk factors, is required to monitor and value intervention programmes to reduce ECC[15]. Based on the results of the present oral health survey, ECC remains prevalent and affects approximately half of the preschool children in Hong Kong. The caries statuses of Hong Kong kindergarten children have not been improved during the past two decades[8,9]. In the present study, the mean dmft score in 3- to 5-year-old children, of 2.1, was similar to that obtained in previous research (dmft = 2.2)[9]. Compared with Taiwan (89%)[16] and Mainland China (70%)[5], Hong Kong has a much lower ECC prevalence (55%) among 5-year-old children. However, when compared with

Table 2 Caries prevalence and mean decayed, missing and filled teeth (dmft) score of independent variables

Variables (number of children)	Caries prevalence (%)	*P**	Mean dmft (SD)	*P*
Birthplace				
Hong Kong (1,081)	45.2	0.010	2.1 (3.4)	0.003†
Other (110)	57.3		2.4 (3.1)	
Parenthood				
Both parents (1,087)	46.1	0.387	2.0 (3.3)	0.159†
Single parent or others (104)	48.1		2.6 (4.0)	
Main caregiver				
Parent (824)	48.1	0.004	2.1 (3.3)	0.004‡
Grandparent (211)	48.3		2.4 (3.9)	
Helper or others (156)	34.0		1.5 (2.9)	
Father's education				
Primary or below (71)	59.2	<0.001	3.3 (4.4)	<0.001‡
Secondary (697)	50.2		2.2 (3.4)	
Tertiary or above (425)	37.9		1.8 (3.2)	
Mother's education				
Primary or below (101)	61.4	0.001	2.6 (3.3)	<0.001‡
Secondary (684)	47.5		2.2 (3.5)	
Tertiary or above (406)	40.6		1.9 (3.2)	
Family income (HK$)				
Less than 15,000 (424)	59.4	<0.001	2.8 (3.9)	<0.001‡
15,001–30,000 (420)	47.4		2.1 (3.2)	
More than 30,000 (347)	29.1		1.1 (2.6)	
Bottle-feeding duration				
24 months or less (456)	48.2	0.548	2.1 (3.2)	0.880‡
More than 24 months (453)	45.7		2.1 (3.4)	
Still fed with bottle (282)	44.3		2.1 (3.7)	
Frequency of daily snacking				
2 times or less (676)	41.7	<0.001	1.8 (3.2)	<0.001†
More than 2 times (515)	47.6		2.4 (3.6)	
Age when starting toothbrushing				
24 months or less (830)	43.6	0.004	2.0 (3.4)	<0.001†
More than 24 months (361)	52.6		2.4 (3.4)	
Frequency of daily toothbrushing				
2 times or less (410)	50.7	0.032	2.4 (3.5)	0.002†
More than 2 times (781)	44.0		2.0 (3.3)	
Dental visit experience				
Yes (214)	59.8	<0.001	3.7 (4.4)	<0.001†
No (977)	43.3		1.7 (3.0)	
Parental dental knowledge level				
Low (53)	64.2	<0.001	3.8 (4.7)	<0.001‡
Middle (647)	50.2		2.3 (3.5)	
High (490)	39.2		1.6 (2.9)	

*Chi-square test.
†Mann–Whitney *U*-test.
‡Kruskal–Wallis test.

developed countries, Hong Kong has a higher ECC prevalence than the USA (23% in 2012)[17] or the UK (31% in 2013)[18].

