Caries risk assessment programmes for Hong Kong children

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KEY MESSAGES

1. Several caries risk factors/indicators were identified and serve as important references for targeted education and intervention in Hong Kong children.
2. A caries risk assessment programme outperformed other programmes and is epidemiologically and clinically useful for identifying caries-susceptible children.
3. The findings of this study will contribute to cost-effective caries prevention/intervention and optimised treatment planning.

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Introduction

The prevalence of dental caries (tooth decay) in early childhood is high. Early childhood caries (ECC) is associated with caries in permanent dentition and lethal systemic infections. In many developed countries, 25% of children bear 75-80% of caries lesions. Caries prevention should be targeted at high-risk individuals. Identifying high-risk pre-schoolers through caries risk assessment (CRA) is of great importance for caries control and cost control. The CRA should also be an integral part of diagnosis and treatment planning to optimise clinical outcomes.

Several CRA programmes have been developed for pre-schoolers, including the Caries-risk Assessment Tool (CAT),[1] the Caries Management by Risk Assessment (CAMBRA),[2] the Cariogram,[3] and the NUS-CRA biopsychosocial models.[4] This study aimed to compare the accuracy of various CRA programmes in predicting the caries risk among Hong Kong pre-schoolers.

Methods

This study was conducted from October 2009 to March 2012. Ethical approval was obtained from the Institutional Review Board of the University of Hong Kong / Hospital Authority Hong Kong West Cluster (#UW 08-400). Parental written consent was obtained for all grade-1 participants (3 years of age) from four kindergartens.

At baseline, each child and his/her parent/guardian were required to complete a questionnaire, an oral examination, and a biological test. The questionnaire was completed by the child's parents to collect information about the child's socio-demographic background, oral health behaviour (diet, oral hygiene habits, use of topical fluorides, and utilisation of dental services), and systemic condition, as well as parental knowledge of and attitude toward oral health. The oral examination was performed by a trained and calibrated examiner. Examination was repeated in 10% of subjects to assess intra-examiner reliability. The tooth status was mainly assessed by visual inspection, aided by tactile inspection if necessary. No radiographs were taken. The World Health Organization diagnostic criteria and procedures were followed and caries was recorded at the cavitation level. White-spot lesions—a risk indicator in the CAT and CAMBRA programmes—were also recorded. Oral hygiene status was evaluated using the Silness-Löe Plaque Index. Any developmental defect (eg hypoplasia) or dental appliance was recorded. The biological test assessed the stimulated saliva flow rate, buffering capacity, and levels of *mutan Streptococci* and *Lactobacilus*. Standard laboratory procedures were followed for the incubation of bacteria, acquirement of readings, and disposal of biological waste.

Children's caries risk was assessed using the various CRA programmes (CAT, CAMBRA, Cariogram, and NUS-CRA). For the CAT and CAMBRA, children were classified into 3 risk groups based on risk factors/indicators. For the Cariogram and NUS-CRA, caries risk was calculated using algorithms and expressed as % chance of caries in 1 year. In addition, both comprehensive and screening programmes were used, with and without biological tests. Rating criteria stipulated in the user instructions of each programme were followed.

The tooth status of each child was reviewed after 6, 12, and 18 months. The change in number

of decayed, missing, or filled teeth (Δdmft) was calculated as the disease outcome. The information on dental care received by the child during the follow-up period was also collected. When Δdmft was ≥0, risk factors/indicators were identified through multiple logistic regression. The performance of the CRA programmes was compared using receiver operating characteristics (ROC) analysis, by comparing the predicted risk with the short-term (6-month), medium-term (12-month) and long-term (18-month) caries incidence (Δdmft ≥0) [dichotomous]. The performance measures included sensitivity, specificity, accuracy, positive and negative predictive values, and area under ROC curve (AUC).

Results

Of 585 eligible children, 560 participated (response rate, 96%). At baseline, 544 participants (282 boys and 262 girls) were examined. After 6, 12, and 18 months, 508 (93%), 485 (89%), and 462 (85%) of participants were followed up. The intra-examiner reliability was high (Kappa=0.964). Those who completed the study and those who were lost to follow-up were comparable in terms of socio-demographic background and baseline caries experience, except that more girls than boys did not complete the study (P<0.05).

Within 12 months, 178 (36.7%) children developed new caries (Δdmft >0). The mean±standard deviation increment in dmft was 0.78±1.36. Several caries risk factors were identified, including father's education level, prolonged breastfeeding, bedtime feeding, sweet intake, toothbrushing frequency, residential history in a non-fluoridated community, plaque amount, past caries, and levels of *mutan Streptococci* and *Lactobacilus* (P<0.05).

