

# Analysis of Forecasting Indexes for Dental Caries in 3- to 6-year-old Children

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**Objective:** To analyse a possible predictive index for dental caries in 3 to 6 year old children in urban Beijing.

**Methods:** Using random cluster sampling, 2,333 participants from six kindergartens, comprised of 35.7% 3-year-olds, 32.4% 4-year-olds and 31.9% 5-year-olds in urban Beijing were selected. At baseline, questionnaires were administered to about half of the parents. Children's oral health condition was examined at baseline and 6, 12 and 18 months later. In total there were 1,094 children who completed the 18-month evaluation.

**Results:** The baseline caries prevalence was 56.4%, and the mean dmft (decayed, missing and filled primary teeth) and dmfs (decayed, missing and filled primary surfaces) were 2.66 and 5.60, respectively. There were 62.3% parents who were aware of oral health knowledge, and amongst which the accuracy rate for attitudes regarding oral healthcare was 82.1%. The caries incidence in children who completed the evaluation was 55.3%, and mean increases in dmft and dmfs were 1.62 and 3.93, respectively. Predictive factors related to caries incidence were "past caries experience" [odds ratio (OR) = 4.969,  $P < 0.001$ ], "parents help children brush teeth daily" (OR = 0.851,  $P = 0.046$ ), and "parents consider that primary caries need to be treated" (OR = 1.270,  $P = 0.031$ ). The sensitivity and specificity of "past caries experience" were 69.4% and 73.2%, respectively, and the sensitivity of the three indices combined was 88.4%.

**Conclusion:** "Past caries experience" was an important predictor for primary caries incidence, and can be used in combination with "parents help children brush teeth daily" and "parents consider that primary caries need to be treated" as a predictive index.

**Key words:** children, dental caries, forecasting index, primary teeth  
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Children are a key target group in the prevention and treatment of oral diseases. Dental caries is the most common paediatric oral disease, and its prevention and control in children should be considered. Caries is a

common, complex, chronic disease resulting from the development of an imbalance between multiple risk factors and protective factors over time<sup>1</sup>.

The prevalence of caries in primary teeth in China is extremely high. The third National Oral Health Survey, performed in 2005, showed that the prevalence of dental caries was 66.0% and the average decayed, missing and filled primary teeth (dmft) index was  $3.50 \pm 4.08$  in 5-year-olds<sup>2</sup>. Furthermore, caries in primary teeth, especially which progress rapidly, is difficult to control, and can impact the oral and general health of children<sup>3</sup>. However, dental personnel and resources are limited and their distributions are not uneven, making the prevention and control of dental caries difficult.

Susceptibility to caries differs amongst individuals<sup>4</sup>, and the characteristics of caries, sensitive sites and risk factors differ among age groups<sup>5</sup>. Epidemiological

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studies have shown that the distribution of caries is not uneven, with most caries occurring in high-risk populations. The third National Oral Health Survey showed that most (79.3%) caries occurred in one-third of children, and that the mean dmft index (and thus significant caries index [SiC]) in this high-risk group was 8.332. Limited dental resources should be applied first to these high-risk children to prevent more caries.

Children aged 3 to 6 years old usually go to kindergartens in China and are readily influenced by the educational environment. The objectives of this longitudinal investigation performed in kindergartens was to determine the characteristics of dental caries in these children and to assess a possible predictive index to identify children with high-risk factors of dental caries, and to help the prevention and control of dental caries in kindergartens.

## Materials and methods

### *Enrollment of participants*

Subjects were selected by a random cluster sampling method. Six kindergartens in urban areas of Beijing were enrolled in this study, and all children in these six kindergartens were invited to participate except those with systemic diseases or handicapping conditions. Children who could not cooperate and finish the examination or whose parents refused to participate were also excluded. The required number of subjects was calculated according to the formula:  $N = t^2PQ/d^2$  ( $t$ : constant term and  $t = 1.96$ ,  $P$ : expective prevalence,  $Q = 1 - P$ ,  $d$ : allowable deviation and  $d = 10\%$ ). The reported prevalence of dental caries amongst 3-year-old children in Beijing is 56.52%<sup>6</sup>. With a 20% margin, it was determined that the study sample should include 380 participants in each layer (males and females; 3-, 4- and 5-year olds); thus, an estimated 2,280 subjects were required. In total, 2,333 participants (1,211 (51.9%) boys and 1,122 (48.1%) girls) were enrolled in the baseline investigation. The study sample comprised 831 (35.7%) 3-year-olds, 757 (32.4%) 4-year-olds and 745 (31.9%) 5-year-olds.

All parents of enrolled children provided written informed consent. The study protocol was approved by the Human Research Ethics Board of Peking University Health Science Center, Beijing (No. IRB00001052-10090).

