Predictors of Dental Caries Development in 1.5-Year-Old High-Risk Children in the Japanese Public Health Service

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Abstract

Objectives: *The purpose of this study was to construct prediction models for 1.5-year-old children who were at risk for the development of caries.* ***Methods:*** *The participants were 5,107 Japanese children who resided in 21 municipalities in the Shizuoka prefecture and received oral health examinations at both 1.5 and 3 years old. General practitioners in the respective municipalities conducted the examination and the evaluation of plaque deposit. At the examination at 1.5 years old, the guardians were asked to complete a questionnaire concerning the child care environment and the health habits of the children and themselves. They were divided into four groups based on the population of the concerned municipality. Approximately 30 percent of the subjects in each group were found to be in the high-risk category ($\Delta dft \geqq 1$ during both examinations). A stepwise multivariate logistic regression analysis in each group was performed using high-risk subjects as the dependent variable and 28 independent variables from the examination at 1.5 years old and the questionnaire.* ***Results:*** *A significant model could be constructed for each group using eight to 14 independent variables, respectively. The variables common to more than three groups are related to the child's characteristics, especially sugar consumption, feeding, and caries experiences. The predictive ability of the models had a sensitivity of 58.0 to 64.0 percent and a specificity of 64.1 to 70.5 percent. Because the negative predictive value was 77.4 to 80.5 percent, these models might be considered to be in the permissible range.* ***Conclusions:*** *The models could not predict caries risk but may be able to predict those cases who will not develop caries.*

Key Words: caries predictor of deciduous teeth, 1.5-year-old children, follow-up study, public health dentistry

Introduction

In Japan, oral health examinations for both 1.5- and 3-year-old children are implemented by the governments of municipalities under the law of child and maternal health and welfare. At the examinations, the children and their guardians also receive dental health education. Recently, along with a decreasing trend in the occurrence of dental caries in deciduous teeth, the distribution of individuals according to the number of carious lesions is becoming increasingly skewed among children. In such a situation, the appropriateness of targeting costly caries preventive measures to whole populations of children has been questioned, and it has been proposed that protection against caries be concentrated instead on those at a high risk. It would be useful to be able to determine a child's risk of developing caries and thus apply appropriate preventive measures. Takatoku and colleagues (1) reported in a prospective study of 1.5-year-olds that an intensified preventive program targeting high-risk children decreased the rate of caries increment to the same level as that of children with an anticipated low risk. Because the health behavior of young children might depend on the philosophies of their parents, it seemed that all children may not be able to receive basic prevention equally. Therefore, it becomes necessary for professionals and governments to efficiently distinguish those children at risk and support them.

Some reports (2, 3) studying the prediction of children at risk for dental caries exist, and caries activity test related to a bacteriological criterion, e.g., the level of salivary mutans streptococci, was used. The test seems to be unsuitable for young children or for a public health program as it is difficult to collect a saliva sample from a young child. Even if a saliva sample can be collected, the low salivary levels of mutans found in children are not likely to indicate the lack of caries risk (4). A screening examination such as the health checkup at 1.5 years old to distinguish children at risk followed immediately by caries preventive measures might be a worthwhile public health service. With this in mind, the salivary test would not be appropriate. Grindefjord and colleagues (5) and Mohan and colleagues (6) reported that the presence of mutans streptococci in children was correlated with the consumption of sugar-containing beverages. Besides, Powell (3) indicated after reviewing recent multifactorial

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prediction models for adults and children that clinical variables, especially past caries experience, are confirmed as the most significant predictors. In addition, it has been reported that caries prevalence in primary teeth was different among areas (7, 8), and lower caries prevalence had a close relationship to the urbanization of the community. Information related to caries predictors of primary teeth from previous reports (9, 10) was also available.

The purpose of this study was to construct a prediction model, consisting of predictors obtained from a questionnaire and clinical findings at the dental checkup, for 1.5-year-old children at risk in respective areas grouped according to the population size of the municipalities.