Table 3 Caries risk factors of the study children (ZINB regression): the output of the final model comprised two parts, namely the zero-inflated part (A) and the negative binomial process (B)

(A) Zero-inflated portion (dmft = 0)	Odds ratio	95% CI	*P*	Pairwise comparison
Age (years)				
(1) 3*			<0.001	(1)>(2)>(3)
(2) 4	0.66	0.45–0.97		
(3) 5	0.42	0.28–0.63		
Birthplace				
(1) Hong Kong*			0.046	
(2) Other	0.54	0.30–0.99		
Parenthood				
(1) Both parents*			0.041	
(2) Single parent or other	1.82	1.03–3.22		
Family income (HK$)				
(1) ≤ 15,000*			<0.001	(3)>(2)>(1)
(2) 15,001–30,000	1.94	1.29–2.92		
(3) >30,000	5.27	3.38–8.23		
Frequency of daily snacking				
(1) 2 times or less*			0.001	
(2) More than 2 times	0.60	0.44–0.82		
Dental visit experience				
(1) Yes*			<0.001	
(2) No	2.14	1.43–3.21		
Increase VPI score by 10%	0.87	0.73–0.98	0.017	

(B) Negative binomial portion (dmft>0)	Incidence rate ratio	95% CI†	*P*	Pairwise comparison
Gender				
(1) Female*			0.008	
(2) Male	1.25	1.06–1.48		
Family income (HK$)				
(1) ≤ 15,000*			0.030	(1),(2) > (3)
(2) 15,001–30,000	0.98	0.81–1.19		
(3) >30,000	0.73	0.57–0.93		
Dental visit experience				
(1) Yes*			<0.001	
(2) No	0.51	0.42–0.63		
Parental dental knowledge				
(1) Low*			0.023	(1),(2) > (3)
(2) Middle	0.84	0.60–1.17		
(3) High	0.68	0.48–0.96		
Increase VPI score by 10%	1.09	1.03–1.15	0.001	

*Reference group. dmft, decayed, missing and filled teeth; VPI, visible plaque index; ZINB, zero-inflated negative binomial.

Although the Department of Health has organised several oral health-promotion activities, no improvement has been made in preschool child oral health. This may be because of the unsatisfactory participation rate of kindergartens and parents[19]. Possibly, the prevailing preventive measures may be ineffective or inaccessible. Factors affecting parental involvement and school administrators' decision to participate in this programme should be further explored. The present study affirms that untreated decay in primary

teeth is a widespread phenomenon in Hong Kong, as almost all decayed teeth (95%) were left untreated. This denotes that dental service use among preschool children remained low. The majority (75%) of the 5-year-old children had never visited a dentist according to the previous oral health survey, and the parents who did take their children to a dentist did so in an effort to alleviate their child's dental pain[10]. The present survey revealed that one (14%) in seven children had severe ECC with multiple carious lesions (dmft > 5). Oral health education alone, without clinical preventive and curative measures, may not be able to manage the burden of tooth decay, particularly among those with severe ECC.

In the present study, the distribution of dmft scores was positively skewed. Because the standard assumption of normality was unmet, the use of multiple linear regression models would not be suitable[20]. Poisson regression can be considered for handling non-negative integer count data. However, the dmft data were over-dispersed (the variance was larger than the mean), so the negative binomial regression model used in this study would be more appropriate than the Poisson regression model. According to the result of the final ZINB model, several significant factors, including demographic and socio-economic backgrounds and oral health-related behaviours, were associated with the prevalence and severity of ECC. The results of the present study indicate that the occurrence of caries in young children is a complex interaction. A well-established link existed between lower economic status and higher ECC prevalence and severity in the present study. Similarly to previous results[9,21], a social gradient in young children is obvious in Hong Kong: the higher the household income, the better the dental status of the child. Therefore, children living in poverty should be prioritised if oral health resources are limited. Our study indicated that parental dental health knowledge is significantly associated with child caries experiences. There is a need to raise parental dental knowledge and literacy, as well as to reinforce positive attitudes with active parental involvement. To achieve this, pregnant women should be advised to seek family-oriented oral health counselling during pregnancy. It is recommended for the first dental visit to take place by 12 months of age in order to assess caries risk and to provide early intervention if needed[22]. In contrast, Hong Kong preschool children who had previously visited a dentist had a higher chance of having caries prevalence and higher dmft scores compared with those without dental visit experiences. This implies that dental treatment had been sought as these children had already encountered oral health problems. Despite the fact that ECC prevention programmes are offered, their effectiveness in achieving the goal of a significant reduction in ECC has not yet been proved. Our results suggest the need to revise preventive programmes to reduce oral health disparities among Hong Kong preschool children.