### *Baseline investigation*

#### Examination of children's oral health

To obtain clinical information, oral health examinations were performed using a plane mirror, a community periodontal index probe and artificial light. Examination included determination of the debris index simplified (DIS), the average decayed, missing, and filled primary teeth (dmft) and the average decayed, missing, and filled primary surfaces (dmfs) index. Before examination, oral cleaning was not required.

Before the baseline investigation, dental professionals who participated in the third National Oral Health Survey of China conducted a training program. Four clinicians from the Department of Preventive Dentistry Peking University School and the Hospital of Stomatology were trained as examiners. Kappa values were calculated for standard assessment of examiner consistency. Each examiner performed repeated examination for at least 10 children and calculated dmft as a Kappa value. Inter-examiner kappa values were 0.79 to 0.91 before the survey; during the survey, each examiner repeated standard assessment by examining 10 children twice, where inter-examiner kappa values ranged from 0.80 to 0.93 and intra-examiner kappa values were 0.81 to 0.97.

#### Oral health questionnaire administration to parents

Questionnaires were distributed to about half of participants' parents for feasibility. Questionnaire investigations underwent the preliminary experiment in about 50 parents before the study and some questions, words and question sequences were revised. The questionnaire included items regarding risk factors related to caries in children that had been reported in the literature, social demographic data, children's dietary and oral hygiene habits, and parents' oral "knowledge, attitudes and practices". According to the accuracy of questions about parents' oral health knowledge and parents' attitudes toward oral healthcare, the awareness rate and the accuracy rate were calculated.

#### Longitudinal investigation

Evaluations similar to the baseline examination were performed at 6, 12 and 18 months after baseline investigation to evaluate the progress of dental caries in the children. In total, 1,094 children (550 [50.3%] males and 544 [49.7%] females) aged 3 to 4 years old at baseline completed the 18-month evaluation. Others failed to complete it because they moved to another kindergarten or went to primary school or they missed the examination.

**Table 1** Caries status by gender and age group.

Group	Dmft		Dmfs		Caries prevalence	SiC	
	Mean	SD	Mean	SD		Mean	SD
Male	2.76	3.59	5.92	8.65	58.96%	6.51	3.47
Female	2.55	3.49	5.41	8.19	53.65%	6.49	3.31
<i>P</i>	0.582 <sup>a</sup>		0.546 <sup>a</sup>		0.006 <sup>b</sup>	0.350 <sup>a</sup>	
3 years	1.75	2.99	3.71	7.12	42.72%	4.94	3.34
4 years	2.70	3.54	5.62	8.14	57.86%	6.79	3.28
5 years	3.65	3.83	7.91	9.46	70.20%	7.77	2.92
<i>P</i>	< 0.001 <sup>c</sup>		< 0.001 <sup>c</sup>		< 0.001 <sup>d</sup>	< 0.001 <sup>c</sup>	
Total	2.66	3.54	5.67	8.43	56.41%	6.50	3.40

<sup>a</sup> Independent t-test,  $P > 0.05$ ; <sup>b</sup> crosstab analysis,  $0.001 < P < 0.01$ ; <sup>c</sup> analysis of variance,  $P < 0.001$ ; <sup>d</sup> crosstab analysis,  $P < 0.001$

**Table 2** Oral hygiene status by gender and age group.

DIS	Total	Gender		Age group		
		Male	Female	3 years	4 years	5 years
Mean	1.35	1.40	1.30	1.41	1.34	1.29
SD	0.56	0.56	0.55	0.56	0.54	0.57
<i>P</i>		< 0.001 <sup>a</sup>		< 0.001 <sup>b</sup>		

<sup>a</sup> Independent t-test,  $P < 0.001$ ; <sup>b</sup> analysis of variance,  $P < 0.001$ .

### Data analysis

The Statistical Product and Service Solutions (SPSS) software (Version 12.0, SPSS, Illinois, USA) was used to analyse the data. Differences in dmft and dmfs indices between genders and amongst age groups were analysed using the independent t-test and one-way analysis of variance. Differences in caries prevalence between genders and amongst age groups were tested using crosstab analysis. Binary forward stepwise logistic regression analysis was used to evaluate the predictive index of dental caries incidence. Sensitivity and specificity were calculated at 18 months for each predictive index and a different combination of predictive index if there were more than one.