Methods

Participants. The oral health examination at both 1.5 and 3 years old has been administered by all municipal governments in Japan based on the law of child and maternal health and welfare. In this study, in areas consisting of the 21 municipalities in the Shizuoka prefecture, there were 6,738 children who received the examinations at the age of 1.5 years between November 1997 and October 1998. In the respective municipalities, the rate of children having the examinations ranged from 84 to 100 percent (average 93 percent). These municipalities were selected because there were no caries preventive programs for deciduous teeth as a dental health policy, and because the fluoride concentration of the drinking water in those areas was less than 0.1 ppm.

The children analyzed in this study were selected based on three criteria: a) the children had an examination at 3 years old; b) the questionnaire was filled completed by their parents; and c) the children had the information about the deposition of plaque on the labial surfaces of their upper incisors observed at the examination at 1.5 years old. Based on these three criteria, 5,107 children were selected.

During the analysis the children were divided into four groups as follows: the group of N-city, F-city, and Y-city (urban areas ranging from middle- to small-scale), with the fourth group of the remaining municipalities being designated as a rural area. The annual number of births was 2,200, 1,200, 1,100, and from 7 to 700, respectively.

Examination Procedures. The children were ordinarily screened for dental caries at the examinations at both 1.5 and 3 years old, and they were evaluated for plaque deposited on the labial surfaces of the upper incisor teeth at the first examination. General practitioners in the respective municipalities conducted the oral health examination. Before the beginning of this study, all practitioners who took part in the examination attended lectures in order to familiarize themselves with the diagnostic criteria of dental caries and plaque deposition. All lectures were given by a dentist using a document and visuals describing the criteria and illustrating the incipient caries condition. The criteria were based on those published by the World Health Organization (11) and distinguished demineralization from actual dental caries. The plaque deposit was assessed according to what was visible to the naked eye.

Questionnaire. The mothers or fathers of the children were asked to fill in a questionnaire containing 21 items at the examination at 1.5 years of age. The questionnaire was sent to parents with an explanation of the objective of this investigation before the examination. The parents who consented to participate in the investigation filled in the questionnaire and submitted it at the examination. The items and categories concerning the child care environment and oral health habits of children were derived from literature (9, 10), and indicated in Table 1.

Statistical Methods. Logistic regression analysis was used to estimate the difference in the logarithmic risk of being a caries-active child. The construction of the logistic models for the four groups was carried out as follows. The high-risk subjects were considered as the dependent variable in the statistical analysis. High-risk subjects were defined as children who had an increment of more than one carious tooth from the age of 1.5 to 3 years.

The 28 available independent variables consisted of 21 variables from the questionnaire and seven variables in the oral examination at 1.5 years. First, they were examined with regard to the significance in relation to the dependent variable using logistic regression analysis, the *t*-test, and the Mann–Whitney *U* test. Then, a stepwise multivariate logistic regression analysis was carried out using independent variables that achieved significance at $P < 0.1$ from the said analysis. Moreover, the odds ratios of the independent variables adopted in this analysis were considered to be significant at $P < 0.1$. The discriminative function of the children at high risk was developed using a logistic regression model composed of these independent variables in each group. The predictive ability of the discriminative function was calculated. All analyses were conducted using the STATA 6.0 (Stata Corp., College Station, TX) statistical package.

Results

Ultimately, 5,107 children, representing 76 percent (71 to 83 percent in each group) of the children screened at the examination at 1.5 years were analyzed. The children had 2.40 (±1.17) to 3.01 (±1.24) mean increased dft (±standard deviation) between the ages of 1.5 and 3 years according to the group. The proportion of the children who had more than one carious tooth during the periods, i.e., who were in the high-risk category based on our definition, ranged from 29.0 to 35.0 percent (Table 2).