Table 1 shows the caries increment among children classified in different risk groups by different study programmes. In the CAT and CAMBRA, most children were defined as high risk; only a small proportion was defined as moderate risk. Under the CAT, no participant was rated as low risk. In contrast, under the Cariogram and NUS-CRA, most children were defined as very low or low risk. Overall, there was a gradient in caries increment from lower to higher risk groups under all programmes. Nevertheless, no significant difference in caries increment was noted between some of the risk groups.

Table 2 shows the positive and negative predictive values of the CRA programmes. For CAMBRA, both possible cut-off points (≥moderate risk and ≥high risk) were explored. With CAT, no child was considered as low risk, and thus ≥moderate risk was no more a valid cut-off point, and only the ≥high risk cut-off point was used. For Cariogram and NUS-CRA, the best cut-off points identified by the ROC analysis were selected. Based on these cut-off points, children were classified by each programme as susceptible or non-susceptible.

Across all programmes, susceptible children had significantly higher mean caries increment and % with new caries than non-susceptible children. For CAMBRA, compared with ≥moderate risk, ≥high risk had a higher sum of sensitivity and specificity (138% vs 118%). Both CAT and CAMBRA had extremely high sensitivity (99% and 94%) but low specificity (5% and 44%) in predicting ECC. Cariogram and NUS-CRA had a better balance between sensitivity and specificity. Compared with Cariogram, both versions of NUS-CRA models had a higher validity in predicted caries. Among all models, only the NUS-CRA comprehensive model reached a sum of sensitivity and specificity above 160%,[5] compared with 158% for the NUS-CRA screening model.

The performance of the programmes that generate continuous risk outcome (ie Cariogram and NUS-CRA) was also compared using ROC curves (Fig). Both the screening and comprehensive versions of NUS-CRA generated better prediction (higher AUC) than their Cariogram counterparts.

All models predicted mid-term (ie 12 months) caries increment better than short-term (6-month) and long-term (18-month) caries increment.

Discussion

The CAT and CAMBRA had an extremely high sensitivity but low specificity; almost all children with new caries were defined as high risk, but many children without new caries were also defined as high risk (ie a high false positive rate). Such overestimation may have stemmed from some of the classification criteria, of which some single factors/indicators alone were sufficient to justify a high-risk diagnosis. With high sensitivity, CAT and CAMBRA may be useful when failure to identify and treat any high-risk child is absolutely unacceptable and is the only concern. Nonetheless, the low specificity (overestimation of risk) leads to overtreatment and a waste of resources.

The Cariogram and NUS-CRA were superior in predicting ECC. The Cariogram is intended to assess risk at all age groups. A single programme applicable to all age groups would be convenient to clinicians. Nonetheless, the Cariogram has a high performance in adolescents and elders but a relatively unsatisfactory performance in children. It may be reasonable to incorporate some age-specific factors (eg milk bottle use) into Cariogram and recalibrate the built-in algorisms for young children. The NUS-CRA had a highly stable sensitivity and specificity in our sample and in Singaporean children,[4] supporting its use in Asian populations.

A periodical review of children's caries risk is recommended. Nevertheless, it remains unclear how

TABLE 1. Caries increment among children in different risk groups defined by each caries risk assessment programme (republished with permission of Elsevier, from Gao X, Di Wu I, Lo EC, Chu CH, Hsu CY, Wong MC. Validity of caries risk assessment programmes in preschool children. J Dent 2013;41:787-95.)

