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Risk indicators for early childhood caries in Taiwan

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Abstract – *Objectives:* The purpose of this study was to investigate the prevalence, patterns, and etiological factors for caries in children. *Methods:* A total of 981 children less than 6 years of age were examined using a dental mirror and explorer. A parent or a caregiver was asked to complete a questionnaire regarding information about the child, the household, and oral hygiene. The prevalence and patterns of dental caries including pit and fissure caries, facial/lingual caries, molar proximal caries, and facial/lingual molar proximal lesions, were analyzed. Each child was classified as caries free or as having one of these four caries patterns. *Results:* Weighted mean deft was 0.14 at age 2, 2.58 at age 3, 4.41 at age 4, 6.94 at age 5, and 7.31 at age 6. Weighted mean defs was 4.71, 8.44, 16.45 and 18.64 at ages 3, 4, 5, and 6, respectively. By age 2, 5.09% of children had caries. By age 6, 89.38% of children had caries. By age 3, 30.02% of children fitted the facial and lingual pattern of caries and by age 6, 52.90% of children fit the 'facial-lingual and molar-proximal' pattern, indicating extensive smooth surface decay. The total prevalence of early childhood caries was 56%. Multivariate-adjusted odds ratios identified factors associated with the high caries experience of the young children and found caries was strongly associated with the lack of proper tooth brushing and high consumption of sweets. Higher caries scores were also associated with areas of low urbanization. *Conclusions:* The findings of this survey indicated a high level of untreated caries among children in Taiwan.

Key words: caries patterns; dental caries; early childhood caries; primary dentition

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Taiwan's economy has progressed steadily and the health status of the people in Taiwan has also improved considerably (1). However, the prevalence of dental caries is one exception to these advances in the economy and health status. A national survey showed that the prevalence of dental caries in elementary and junior high school students was approximately 94% (2). A recent study reported that the prevalence of caries among preschool-aged children was between 85% and 88% (3). However, only a limited number of studies have documented the occurrence of dental caries for preschool-aged children in Taiwan. The most recent large-scale dental survey was conducted in 1971, and in that survey, the mean deft was 4.3 for 3-year olds and 8.5 for 5-year olds (4).

Early childhood caries (ECC), which involves children under the age of 6 years, encompassses specific teeth and surfaces (5). Traditionally, dental caries have been measured by the mean number of decayed, missing, and filled teeth/surfaces (deft/defs). The deft/s may not be the most useful and appropriate index for caries studies because of the high population variance and non-normal distribution of caries (6). Caries prevalence among different populations and its extent in individuals varies. Sites of dental caries in the primary dentition seem to be related to varying etiologies. Thus, there is a need for a more descriptive caries index (7–10). Major caries site groupings related to etiology include, for example, pit and fissure caries and caries of the proximal surfaces of molars. While the concept of caries occurrence in a specific pattern has an intuitive basis, the use of cluster analysis has confirmed the notion that children develop caries in a fairly small number of distinct patterns (11). The timing of appearance of specific caries can be tracked by assessing caries patterns

for specific age groups, beginning with the youngest children in a population. The affliction of a specific type of caries and its pattern have not been studied systematically in Taiwan. Such a study could be used as a basis for estimation of the current dental status and future needs for oral health care. As fluoride is not added to the water in Taiwan, a systematic study of caries experience and patterns at each age group could show the progression of the disease in a population with a cultural and fluoridation status distinct from other nations, such as the United States (12).

This national dental health survey of children younger than the age of 6 in Taiwan was conducted from the years of 1995 to 1997. The purpose of this investigation included the following: 1) to develop and evaluate caries patterns and to determine the national estimates of ECC and S-ECC for children between the age of 0 and 6 years, and 2) to study the relationship between disease characteristics and prevalence as well as the risk indicators within this population.