## Results

### Results of baseline oral examination

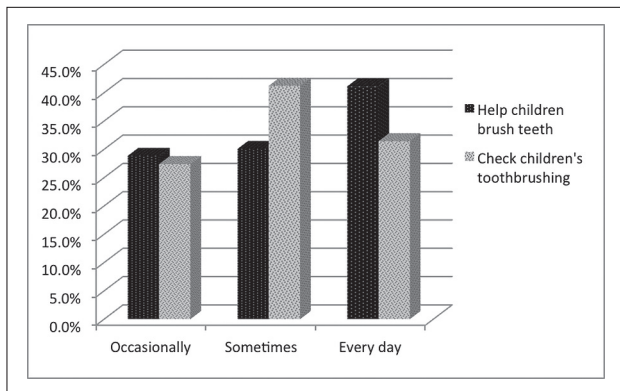
At baseline, the prevalence of caries was 56.4% and the mean dmft and dmfs indices and SiC were 2.66 (stand-

ard deviation [SD] = 3.54), 5.67 (SD = 8.43) and 6.50 (SD = 3.40), respectively. Caries was more prevalent in males (59.0%) than in females (53.7%;  $P = 0.006$ ). No significant difference in mean dmft or dmfs index or SiC was observed between males and females ( $P > 0.05$ ; Table 1). The prevalence of caries in 3-, 4-, and 5-year-olds was 42.7%, 57.9%, and 70.2%, respectively, and mean dmft and dmfs indices and SiC differed significantly amongst age groups ( $P < 0.001$ ; Table 1).

The DIS of all subjects was 1.35 (SD = 0.56), and was significantly higher among males (1.40; SD = 0.56) than among females (1.30; SD = 0.55;  $P < 0.001$ ). The DISs of 3-, 4- and 5-year olds were 1.41 (SD = 0.56), 1.34 (SD = 0.54), and 1.29 (SD = 0.57), respectively, with significant differences observed amongst age groups ( $P < 0.001$ ) (Table 2).

### Results of oral questionnaire investigation at baseline

In total, 1,223 questionnaires were distributed and 945 were collected (response rate: 77.3%). Responses to



**Fig 1** Frequency of parents' help with and checking of children's toothbrushing.

questionnaires administered at baseline showed that 60.5% of children's caretakers were their mothers and 28.4% were their grandparents. In total, 59.3% of the children were mainly breastfed before 4 months old, 19.1% of the children were fed artificially and 21.6% were fed equally by both methods. Of the children, 45.2% did not eat cariogenic food daily and only 8.3% usually drank milk before going to bed. Before the age of 1 years old 19.7% of children began to brush their teeth, and 92.3% began to brush their teeth before the age of 3 years old. Only 41.1% of parents reported helping their children brush their teeth and 31.4% of parents checked the results of children's toothbrushing everyday (Fig 1). During the previous 12 months, children visited the clinician on average 1.60 (SD = 1.42) times. The awareness rate for parents' oral health knowledge was 62.3%, and the accuracy rate for attitudes toward oral healthcare was 82.1%.

#### *Results of oral examination at 18 months*

In total, 601 3-year-olds and 493 4-year-olds completed the 18-month longitudinal investigation. The caries prevalence in these 1,094 children increased from 50.4% at baseline to 64.9% at 18 months (Table 3). The caries incidence was 55.3% and the mean increases in dmft and dmfs indices were 1.62 (SD = 2.09) and 3.93 (SD = 5.29), respectively.

#### *Analysis of the predictive index of caries in primary teeth*

The predictive index of caries in primary teeth was analysed using binary forward stepwise logistic regression with caries incidence serving as the dependent variable and caries status (decayed teeth (dt), filled teeth (ft),

missing teeth (mt) and dmft prevalence), socioeconomic status (gender and age of children; education, occupation and income of parents), eating habits and oral hygiene behaviour serving as independent variables. The results showed that the factors related to the predictive index of caries incidence were "caries experience" (odds ratio [OR] = 4.969,  $P < 0.001$ ), "parents help children brush teeth daily" (OR = 0.851,  $P = 0.046$ ), and "parents consider that caries in primary teeth needs to be treated" (OR = 1.270,  $P = 0.031$ ). The sensitivity and specificity of "caries experience" were 69.4% and 73.2%, respectively, and the positive and negative predictive values of the index were 76.2% and 65.9%, respectively. The sensitivity of a combination of the three predictive indices mentioned above was 88.4% (Table 4).

#### **Discussion**

It has been reported that almost 80% of caries occurs in 20% of children<sup>7,8</sup>. Bratthall<sup>9</sup> introduced the SiC, which is the dmft / dmft of one-third of children with the worst caries. The SiC values of 3-, 4- and 5-year-olds in this study were 4.94, 6.79 and 7.77, respectively, and the mean SiC (6.50) was much higher than the mean dmft index (2.66). Thus, the predictive identification of children at high risk of caries, as a target population, would aid the effective prevention and control of caries and help to maximise the use of dental resources<sup>10</sup>. This longitudinal investigation performed in kindergartens in urban areas of Beijing suggested that better caries prevention and control is needed in kindergartens.