Caries risk assessment programme	No. of children	Mean±SD caries increment (change in No. of decayed, missing, or filled teeth [Δdmft])*	% with new caries (Δdmft >0)*	Relative risk (95% CI) for new caries*
Caries-risk Assessment Tool (CAT) [screening]				
Low risk	0	-	-	-
Moderate risk	18	0.17±0.51	11.1	1 (reference)
High risk	467	0.80±1.37	37.7	2.01 (1.06–2.52)
CAT (screening) excluding socioeconomic risk factors				
Low risk	0	-	-	-
Moderate risk	20	0.20±0.52	15.0	1 (reference)
High risk	465	0.80±1.38	37.6	1.81 (0.99–2.38)
CAT (comprehensive)				
Low risk	0	-	-	-
Moderate risk	11	0±0	0	-
High risk	474	0.79±1.37	37.6	-
CAT (comprehensive) excluding socioeconomic risk factors				
Low risk	0	-	-	-
Moderate risk	13	0.08±0.28	7.7	1 (reference)
High risk	472	0.79±1.31	37.5	2.20 (0.95-2.64)
Caries Management by Risk Assessment (CAMBRA) [screening]				
Low risk	68	0.10±0.39	7.4	1 (reference)
Moderate risk	77	0.13±0.50	7.8	1.04 (0.42-1.85)
High risk	340	1.06±1.51	49.1	2.39 (2.00-2.58)
CAMBRA (comprehensive)				
Low risk	137	0.20±0.76	10.9	1 (reference)
Moderate risk	85	0.27±0.68	16.5	1.31 (0.81-1.83)
High risk	263	1.24±1.58	56.7	2.34 (2.11-2.50)
Cariogram (screening)				
Very low risk	222	0.34±0.90	18.0	1 (reference)
Low risk	100	0.72±1.22	35.0	1.60 (1.24-1.93)
Moderate risk	112	1.02±1.31	53.6	2.05 (1.76-2.27)
High risk	44	2.07±1.63	86.4	2.57 (2.37-2.66)
Very high risk	7	3.43±3.82	71.4	2.37 (1.51-2.65)
Cariogram (comprehensive)				
Very low risk	268	0.34±0.88	18.7	1 (reference)
Low risk	109	0.77±1.21	42.2	1.77 (1.45-2.05)
Moderate risk	52	1.56±1.63	67.3	2.29 (1.99-2.48)
High risk	47	2.02±1.71	83.0	2.52 (2.30-2.63)
Very high risk	9	2.67±2.96	88.9	2.60 (1.94-2.71)
NUS-CRA (screening)				
Very low risk	249	0.25±0.77	12.4	1 (reference)
Low risk	68	0.56±1.04	32.4	1.80 (1.39-2.14)
Moderate risk	54	1.48±1.73	66.7	2.43 (2.19-2.57)
High risk	97	1.56±1.39	75.3	2.52 (2.38-2.61)
Very high risk	17	2.71±2.52	94.1	2.68 (2.43-2.72)
NUS-CRA (comprehensive)				
Very low risk	265	0.17±0.69	8.7	1 (reference)
Low risk	79	0.85±1.11	49.4	2.33 (2.08-2.50)
Moderate risk	42	1.26±1.38	66.7	2.52 (2.31-2.63)
High risk	49	2.10±1.63	83.7	2.64 (2.53-2.69)
Very high risk	50	2.18±1.87	94.0	2.70 (2.63-2.72)
All subjects	**485**	**0.78±1.36**	**36.7**	

* There is significant difference between risk groups with different ranks. The Chi-square test is used to compare proportions. The Fisher's exact test is used when the count in any cell of a 2x2 table is <5. The Tukey post-hoc test or independent *t*-test (as appropriate) is used to compare means when the distribution and homogeneity of variance is normal; otherwise, the Mann–Whitney *U* test or Kruskal–Wallis test (as appropriate) is used. Odds ratios and their confidence intervals are generated from logistic regression and converted to relative risk.

TABLE 2. Validity of caries risk assessment programmes in predicting caries (republished with permission of Elsevier, from Gao X, Di Wu I, Lo EC, Chu CH, Hsu CY, Wong MC. Validity of caries risk assessment programmes in preschool children. J Dent 2013;41:787-95.)

Cut-off point of predicted risk	No. of children	Mean±SD caries increment (change in No. of decayed, missing, or filled teeth [Δdmft])*	% with new caries (Δdmft >0)*	Relative risk (95% CI) for new caries (Δdmft >0)*	Sensitivity (%)	Specificity (%)	Sensitivity+ specificity (%)	Accuracy (%)
Caries-risk Assessment Tool (CAT) [screening]								
≥High								
Non-susceptible	18	0.17±0.51	11.1	1 (reference)	98.9	5.2	104	39.6
Susceptible	467	0.80±1.37	37.7	2.01 (1.06–2.52)				
CAT (screening) excluding socioeconomic risk factors								
≥High								
Non-susceptible	20	0.20±0.52	15.0	1 (reference)	98.3	5.5	104	39.6
Susceptible	465	0.80±1.38	37.6	1.81 (0.99–2.38)				
CAT (comprehensive)								
≥High								
Non-susceptible	11	0±0	0	-	100	3.6	104	39.0
Susceptible	474	0.79±1.37	37.6					
CAT (comprehensive) excluding socioeconomic risk factors								
≥High								
Non-susceptible	13	0.08±0.28	7.7	1 (reference)	99.4	3.9	103	38.9
Susceptible	472	0.79±1.31	37.5	2.20 (0.95–2.64)				
Caries Management by Risk Assessment (CAMBRA) [screening]								
≥Moderate								
Non-susceptible	68	0.10±0.39	7.4	1 (reference)	97.2	20.5	118	48.6
Susceptible	417	0.89±1.42	41.5	2.28 (1.83–2.53)				
≥High								
Non-susceptible	145	0.12±0.45	7.6	1 (reference)	93.8	43.6	138	62.0
Susceptible	340	1.06±1.51	49.1	2.38 (2.13–2.53)				
CAMBRA (comprehensive)								
≥Moderate								
Non-susceptible	137	0.20±0.76	10.9	1 (reference)	91.6	39.7	131	58.7
Susceptible	348	1.00±1.47	46.8	2.20 (1.91–2.40)				
≥High								
Non-susceptible	222	0.23±0.73	13.1	1 (reference)	83.7	62.9	147	70.5
Susceptible	263	1.24±1.58	56.7	2.27 (2.07–2.42)				
Cariogram (screening)								
≥38.5% chance of caries								
Non-susceptible	305	0.40±0.95	21.6	1 (reference)	62.9	77.9	141	72.4
Susceptible	180	1.41±1.67	62.2	2.16 (1.94–2.32)				
Cariogram (comprehensive)								
≥37.6% chance of caries								
Non-susceptible	304	0.41±1.01	20.7	1 (reference)	64.6	78.5	143	73.4
Susceptible	181	1.38±1.62	63.5	2.17 (1.95–2.35)				
NUS-CRA (screening)								
≥32.8% chance of caries								
Non-susceptible	307	0.28±0.79	15.3	1 (reference)	73.6	84.7	158	80.6
Susceptible	178	1.64±1.67	73.6	2.45 (2.32–2.54)				
NUS-CRA (comprehensive)								
≥35.2% chance of caries								
Non-susceptible	301	0.28±0.89	13.0	1 (reference)	78.1	85.3	163	82.7
Susceptible	184	1.59±1.58	75.5	2.47 (2.35–2.56)				