Materials and methods

The total number of cities, villages, and townships in Taiwan is 309. These geographic locations were divided into 10 administrative strata based upon the socioeconomic status (SES) and degree of urbanization as follows: 1) developing area; 2) mountainous area; 3) industrial area; 4) hilly area; 5) remote area; 6) service business area; 7) combination area; 8) metropolitan area in Taipei city (northern area of Taiwan); 9) metropolitan area in Kaoshiung city (southern area of Taiwan); 10) five well developed county administration centers. We designated the population elements into these 10 strata. The sample design in this study was based on the principle of stratification, using multi-stage sampling with unequal sample probability. Each population group had a different chance to appear in the sample due to different location, age, and gender characteristics. The population of interest in this investigation was Taiwanese children under age 6, excluding children in the orphanages. Taipei, Kaoshiung, and five other cities were categorized as high urbanization areas. The medium urbanization category consisted of the developing, industrial, and service business areas. Finally, the mountainous, remote, and hilly areas were clustered as low urbanization groups.

In this survey, two-stage sampling was conducted within each stratum to assure random sampling. The first stage was the selection of districts from 10 strata using the Probabilities Proportional to Sizes method. The number of sampling districts for each stratum was proportional to the number of children under age six within each stratum. There were 25 districts represented in this study. In the second stage, cluster sampling was conducted to select a sample of 15 blocks from each sampled district. Each block was composed of 15 geographically neighboring house units. Hence, there were 225 household sampling units within each sampled district. In each house sample, children under the age 6 were the subjects of this survey.

Computer-selected two-dimensional random coordinate points were applied to the position of each district on the map. A valid coordinate point determined the first house unit of a sampling block. A valid coordinate point had to contain 15 neighboring house units within a radius of 100 m. The maps played an important role in our survey. However, current maps could not completely describe the most recent and precise distribution of all streets. Therefore, in the process of selecting blocks, a Global Position System was utilized to help determine the position of the first house unit.

House visitors were sent to each random sampling home unit to introduce the survey and to invite the family to participate in this survey. If there were children under the age of 6 in the house unit, the child would be scheduled for a dental examination.

A total of 5625 house units were sampled and 1681 house units had children under the age of 6. A total of 981 children were available for dental examinations. Children who were absent from the household during survey were asked to take the examination on the following day. If the child was not available on the following day, he/she was excluded from the study. Dental examinations that excluded radiographs were performed by three pediatric dentists. The examination procedure, instruments used, and diagnostic criteria were based on the WHO guidelines (13).

Parental interviews were carried out by trained interviewers. The parent or the caregiver was also asked to complete a questionnaire about their child which provided information in the following areas: demographics, medical and dental history, diet/feeding habits, bottle weaning and brushing/oral hygiene practice.

Interexaminer calibration was done by comparing independent dental examinations of randomly selected children. Calibration studies were carried out in a local kindergarten where twenty 3- to 5-year-old children were assessed. Values for kappa statistics for the interexaminer agreement (14) were 0.97 and 0.98.

Caries classifications were based on caries site grouping. Five caries patterns were classified based on site of formation as follows (8).

Caries free

Lesions associated with developmental defects:

- *Pit and fissure defects*. One or more lesions at sites of pit and fissure enamel defects in primary molars; occlusal surfaces of any molar as well as lingual surfaces of maxillary second molars and facial surfaces of mandibular second molars.

Smooth surface lesions:

- *Facial-lingual lesions* (only cavitated lesions were included; 'white spot' lesions were not). One or more lesions on a facial or lingual surface of any tooth or a proximal surface of an incisor tooth. Buccal surfaces of mandibular second molars and lingual surfaces of maxillary second molars were not considered smooth surfaces.
- *Proximal molar lesions*. One or more lesions on the proximal surfaces of the primary molars or distal surfaces of the primary canines.
- *Facial-lingual/molar approximal lesions*. One or more of both types of smooth surface lesions.

Each child was placed in only one of the five categories (8). Children were classified by site/pattern-oriented caries classification. For children with both smooth surface lesions and defect-associated lesions, classification priority was given to smooth surface lesions. For example, if a child had lesions in pit and fissure defects as well as proximal surfaces of the molars, the child was classified in the molar proximal group.