At present, several oral health schemes have been implemented. Water fluoridation is one of the most cost-effective measures for reducing ECC in Hong Kong. Caries prevalence had declined remarkably from 97.5% in 1960 to 77.5% in 1981[8], and to approximately 50% in the 1990s[23]. This is in accordance with the results of the Cochrane systematic review that the introduction of water fluoridation resulted in children having a reduction in caries of approximately 35%[24]. However, no further caries reduction has been observed in the last two decades.

Our findings indicated that both non-modifiable (socio economic background) and modifiable (oral health-related knowledge and habits) risk factors were significantly related to ECC. Poor oral hygiene, low parental dental knowledge and high frequency of snacking are the most important modifiable factors that need to be addressed. Primary prevention programmes should encourage changes in behaviours and lifestyles to forestall this impending epidemic of ECC. The health-promoting school initiatives can be used as examples of the most effective and sustainable ways to modify these factors. In Scotland, a school-based supervised toothbrushing programme was found to be very successful in reducing dental caries among 5-year-old children[25]. Sodium fluoride, which is a simple and effective treatment for caries prevention, can be used in outreach dental care. In addition, because of its effectiveness, safety and ease of use, silver diamine fluoride can be incorporated into school-based health programmes for arresting cavitated dentine caries[26]. However, as dental caries is influenced by the same modifiable risk factors as other non-communicable diseases, rather than taking individualistic approaches, a common risk approach, such as the food policy development, should be adopted to address both the oral health problem and the general health problem[27].

Some limitations of the present study should be addressed. The study children were selected based on the unit of the kindergarten. Use of the cluster sampling method could help to reduce the cost and time, and increase the operational efficiency, of conducting a survey in a large area. However, a sampling error may occur if the limited number of clusters included fails to include a large proportion of the population. Owing to the nature of the cross-sectional study, our results could identify only the association between risk factors and ECC. Further cohort research will be essential for determining the predictors of ECC. Nevertheless, the present study has several strengths, such as obtaining a high response rate (89%), a sufficient sample size (more than 1,200 children) and high

intra-reliability (kappa value = 0.97). The participating children also came from a broad socio-economic background, and their gender distribution was as estimated, representing kindergarten children in Hong Kong.

In summary, ECC is prevalent among 3- to 5-year-old kindergarten children in Hong Kong. Untreated ECC is a common phenomenon. Caries prevalence dramatically increases with increasing age among kindergarten children. The caries experiences of the study children were significantly associated with gender, family income, parental dental knowledge, dental visit experience and oral hygiene.

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Conflict of interest

All authors declare no conflict of interest.

