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Feasibility of plaque disclosing gel identification for caries-risk Thai schoolchildren

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Objective: To evaluate the usefulness of plaque disclosing gel for predicting caries risk in schoolchildren.
Material and methods: Clinical examination of children was conducted to assess dental caries experience and stimulated salivary was collected to assess salivary flow rate and buffer capacity. Plaque disclosing gel was applied onto the tooth surfaces to identify the plaque type by observing the gel color. Information on dietary and oral hygiene habits was obtained via questionnaire-guided interviews. The data were analyzed by descriptive statistics, Chi-square test and multiple logistic regression analysis.
Results: A total of 125 9- to 16-year-old from 6 schools in Bangkok were recruited into the study. Caries prevalence for the whole group was 60.0%. Children with caries had a significantly lower salivary flow rate and higher levels of strong acid producing plaque compared with caries-free children. Caries risk was increased in the presence of strong acid producing plaque with a sensitivity/specificity of 78.4%/44%. The Hosmer-Lemeshow goodness-of-fit test indicated that the model was also well calibrated (p= 0.915); the area under the receiver operating characteristic (ROC) curve was 0.677.
Conclusions: The determination of plaque type is useful for identifying caries risk in schoolchildren. Using plaque disclosing gel might be practical and useful for screening caries-risk schoolchildren.

Keywords: caries prediction, caries risk, dental plaque, plaque disclosing gel, schoolchildren.

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Introduction

Despite the advances in caries control in many countries, dental caries remains a common chronic childhood disease. Dental treatment has become paramount of increasing healthcare costs and it is not feasible to apply them to the whole population. The current system has a limited capacity to find ways for prediction new carious for preventing their progression and occurrence, particularly to children. It is valuable if it has practical, useful and accurate screening for caries-risk schoolchildren. The presence of acidogenic flora in the dental plaque biofilm is the major etiological factors of caries [1,2]. Firstly, mainly of gram-positive cocci and rods of bacteria formed as young plaque, after that increasing amounts of gram negative anaerobic bacteria become as mature plaque [3]. Many bacterial species in the dental plaque are capable of producing acids from various sugars and develops dental caries [4,5]. Therefore, the amount of plaque and type of plaque biofilm might be useful for predicting caries development.

Plaque disclosing gel (GC Tri Plaque ID Gel) [6] is a solution that when applied on the tooth, makes plaque visible by staining roughness and foreign matter on the tooth [7]. This gel is a simple test for identifying new, mature, and acid producing biofilm by displaying three colors (red/pink, dark blue/purple, and light blue, respectively) based on the type of dental plaque[6]. Disclosing agents

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work by staining dental plaque with dye components. This staining occurs due to ionic interactions due to charge differences between the components of plaque and dyes [3]. Furthermore, plaque disclosing gel is considered a motivational tool for educating patients about the plaque that remains on the tooth surface after brushing. Even though, the GC Tri Plaque ID Gel are more expensive than erythrosine dye, using the GC Tri Plaque ID Gel might be beneficial for identifying the one with acidogenic plaque. However, there are few studies concerning using a plaque disclosing agent as a tool for predicting caries development in school children. Therefore, the purpose of this study was to evaluate the usefulness of plaque disclosing gel for predicting caries risk in Thai schoolchildren.

Materials and methods

The present cross-sectional study participants were comprised of healthy 9–16-year-old schoolchildren from 6 public schools in the Bangkok. GC Tri Plaque ID Gel (GC Corporation., Tokyo, Japan) [8] was used to identified different plaque type.

The calculation of sample size in this study based on the following rules of thumb[9] that the minimum ratio of observations to variables is 15:1 for a logistic regression analysis. The study protocol was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2016-103) with consent for accessing data from the Department of Community Dentistry, Chulalongkorn University.

Methods

Questionnaire-guided interview

The questionnaire-guided interview and oral examination were performed by trained dental students under supervision. The questionnaire consisted of two parts. The first part consisted of general information such as the children's age, sex, mother's/father's occupation, family income, and dwelling type. The second part consisted of five questions related to the children's medical and oral health history. The participants were asked whether they had any diseases, whether they regularly took any medicine, whether they wore orthodontic appliances, how often they ate sugary food, and whether they usually used any fluoride-containing products.

Oral examination, salivary flow rate and buffering capacity

Clinically active caries were recorded and the dental plaque score was determined according to the Simplified Oral hygiene Index (S-OHI). This index assesses the amount of debris found on the buccal or lingual surface of each of the selected teeth[10]. The saliva from a five-minute paraffin chewing procedure was collected to determine the stimulated salivary flow rate. The saliva buffering capacity was identified by testing the salivary end pH after adding 0.5 milliliter of a mild acid (Hydrochloric Acid 0.5 mol/L) into the equally amount of saliva. The Color Strip is a simplified method for assessing the salivary end pH. These strips were soaked in the mild acid-saliva mixture and the resulting color was compared with the standard color chart for determining the salivary end pH. There were three possible results: 1) low buffer capacity: pH <4.5, 2) inadequate buffer capacity: pH 4.5-6.5, and 3) normal or good buffer capacity: pH >6.5.