ECC is defined as 'the presence of one or more decayed, missing (due to caries), or filled tooth surfaces in any primary tooth in a child 71 months of age or younger'. In children younger than 3 years of age, any sign of smooth surface caries is indicative of Severe Early Childhood Caries (S-ECC). From ages 3 to 5, S-ECC is defined as one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth (definition no. 1), or decayed, missing or filled surface (dmfs) values of 4 or higher at age 3; 5 or higher at age 4; or 6 or higher at age 5 (definition no. 2) (5).

Statistics

The likelihood of developing caries due to a specific factor was presented as an odds ratio, which is an indicator for the strength of association. The statistical significance was tested with Mantel–Haenszel chi-square test in univariate analyses while a multiple logistic regression and stratified analyses were applied to the tests in multivariate models adjusting to the confounding variables. Graphic plots were employed to present the distribution and relationship between risk factors and caries status in this study.

Results

The randomly selected sample of children provided an estimate of dental caries prevalence for the 1.9 million children between the age of 0 and 6 years in Taiwan. The sample population consisted of 114 children of age 1, 182 children of age 2, 182 children of age 3, 178 children of age 4, 147 children of age 5, and 178 children of age 6. Data were collected on 981 children (526 boys and 455 girls). All of the data were weighted according to the 1995 national census of population distribution. The average deft scores were zero for children of age 1, 0.14 for age 2, 2.58 for age 3, 4.33 for age 4, 6.65 for age 5, and 6.72 for age 6. The increased deft score from 0.14 at age 2 to 2.58 at age 3 is an increase of 17-fold (Table 1). After age 3, there is a steady increase for both defs and deft scores. The average defs scores were zero for children age 1, 0.20 for age 2, 4.71 for age 3, 8.26 for age 4, 15.78 for age 5, and 17.11 for age 6. Essentially, the def score was dominated by unrestored caries and there was no treatment until age 4.

Distribution of caries patterns for all age groups is shown in Fig. 1; 3.98% of children at age 2 fit the facial-lingual caries pattern, that is, 78% of the caries positive children. For children of age 3, 30% (50.5% of the caries positive children) fit the facial-lingual pattern and 24% (42% of the caries positive) of children fall into pit and fissure caries pattern. Also at this age level, 5% of the children experienced facial-lingual and molar approximal caries. At age 4, the facial-lingual and molar approximal pattern increased two to three times that of the 3-year olds (13.26 versus 5.12) and molar approximal pattern increased three times (3.64 versus 0.87). Overall, the percentage of children affected by molar approximal caries pattern is the lowest

Table 1. Caries (ECC) prevalence and mean deft, mean defs among Taiwanese children in relation to age

Age (years)	No. of children	% Children affected ± SD	*d*	*E*	*f*	deft ± SD	% of *d*/dmft	*d*	*e*	*f*	defs ± SD	% of *d*/dmfs
1	114	0.0 ± 0.00	0	0	0	0.0 ± 0.00	0	0	0	0	0 ± 0.00	0
2	182	5.09 ± 2.97	0.14	0	0	0.14 ± 0.95	100	0.20	0	0	0.2 ± 1.51	100
3	182	60.12 ± 6.61	2.58	0	0	2.58 ± 3.55	100	4.71	0	0	4.71 ± 7.83	100
4	178	75.00 ± 5.58	4.33	0	0.08	4.41 ± 4.31	98	8.26	0.01	0.17	8.44 ± 10.32	98
5	147	89.13 ± 3.77	6.65	0.05	0.25	6.94 ± 5.19	96	15.78	0.24	0.43	16.45 ± 17.01	96
6	178	89.38 ± 4.11	6.72	0.14	0.44	7.31 ± 5.04	92	17.11	0.72	0.80	18.64 ± 15.57	92