A significant logistic regression model ($P < 0.001$) could be constructed for each group. Table 3 shows the independent variables entered in the logistic model with regressive coefficients and odds ratios for each group. Eight to 14 independent variables were found to

Table 1
Independent Variables Studied in 1.5-Year-Old Children

Independent variable	Category
From the clinical examination	
Number of erupted teeth	
Number of decayed teeth	
Number of filled teeth	
Number of decayed and filled teeth	
Number of teeth with demineralized surfaces	
Classification based on the position of tooth decayed or filled, which was suggested by the Ministry of Health and Welfare in Japan.	0, caries free; 1, "upper anterior teeth" or "upper and lower posterior teeth"; 2, both "upper anterior teeth" and "upper and lower posterior teeth"; 3, lower anterior teeth are contained
Plaque on upper incisors	Whether plaque is visible or not
From the questionnaire	
Questions about the health environment of children	
Gender	Boy, girl
Order of birth	First, second, third, and over
Father's occupation	(Farmer, fisherman, forestry technician), (Self-employed), (Salesman), (Skilled occupation), (Office worker, engineer, teacher, pharmacist, etc.)
Family structure	With grandparents, nuclear family
Guardians at daytime	Mother, grandmother, babysitter, nursery school
Do you make an effort to prevent dental caries for your child?	Much, slight, hardly at all
Do you brush your child's teeth everyday?	Yes, no
Do you use toothpaste in brushing your child's teeth?	Everyday, sometimes, no use
Is your child still nursed on his/her mother's milk?	Yes, no
Does your child still drink milk using a nursing bottle?	Yes, no
How many times a day does your child drink sugar-containing beverages?	Seldom, once, twice, more than three times
How many times a day does your child drink canned fruit juice?	Seldom, once, twice, more than three times
How many times a day does your child have snacks?	Seldom, once, twice, more than three times
How many times a day does your child have sweets?	Seldom, once, twice, more than three times
Questions about the behavior of parents	
What is your favorite TV program?	Whether the answer of news program is chosen or not
Please choose two among seven selective answers containing news, drama, music, variety show, etc.	
Do you know how much caries preventive effect is there in fluoride application and use of fluoride toothpaste?	Yes, no
Does the toothpaste used in your family contain fluoride?	Yes, no, unknown, not using toothpaste
Do you use dental floss or interproximal brushes?	Using (everyday, sometime, previously), not using, unknown
How many times a day do you have snacks?	Seldom, once, twice, more than three times
Do you have decayed teeth necessary to treat?	Yes/under treatment, no, unknown
How many times can you take your child to a dental clinic for dental caries prevention?	Once a year, twice a year, four times a year, six times a year, once a month

be significant ($P < 0.1$) in each stepwise logistic regression analysis. These variables are shown in descending order based on the number of the group. Two independent variables – frequency of drinking sugar-containing beverages and frequency of having sweets among the children – were selected by all four groups. Six common variables – prolonged breastfeeding, bottle-feeding, caries experience, demineralized teeth, dental treatment needs of mother, and order of birth – were selected by three groups. Prolonged breastfeeding and bottle-feeding up to 1.5 years were related to caries development. Children whose mother needed dental treatment would be at higher risk. Firstborn children tended to be at a lower risk and children born third or later were at a higher risk. Two variables (family structure and guardians in daytime) were included in two groups (other municipalities and N-city) and indicated that children living with grandparents and/or cared for by grandparents as a substitute for their mother who worked in the daytime would be at a higher risk. Tooth-brushing by parents was not selected in any of the four groups. However, the variable of the use of fluoride toothpaste was significant in two groups. Especially, using fluoride

Table 2
Number (%) of Children with Increased Carious Teeth and Mean Increased Carious Teeth from 1.5 to 3 Years Old According to Group Based on Municipality

Group	Number of children	Number of carious teeth at 1.5 years old		Number of carious teeth at 3 years old		Children with increased carious teeth		Number of increased carious teeth	
		Mean	SD	Mean	SD	Number	%	Mean	SD
N-city	1,403	0.06	0.49	1.35	2.99	407	29.01	1.30	2.88
F-city	913	0.12	0.74	1.29	2.58	289	31.65	1.17	2.40
Y-city	714	0.05	0.41	1.29	3.08	207	28.99	1.24	3.01
Other municipalities	2,077	0.10	0.67	1.49	2.88	727	35.00	1.39	2.78

SD, standard deviation.

toothpaste everyday had an influence on decreasing the risk of future caries development in Y-city. The variable of plaque deposition was selected in only one group (F-city). On the whole, more variables based on the characteristics of children met the criterion as predictors than those of the parents/mother.