* Significantly different between susceptible and non-susceptible children. The Chi-square test is used to compare proportions. The Fisher's exact test is used when the count in any cell of a 2x2 table is <5. The independent *t*-test is used to compare means when the distribution and homogeneity of variance is normal; otherwise, the Mann–Whitney *U* test is used. Odds ratio and its confidence intervals are generated from logistic regression and converted to relative risk

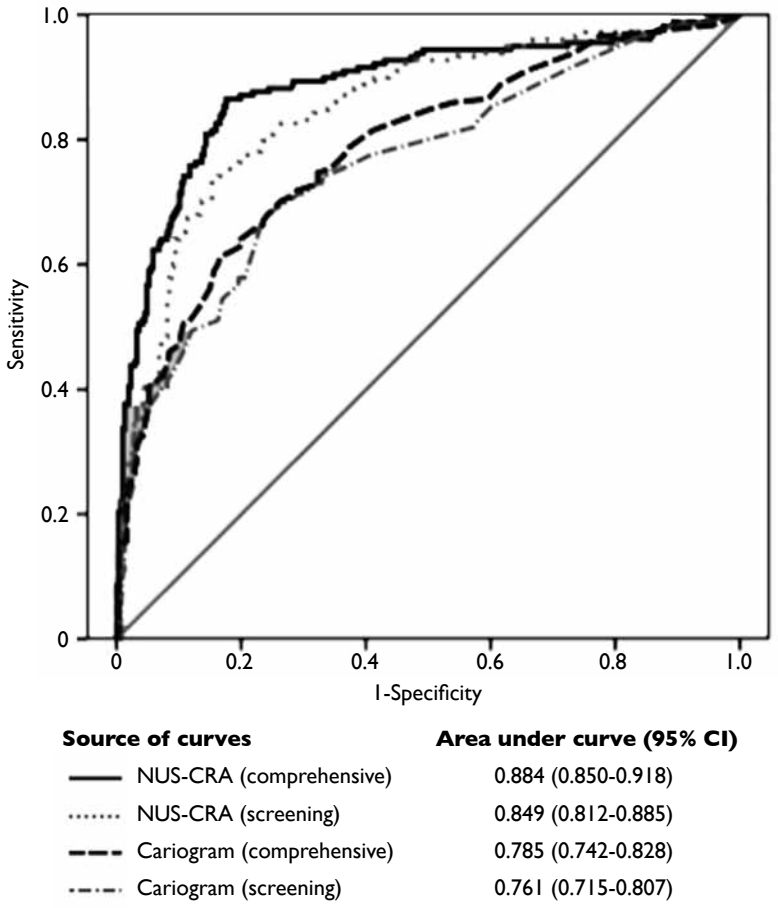

FIG. Receiver operating characteristic curves for programmes with continuous outcomes (republished with permission of Elsevier, from Gao X, Di Wu I, Lo EC, Chu CH, Hsu CY, Wong MC. Validity of caries risk assessment programmes in preschool children. J Dent 2013;41:787-95.)

frequent such review should occur. Across all CRA programmes, the prediction for 12-month caries increment was more accurate than for 6-month and 18-month outcomes. As caries is a chronic disease, a 6-month follow-up may be inadequate for the results of interaction of various factors to be manifested in the form of cavitation. In addition, young children are in the process of changing and establishing their habits, change in their risk profile over an 18-month period may be dramatic. Our findings support the timeframe adopted by Cariogram and NUS-CRA (ie prediction of risk in the coming year) and a periodical risk review on a 12-month basis. These findings will contribute to cost-effective caries prevention/intervention and optimised treatment planning.

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