REFERENCES

1. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990-2016: asystematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017 390:1211–1259.
2. American Academy of Pediatric Dentistry. Policy on early childhood caries (ECC): classifications, consequences, and preventive strategies. *Pediatr Dent* 2017 39: 59–61.
3. Wong HM, McGrath CP, King NM *et al.* Oral health-related quality of life in Hong Kong preschool children. *Caries Res* 2011 45: 370–376.
4. Duangthip D, Gao SS, Lo EC *et al.* Early childhood caries among 5- to 6-year-old children in Southeast Asia. *Int Dent J* 2017 67: 98–106.
5. Zhou X, Xu X, Li J *et al.* Oral health in China: from vision to action. *Int J Oral Sci* 2018 10: 1.
6. Census and Statistics Department. Hong Kong Statistics: Population 2018. Available from: https://www.censtatd.gov.hk/hkstat/sub/so20.jsp. Accessed 1 July 2018.
7. Gao SS, Chen KJ, Duangthip D *et al.* Oral health care in Hong Kong. *Healthcare (Basel)* 2018 6: 45. https://doi.org/10.17796/1053-4625-42.5.8.
8. Lee GH, Pang HN, McGrath C *et al.* Oral health of Hong Kong children: a historical and epidemiological perspective. *Hong Kong Med J* 2016 22: 372–381.
9. Chu CH, Lo EC, Ho PL. Oral health status and behaviours of preschool children in Hong Kong. *BMC Public Health* 2012 12: 767.
10. Department of Health, Government of the Hong Kong Special Administrative Region. Oral Health Survey 2011. Available from: http://www.toothclub.gov.hk/en/en_pdf/Oral_Health_Survey_2011/Oral_Health_Survey_2011_WCAG_20141112_(EN_Full).pdf. Accessed 15 June 2018.
11. Department of Health, Government of the Hong Kong Special Administrative Region. Tooth Club. Available from: http://www.toothclub.gov.hk/en/en_home_01.html. Accessed 1 July 2018.
12. World Health Organization (WHO). Oral health surveys-basic methods Geneva: World Health Organization; 2013. Available from: http://apps.who.int/iris/bitstream/10665/97035/1/9789241548649_eng.pdf?ua=1. Accessed 15 June 2018.
13. Chen KJ, Gao SS, Duangthip D *et al.* Dental caries status and its associated factors among 5-year-old Hong Kong children: a cross-sectional study. *BMC Oral Health* 2017 17: 121.
14. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *Int Dent J* 1975 25: 229–235.
15. Phantumvanit P, Makino Y, Ogawa H *et al.* WHO global consultation on public health intervention against early childhood caries. *Community Dent Oral Epidemiol* 2018 46: 280–287.
16. Tsai AI, Chen CY, Li LA *et al.* Risk indicators for early childhood caries in Taiwan. *Community Dent Oral Epidemiol* 2006 34: 437–445.
17. Dye BA, Thornton-Evans G, Li X *et al.* Dental caries and sealant prevalence in children and adolescents in the United States, 2011-2012. *NCHS Data Brief* 2015 191: 1–8.
18. Health and Social Care Informatic Center, National Statistics. Children's oral health report 2015. Available from: http://www.hscic.gov.uk/catalogue/PUB17137/CDHS2013-England-Report.pdf. Accessed 15 June 2018.
19. Cheng DYC. Oral health promotion by the department of health. *Dental Bulletin* 2008 13: 8–10.
20. Chau AMH, Lo ECM, Wong MCM *et al.* Interpreting poisson regression models in dental caries studies. *Caries Res* 2018 52: 339–345.
21. Gao SS, Duangthip D, Lo ECM *et al.* Risk factors of early childhood caries among young children in Hong Kong: a cross-sectional study. *J Clin Pediatr Dent* 2018 42: 367–372.
22. American Academy of Pediatric Dentistry. Perinatal and infant oral health care. *Pediatr Dent* 2017 39: 208–212.
23. Chu CH, Fung DS, Lo EC. Dental caries status of preschool children in Hong Kong. *Br Dent J* 1999 187: 616–620.
24. Iheozor-Ejiofor Z, Worthington HV, Walsh T *et al.* Water fluoridation for the prevention of dental caries. *Cochrane Database Syst Rev* 2015 6:CD010856.
25. Macpherson LM, Anopa Y, Conway DI *et al.* National supervised toothbrushing program and dental decay in Scotland. *J Dent Res* 2013 92: 109–113.
26. Duangthip D, Chen KJ, Gao SS *et al.* Managing early childhood caries with atraumatic restorative treatment and topical silver and fluoride agents. *Int J Environ Res Public Health* 2017 14: 1204. https://doi.org/10.3390/ijerph14101204.
27. Sheiham A, Watt RG. The common risk factor approach: a rational basis for promoting oral health. *Community Dent Oral Epidemiol* 2000 28: 399–406.

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