The predictive ability of each logistic model showed a sensitivity of 58.0 to 64.0 percent, and a specificity of 64.1 to 70.5 percent. The negative predictive value was relatively high at 77 to 80 percent (Table 4).

Discussion

These models were not able to identify high caries-risk susceptible children with a sufficient degree of accuracy. However, the negative predictive value was relatively high at 77 to 80 percent. Because the negative predictive value would help find the group of children who did not require a special caries prevention program, these models might be considered to be in a permissible range.

We used information from a questionnaire completed by parents in order to search the predictors. We framed the questions and answers to force a definite choice by parents. But because they might answer the question based on their subjective judgment, their actual circumstances might be different among individuals even with the same response. It was difficult to collect objective information from a questionnaire filled in by parents. Family income and the years of schooling for parents have been used as predictors in some reports (3, 5, 12) from western countries. However, in Japan we tend to refrain from asking these questions. We thus asked about the occupation of the father in a roundabout way.

The independent variables selected in more than three groups were related to the frequent intake of sweets, prolonged breastfeeding, bottlefeeding, caries experience (dft), and the number of teeth with demineralized surface. These were representative predictors of children at a high risk (12–15). Grindefjord and colleagues (12) and Paunio and colleagues (13) reported the consumption of sugar-containing beverages at 1 year old and at night at the age of 18 months as predictors, respectively. Alaluusua and Malmivirta (15) classified children using a nursing bottle at 1 year old as having a caries risk. Therefore, the consumption of sweet beverages and sweets, prolonged breastfeeding, and bottlefeeding up to 1.5 years played a part in the prediction. Powell (3) indicated that past caries experience was the most significant predictor. Other previous reports (9, 16) have indicated that children with early caries development exhibit a higher risk for further development of new carious lesions.

We also identified that these variables related to past caries experience were indispensable to predict the young children at high risk. The other predictors were the dental treatment needs of the mother and the order of birth. Caries experience of the mother (decayed, missing, and filled teeth), a possible indicator of treatment needs of the mother, was also selected as a predictor in a previous report (9). It was shown that the mother was the primary source of infection of mutans streptococci (17, 18). Also, the mother's dietary habits and tastes probably affect those of her child (5). Birth order was also selected in previous studies (9, 10) and indicated a similar tendency. Sociodemographic variables have been considered to be important in caries prediction models for young children (3). Family structure was selected in the groups that had the highest (25 percent) or the lowest (13.9 percent) proportion of households with grandparents among the four groups in our study. The group with the highest proportion selected variable of guardians too. It was generally considered that grandparents bring up children indulgently, give them more sweets regularly, thus causing their grandchild to be at a higher risk.

Plaque deposit, gender, father's occupation, mother's favorite TV program, knowledge of fluoride use, use of fluoride toothpaste by parents, and use of an interproximal brushing instrument were significant in the model of only one group. Visible plaque was reported as the best risk indicator by Alauusua and Malmivirta

Table 3
Stepwise Logistic Regression Analysis for Children with an Increment of More Than One Carious Tooth from the Age of 1.5 to 3 Years as a Dependent Variable According to Area of Residence