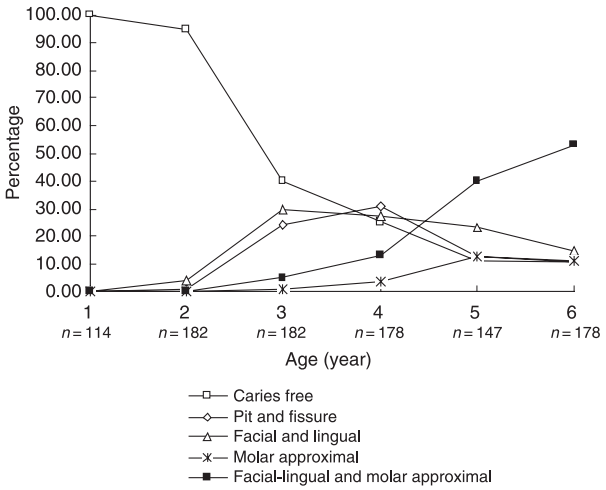

Fig. 1. Percentages of children with identified caries patterns.

among 3- and 4-year olds (0.87% and 3.64%, respectively). At age 5, the percentage of both molar approximal and facial-lingual molar approximal caries patterns dramatically increased to 13% and 40%, respectively. At age 6, more than half of the children experienced the facial-lingual molar approximal caries. The other caries patterns were evenly distributed among the age groups, ranging from 11% to 15%. The percentage of children in the facial-lingual category decreased with age (3- to 6-year olds). However, an increase in the percentage of children experiencing a facial-lingual molar approximal caries was seen. The percentage of children in the caries free category decreased steadily from ages 3 to 5.

The prevalence of ECC for children in this national survey for all ages was 56%. Table 1 shows caries prevalence for specific age groups. In children younger than 3 years of age, any sign of smooth surface caries is indicative of S-ECC (5). Thus, 3.89% of 2-year-old and 36.02% of 3-year-old had S-ECC. The caries S-ECC score was found in 44.94%, 69.39% and 71.35% of the children at ages of 3, 4, and 5, respectively, using case definition 1 and 62.93%, 76.19% and 78.09% of the children at ages of 3, 4, and 5, respectively, using case definition 2.

Figures 2 and 3 illustrate different deft/defs scores in relation to various identified caries patterns. Facial-lingual and molar approximal caries patterns demonstrated the greatest mean deft and mean defs scores, followed by the facial-lingual

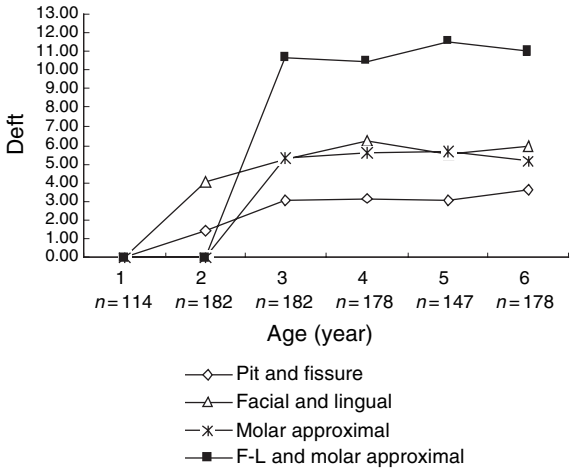

Fig. 2. Identified caries patterns and deft.

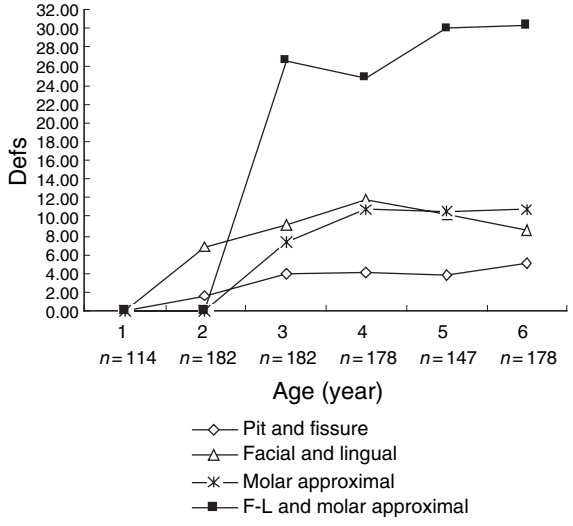

Fig. 3. Identified caries patterns and defs.

and molar approximal categories. Differences between the facial and lingual category and the molar approximal pattern were small after age 3.