Some studies supported that children's caries experience was a significant factor in judging their present and future caries status<sup>11,12</sup>. New caries appears to develop more readily and current caries tends to progress more quickly in children with caries experience. Some authors have also concluded that "caries experience" is the most important predictive index for future caries incidence<sup>13,14</sup>. In this study, binary forward stepwise logistic regression analysis showed that "caries experience" was one of the most important predictive factors (OR = 4.969,  $P < 0.001$ ). Caries experience may reflect the combined effects of positive and negative factors, and it is a comprehensive index for the prediction of potential caries development. The parents whose children had experience of caries must receive more attention, such as the provision of oral education to parents, implementation of preventative measures and performance of dental treatment to prevent new caries.

Some studies have also reported that children who brush their teeth regularly and daily have less caries, and children with poor toothbrushing habits and oral

**Table 3** Changes in oral health parameters.

Age	Examination	Dmft		Dmfs		Caries prevalence	DIS	
		Mean	SD	Mean	SD		Mean	SD
3 years	Baseline	1.75	2.99	3.71	7.12	42.72%	1.41	0.56
	18 months	3.18	4.07	7.10	10.38	60.73%	1.47	0.72
4 years	Baseline	2.70	3.54	5.62	8.14	57.86%	1.34	0.54
	18 months	3.75	3.85	8.11	9.35	69.98%	1.61	0.78
Total	Baseline	2.25	3.28	4.70	7.64	50.40%	1.35	0.54
	18 months	3.44	3.98	7.55	9.94	64.90%	1.53	0.72

**Table 4** Analysis of the predictive index of primary caries.

	Predictive index of primary caries			
	Past caries experience	Three factors combined		
		Past caries experience	Parents help children brush teeth daily	Parents consider that primary caries needs to be treated
Sensitivity	69.42%	88.42%		
Specificity	73.21%	30.17%		
Sum of sensitivity and specificity	142.63%	118.58%		
Positive predictive value	76.23%	57.54%		
Negative predictive value	65.93%	70.87%		

hygiene have more caries<sup>15,16</sup>. Other researchers found that children whose parents have poor oral hygiene and incorrect oral healthcare attitudes have more caries<sup>11</sup>. The present analysis showed that the best predictive index related to caries incidence included not only “caries experience,” but also “parents help children brush teeth daily” (OR = 0.851,  $P = 0.046$ ), and “parents consider that caries in primary teeth needs to be treated” (OR = 1.270,  $P = 0.031$ ). These results also indicated the value of educating parents in order to improve their children’s oral health. In most of the studies, the most important predictive index is “caries experience”, while in this study “parents help children brush teeth daily” and “parents consider that caries in primary teeth needs to be treated”, as predictive indexes, reflect the fact that parents’ knowledge and attitudes influence children’s oral health. If these three predictive indices were combined together as one index, the sensitivity would be higher than when using “caries experience” alone, which also confirms the role of the other two. The awareness rate and the accuracy rate still need to

be improved as the results showed. Parents must be educated in order to help children brush their teeth daily, so that the children develop good oral hygiene and health. Furthermore, parents need to know more about the impacts of caries in primary teeth and realise the importance of treatment.

As dental caries is a complex disease with multiple factors, the combination of several factors in an index for predicting caries in primary teeth would seem to be reasonable<sup>17</sup>. The sensitivity and specificity of a predictive index are typically used to evaluate the accuracy of a predictive model. ‘Sensitivity’ represents the ratio at which children who will have caries are classified correctly according to the definition used, and ‘specificity’ is the probability of correctly classifying children who will not have caries<sup>18</sup>. In a 1-year longitudinal study of 302 5-year-olds, Demers et al<sup>19</sup> developed a predictive index including only two factors (caries experience and Lactobacillus exposure) that demonstrated 78.3% sensitivity and 77.4% specificity. Grindejord et al<sup>20</sup> reported that the cumulative probability of caries was 79.8%

in the presence of all risk factors studied (presence of Mutans streptococci, immigrant background and consumption of sweets and sugar-containing beverages). The results of this study also showed that the sensitivity and specificity of 'caries experience' were 69.4% and 73.2%, respectively, and the positive and negative predictive values of the index were 76.2% and 65.9%, respectively. The sensitivity of the combined index, which comprised 'caries experience', 'parents help children brush teeth daily' and 'parents consider that caries in primary teeth needs to be treated' was 88.4%.

### Conflicts of interest

The authors reported no conflicts of interest related to this study.

### Author contribution

Dr Sisi Wang and Dr Hui Zhang for the study design, data collection and analysis, and preparing the manuscript; Dr Yan Si and Dr Tao Xu for the direction of the research.

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