	N-city			F-city			Y-city			Other municipalities		
	β coefficient	OR	95% CI	β coefficient	OR	95% CI	β coefficient	OR	95% CI	β coefficient	OR	95% CI
Constant (β_0)	−2.59			−2.73			−2.81			−3.28		
Category of independent variables												
Frequencies of sugar-containing beverages/day	0.34	1.4¶	1.2–1.7	0.39	1.5¶	1.3–1.7	0.19	1.2†	1.0–1.4	0.28	1.3¶	1.2–1.5
Frequencies of sweets/day	0.31	1.4¶	1.2–1.5	0.33	1.4‡	1.1–1.7	0.50	1.6¶	1.3–2.1	0.37	1.5¶	1.3–1.7
Prolonged breastfeeding	0.64	1.9‡	1.2–3.0	0.73	2.1†	1.2–3.7				0.79	2.2¶	1.6–3.1
Prolonged bottlefeeding	0.42	1.5‡	1.1–2.1				0.56	1.8†	1.1–2.8	0.53	1.7¶	1.3–2.2
Number of dft	0.68	2.0‡	1.3–2.9				0.67	1.9*	1.1–3.5	0.17	1.2†	1.0–1.4
Number of demineralized teeth	0.37	1.4¶	1.2–1.7	0.48	1.6¶	1.3–2.0				0.31	1.4¶	1.2–1.6
Mother with carious teeth or under treatment				0.42	1.5‡	1.1–2.1	0.54	1.7‡	1.2–2.4	0.25	1.3†	1.1–1.6
Order of birth												
First							−0.29	0.7*	0.5–1.1	-0.32	0.7‡	0.6–0.9
Third and over	0.35	1.4†	1.0–2.0									
Family with grandparents	0.34	1.4‡	1.1–1.8							0.28	1.3‡	1.1–1.6
Guardians at daytime												
Grandmother										0.62	1.9¶	1.4–2.5
Nursery school							−0.48	0.6*	0.3–1.2			
Consumption of canned fruit juice/day				0.15	1.2*	1.0–1.4				0.14	1.1†	1.0–1.3
Use of toothpaste in brushing the child's teeth												
Everyday							−1.05	0.4†	0.2–0.8			
Sometimes										0.48	1.6†	1.2–2.2
Plaque: not visible				−0.37	0.7†	0.5–0.9						
Boy	0.23	1.3*	1.0–1.6									
Father's occupation: office worker, etc.				−0.37	0.7†	0.5–0.9						
No choice of news program										0.49	1.6¶	1.3–1.9
Knowledge of the effectiveness of fluoride use	−0.35	0.7†	0.5–1.0									
No use of fluoride toothpaste by parents										0.62	1.9†	1.1–3.1
Use of an interproximal instrument				−0.84	0.4	0.2–1.1						

* $P < 0.1$.
† $P < 0.05$.
‡ $P < 0.01$.
¶ $P < 0.001$.
OR, odds ratio; CI, confidence intervals; dft, decayed and filled deciduous teeth.

Table 4
Predictive Ability of the Discriminative Functions

	Group			
	N-city	F-city	Y-city	Other municipalities
Cutoff	0.29	0.32	0.29	0.35
Sensitivity	58.0	64.0	61.4	63.4
Specificity	70.5	68.9	64.1	67.5
Positive predictive value	44.5	48.8	41.1	51.2
Negative predictive value	80.4	80.5	80.3	77.4

(15). In our study, plaque deposit did not distinguish the children at risk in the three groups. Equally, the variables of knowledge of fluoride use, use of fluoride toothpaste, and use of an interproximal instrument showed one-sided distribution of subjects. If most people answered the same elective item in the question, the question could not exercise ability as a predictor.

The exceptional instance was use of fluoride toothpaste. While more than 80 percent of the parents brushed their child's teeth every day, less than 8 percent of parents used fluoride toothpaste for the toothbrushing. In this case the variable was selected as a predictor. The early use of fluoride toothpaste indicated effective prevention of caries development.

On the whole, the sociodemographic variables as constructed were not as valuable as predictors as the characteristics of children were. The lack of contribution of the socioeconomic variables to the models may be because of the construction of the variables, suggesting that these variables were limited by lack of validity and reliability.

In conclusion, these models could predict the children with lack of caries. Because the public health service is implemented with limited funds, it might be useful if these models were used to develop operational programs that might be tested to determine if it would help conserve funds by not supplying services to children who do not need them.

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