Table 5 presents various defs scores for identified caries patterns and defs of ECC and S-ECC children at different ages. Children with facial-lingual and molar approximal lesions had an average of 30 surfaces of caries. At age 2, the lesions were primarily located on smooth surfaces (facial-lingual) such that the defs indices were the same as the scores of facial/lingual pattern. The defs scores for S-ECC for children between the ages of 4 and 6 were similar using either definition 1 or 2.

Analysis of the survey questions regarding oral health behavior revealed that the practice of tooth brushing in this population was limited (Table 2), with 67.73% of age 1, 30.04% of age 2, 33.61% of age 3, 37.22% of age 4, 31.86% of age 5, and 43.90% of age 6 children brushing their teeth at least once a day. Multivariate-adjusted odds ratio identified a significant association between tooth brushing before bedtime and caries prevalence (Table 3). Children who did not have their teeth brushed before bedtime were more likely to have caries (odds ratio $= 2.34$, $P < 0.05$).

The majority of children had been bottle-fed at some point of their lives. The use of a night-time bottle was common in all age categories (Table 2), with up to 81% of the subjects having a history of sleeping with a bottle at the time of the survey. At each interview, the parents were asked for the reason for a night-time bottle. The most common response was to give the child more nutrients (83.04%), whereas the second most common answer was 'the child reacted very strongly if no bottle is provided at night'. However, no relationship between night-time bottle use and caries was found; 75% of the children were reported to have a bottle containing a sugary drink, however, the analysis did not identify this as a risk factor for caries.

Information was collected on the children's snack habits (Table 2); 73–83% of the children older than 2 years were reported to favor sweet snacks. Table 3 shows that children with ECC consumed more sweet snacks than the noncaries children, and the difference was statistically significant (odds ratio $= 1.65$, $P < 0.05$).

The 10 strata areas were categorized into high, medium, and low urbanization areas according to the degree of urbanization. Children from different areas appear to have different caries indices. Higher caries sores were significantly associated with low urbanization areas; the odds ratios for areas of medium and low urbanization were 1.73 and 2.39, respectively. ECC greatly increased with age, affecting more than 90% of 4- to 5-year-old children. This pattern of disease was age related, with more caries being seen in children of older age groups (Table 3).

Table 4 shows that birth order was associated with the severity of caries. Later offspring of a mother were at a higher risk of caries than those born earlier. The mean deft was significantly related to the tooth-brushing habit and consumption of sweets. Children who reportedly had their teeth brushed everyday showed lower deft sores (odds ratio $= 1.89$, $P < 0.05$) and children who preferred sweet foods and drinks had higher deft scores (odds ratio $= 3.22$, $P < 0.05$) (Table 4).

Discussion

The findings of this study are subjected to several limitations associated with the nature of field examinations. The reported caries levels are most likely an underestimation of the true prevalence due to two reasons. First, the oral examination did not include radiographs to detect interproximal caries. Second, the criteria used for survey examination were more conservative than the criteria used for diagnosis in other studies that included

Table 2. Percentage of children for each age group with reported oral health behaviors

Age (years)	% of parents reported having children's teeth brushed at least once a day	% of children took a bottle to bed or slept with bottles	% of children favored sweet snacks
1	67.73	79.05	32.11
2	30.04	81.78	74.06
3	33.61	70.96	73.74
4	37.22	76.11	83.73
5	31.86	69.65	79.30
6	43.90	63.31	77.54

Table 3. Multiple logistic regression analysis for the risk of caries among children 0- to 6-year olds in Taiwan

Variables	Caries (%)	No caries (%)	OR	95% CI
Age (years)				
1	0.00	100.00	0	0 to ∞
2	9.34	90.66	1	–
3	57.69	42.31	13.75*	7.48–25.26
4	77.53	22.47	37.44*	19.28–72.70
5	91.16	8.84	103.52*	45.94–233.27
6	92.70	7.30	127.09*	56.09–287.94
Sex				
Females	56.70	43.30	1	–
Males	57.22	42.78	1.40	0.96–2.05
Area (urbanization)				
High	51.72	48.28	1	–
Medium	60.00	40.00	1.73*	1.03–2.91
Low	56.27	43.73	2..39*	1.39–4.11
Favored sweet snacks				
N	42.16	57.84	1	–
Y	63.58	36.42	1.65*	1.07–2.55
Unknown	28.57	71.43	1.13	0.24–5.39
Brush teeth before bed time				
Unknown	32.29	67.71	0.78	0.50–1.23
Every night	75.89	24.11	1	–
No	73.63	26.27	1.83*	1.06–3.16

*$P < 0.05$

noncavitated lesions (15, 16). Since the execution of this study in 1995–1997, caries prevalence and diet patterns may have changed gradually. A more current survey should be conducted in order to compare the changes.

Selecting a representative sample of infants and toddlers is usually difficult because these children are not readily accessible (17, 18). Thus, in general, there is a paucity of caries data for children from birth to 6 years of age in the Taiwanese population as well as worldwide (15, 17, 18). Although we did offer the children a second chance to be examined, study participation did not improve. After further investigating the nonparticipants, we found that the reason for not taking the examination was irrelevant to their oral health or related factors. We deem this nonparticipation as random behavior, and, therefore, should not affect the results of this study. This study provides the first nationwide report on caries prevalence of Taiwanese children from birth to 6 years of age. Although limited by its cross-sectional nature, the results showed the timing of the appearance of specific caries and the progression of the disease in young children. The specific caries pattern analysis revealed the different caries patterns among various age groups that the traditional dmft/s index did not.

This study also provided the first nationwide analysis of various caries patterns, ECC, and S-ECC of primary dentition in Taiwan. The new case definition of ECC is essentially equivalent to 'dental caries in the primary dentition of children aged 0–6' (5). Therefore, the prevalence of ECC should not differ from that of the total population estimated. The deft/s index of ECC is the system that excludes those children without caries; therefore, the estimates are much higher than the traditional deft/s. The case definition of S-ECC is based only on the smooth surfaces of the tooth. Thus, the defs at age 2 is the same as defs of facial/lingual pattern (Table 5). The deft/s of S-ECC that are concentrated on certain surfaces of teeth, e.g. smooth surfaces or maxillary anterior teeth, excluding pit and fissure type of lesions, contribute to a higher estimates of deft/s indices. Should this case definition apply to a population in which pit and fissure caries is the major pattern, the deft/s scores would be much lower. Thus, this new case definition of ECC and S-ECC may not represent the appropriate caries status and therefore will not address a balanced and responsive way to improve the needs for prevention and treatment.

Our results showed a high ECC prevalence of over 56% among the 0- to 6-year-old children. For comparison, the overall prevalence of caries in children younger than 4 years of age in developed countries has been reported to be less than 3–6% (18–21). However, high caries prevalence in native North American populations, ranging from 44% to 90%, has been reported (22). In one of the first large-scale epidemiological studies of children younger than 3 years of age in the United States, Tang et al. reported on the dental caries prevalence in 1475 Arizona children aged 5 months to 4 years enrolled in WIC and Head Start programs (15). In that study, the overall caries prevalence varied from 6% in 1-year olds, 22% in 2-year olds, 35% in 3-year olds and 49% in 4-year olds. The results of the present study indicate that the problem of dental caries is far more serious in Taiwan as opposed to western countries.

The high level of caries in 3-year olds suggests that the disease is well established by that age. The level of increase for the 4-, 5- and 6-year olds are interpreted to mean that the disease continues to progress, but that the major thrust has occurred by age 3. At age 3, most of the primary teeth eruption has been completed. The progression of ECC is usually related to the order of tooth eruption, with the exception of the mandibular incisors (18). The more teeth that experience a cariogenic challenge, the more teeth that will suffer attacks of caries.

Table 4. Loglinear regression model for the risk of increasing number of ECC among children 0- to 6-year-old in Taiwan

Independent variables	Mean ± SD	Median	Q1–Q3	Min–Max	Odds ratios	95% CI
Sex						
Female	3.92 ± 4.77	2	0–7	0–20	1.06	0.99–1.13
Male	3.98 ± 4.87	2	0–7	0–20	1.00	–
Age (years)						
1	0 ± 0	0	0	0	0	0–∞
2	0.29 ± 1.43	0	0	0–16	1.00	–
3	2.58 ± 3.36	1	0–4	0–14	8.95*	6.70–11.96
4	4.70 ± 4.18	4	1–7	0–20	15.81*	11.89–21.02
5	7.54 ± 5.00	8	4–11	0–20	25.24*	18.98–33.55
6	7.94 ± 4.89	8	4–11	0–20	26.74*	20.12–35.53
Ranking of siblings						
1	3.88 ± 4.66	2	0–7	0–20	1.00	–
2	4.02 ± 4.91	2	0–7	0–20	1.14*	1.06–1.22
3	3.96 ± 4.92	2	0–8	0–20	1.06	0.97–1.16
≥4	3.83 ± 4.98	2	0–6	0–20	1.16	0.97–1.40
Unknown	5.30 ± 6.33	2	0–12	0–16	8.25*	3.05–22.32
Get snack easily						
No	2.92 ± 4.17	0	0–9	0–20	1.18	0.67–2.09
Yes	5.22 ± 5.22	4	0–5	0–20	1.41	0.80–2.49
Unknown	3.71 ± 5.63	0	0–9	0–16	1.00	–
Sweet consumption						
Dislike	2.49 ± 3.93	0	0–1	0–16	3.22*	1.19–8.73
Like	4.56 ± 5.00	3	0–8	0–20	4.10*	1.51–11.09
Unknown	2.57 ± 5.02	0	0–4	0–20	1.00	–
Brush tooth everyday						
No	5.83 ± 5.23	5	1–10	0–20	1.89*	1.02–3.48
Yes	4.98 ± 4.69	4	0–8	0–20	1.59	0.86–2.95
Unknown	2.03 ± 3.88	0	0–2	0–20	1.00	–
Brush before bedtime						
No	5.22 ± 5.12	4	0–9	0–20	1.06	0.98–1.15
Yes	5.43 ± 4.87	5	1–9	0–20	1.67	0.90–3.09
Unknown	2.05 ± 3.89	0	0–2	0–20	1.00	–

*$P < 0.05$

Table 5. Comparison of defs of various caries patterns, ECC, S-ECC and the traditional defs of different ages

Item/age (years)	Pit and fissure	Facial/ lingual	Molar proximal	F/L molar proximal	ECC defs	S-ECC defs	Traditional defs
1	0	0	0	0	0	0	0
2	1.6	6.82	0	0	4.88	6.82	0.2
3	3.98	9.24	7.33	26.67	7.34	9.87	4.71
4	4.15	11.82	10.82	24.86	11.76	16.56/14.08[a]	8.44
5	3.7	10.19	10.54	30.07	19.49	23.69/22.86[a]	16.45
6	5.05	8.7	10.79	30.34	21.73	26.09/25.19[a]	18.64

[a]defs by S-ECC definition no. 2.

Although caries progressed with 4-, 5-, and 6-year olds, the rate of new caries formation was not as rapid as in the 2- and 3-year age groups. The level of dental decay found in this study are similar to those found in the 1971 survey (4). We continue to see a high caries rate among young children in Taiwan, and such a rate is significantly higher than the reported caries level in the underserved preschoolers with fluoridated water in the US (7, 8). One implication of this finding is that intervention should begin much earlier than age 3, which should include the prevention of white spot lesions in order to disrupt the initiation of this significant disease.

In addition to high caries prevalence among children aged 3 and older, the high level of decayed (d) scores with low filled (f) scores suggested that a large number of these children had substantial restorative needs. Efforts should be undertaken to increase the dental care to this group

of children, either by raising public awareness or by increasing the availability of dental care services for young children. The early childhood period may be the most important time to build a solid foundation for future dental health. Studies have indicated that the earlier children develop dental caries, the more susceptible they are to future caries (23–25).

Data on the 'pit and fissure' caries pattern is interpreted as to support the hypothesis that this form of disease is clinically significant and children with pit and fissure lesions appear to be at greater risk to develop new lesions than the caries free children (23). A decrease in the percentage of children in the 'pit and fissure' category and the increase of children in the 'molar approximal' category with age shows a progression from pit and fissure to smooth surface caries. The decrease in the number of subjects in the facial-lingual category along with the increase in the 'facial-lingual/molar approximal' category is seen as a progression to include the smooth surfaces of the molars. The data also support the view that most incisor caries have occurred by age 2 and 3 (26, 27), but that later development of incisor caries is still possible.

Regional difference in caries prevalence was observed, which showed that children from low urbanization area had the highest caries levels. Urbanization was analyzed as a factor associated with economic development and SES; factors which have been strongly implicated in the etiology of dental disease (28). Low urbanization areas in this study were remote, hilly, mountainous areas, which tend to be areas experiencing socioeconomic disadvantage. Urbanization has also been associated with increased caries levels (28, 29). This socioeconomic factor is thought to be related to greater access to refined sugars and other changes in lifestyle associated with migration to urban centers (29). Although highly urbanized areas were found to be correlated with increased dental disease prevalence by Barmes (28), this study demonstrates the reverse. Efforts should be made at all levels of SES to improve the dental awareness and availability of oral health services.

Dilley hypothesized that most children at higher caries risk would be the first-born children because parental knowledge and experience in child rearing would be less (30). However, it has been suggested recently that second and third born children tend to be colonized earlier with cariogenic bacteria, especially when the mother's cariogenic flora is at a higher level. Therefore, the later offspring of a mother with mild to moderately high caries may be at a higher risk of caries than offspring born earlier (31). In our study, high caries scores were associated with second or later-born children. Further studies are needed to investigate these reasons.

Studies extending over many years have addressed the effects of frequency, duration and type of diet on dental caries in young children (32–34). Over 50% of the children aged 2 and older in this study favored sweet snacks, with more than 73% of them eating those snacks 'several times a day'. Between 63% and 82% of the parents also reported employing bottle behaviors known to promote dental caries. The significance of bottle-feeding during sleep in the etiology of ECC is currently controversial (17, 18, 35). However, the findings in our study suggested dietary factors other than bottle use, such as consumption of sweets, contributed to ECC in these young children.

A lack of regular tooth cleaning also contributes to the development of a pathognomic oral ecology (36). It appeared that there was lack of knowledge in this population about when brushing should begin and who should do it. Daily brushing and consumption of sweets were significant factors in this study. These findings raise significant questions regarding the cause and the progression of ECC. Current oral health promotion only gives warnings for parents against the use of a night-time bottle. Preventive strategies should be directed toward recognizing the importance of tooth brushing and diet control as well as controlling the primary pathogens (mutans streptococci) involved in the development of ECC.

The findings of this study suggest a high level of caries experience and untreated caries among children in Taiwan. Thus, the children aged 0–6 years in Taiwan are in great need of oral health promotion initiatives. However, as the majority of children in the present survey had low dental treatment rendered to this age group, access to dental care through dental and nondental health professionals must be greatly improved to implement the preventive strategies.

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