The GC Tri Plaque ID Gel [6] was applied onto the tooth surfaces using a cotton swab. After lightly rinsing the mouth with water, the color of the GC Tri Plaque ID Gel was observed for identifying the plaque type (Figure 1). Pink or red on the tooth surface indicated fresh plaque accumulation, dark blue or purple indicated mature plaque that is at least 48 hours old, and light blue indicated mature and strong acid producing plaque.

Statistical Analysis

The data were analyzed using descriptive statistics as median and percentage (%) with the Statistical Package for Social Science (IBM Corp., version 22.0). A logistic regression model was constructed to identify the variables associated with caries risk. Univariate analysis of categorical independent variables and continuous variables with dental caries was assessed using the Chi-square (χ^2) test and the Mann-Whitney U test, respectively. Variables were eligible for entry into multiple logistic regression models if they were significantly associated with dental caries at a $p<0.3$ and at least 2% of the population exhibited that factor. Odds ratios and 95% confidence intervals (CI) were calculated. Receiver operating characteristic (ROC) curves were constructed from the final models, and their area under the ROC curve (AUC) were estimated. The appropriateness of the data for use in generating the ROC was assessed using the Hosmer-Lemeshow goodness-of-fit test. A p value >.05 indicated a good agreement between the observed and predicted dental caries. Discrimination was assessed using AUC to evaluate how well the models identified patients who experienced dental caries. In addition, ROC curves were constructed to determine sensitivity and specificity for children with and without caries.

Figure 1 Different plaque type revealed different color after water rinsing: A. pink indicates fresh plaque; B. dark blue or purple indicates mature plaque; and C. light blue indicates strong acid producing plaque.

Results

A total of 125 schoolchildren were examined for dental caries and dental plaque. The mean age (± standard deviation (SD)) of the participants was 12.3±1.87 and 41.6% were male. The questionnaire data revealed that 98.4% of the participants were healthy and did not regularly take any medicine. A few children (2.4%) wore orthodontic appliances. Most of the schoolchildren could not give information about their mother's/father's occupation, family income, or dwelling type. Thirteen of twenty-one schoolchildren (61.9%) indicated that their parents worked as laborers and 54.7% (29/53) of the schoolchildren had a family monthly income of <15,000 Baht (<US$451.3). Eighty-five children (68.0%) snacked 4–6 times per day and 92.8% used fluoride-containing products.

The prevalence of dental caries for the whole group was 60.0% and 85 children (68%) had soft debris covering one-third to two-thirds of the exposed tooth surface (score 2 based on the S-OHI). Seventy children (56%) had mature plaque (purple) and 32.8% had mature and strong acid producing plaque (light blue). The saliva analysis results indicated that 47.2% of children had an adequate saliva flow rate (>1.0ml/min) and 55.2% had low buffer capacity.

The univariate analysis of the independent variables with dental caries in preliminary analyses (Table 1). The median age was 11.86 years among children with caries and 11.65 years among caries free children. Strong acid producing plaque was detected in children with caries (38.7%), which was higher compared with children without caries (24%). We found that 33.3% of children with caries had a saliva flow rate less than 0.7ml/min. compared with 16% in children without caries.

Table 1 Variables for the Development of Dental Caries.

	Number (%)		Crude OR (95% CI)	p-value[a]
	No decay (n=50)	Decay (n=75)		
Age (years)				
Median (Min, Max)	11.65 (9.29, 16.64)	11.86 (9.74, 16.43)	-	0.101[b]
Sex				
Male	23 (46%)	29 (38.7%)	1	0.415
Female	27 (54%)	46 (61.3%)	1.35 (0.66, 2.79)	
Type of plaque				
Fresh plaque	10 (20%)	4 (5.3%)	1	0.021*
Mature Plaque	28 (56%)	42 (56%)	3.75 (1.07, 13.15)	
Strong acid producing plaque	12 (24%)	29 (38.7%)	6.04 (1.58, 23.09)	
Frequency of snacking				
≤ 3 times/day	8 (16%)	8 (10.7%)	1	0.389
4-6 times/day	35 (70%)	50 (66.7%)	1.43 (0.49, 4.17)	
>6 times/day	7 (14%)	17 (22.7%)	2.43 (0.65, 9.07)	
Saliva flow rate				
> 1.0 ml/min	30 (60%)	29 (38.7%)	1	0.039*
0.7-1.0 ml/min	12 (24%)	21 (28%)	1.81 (0.76, 4.34)	
< 0.7 ml/min	8 (16%)	25 (33.3%)	3.23 (1.26, 8.32)	
Buffer capacity				
high	22 (44%)	34 (45.3%)	1	0.883
low	28 (56%)	41 (54.7%)	0.95 (0.46, 1.95)	
Use a fluoride-containing product				
Yes	48 (96%)	68 (90.7%)	1	0.258
No	2 (4%)	7 (9.3%)	2.47 (0.49, 12.41)	

[a]χ^2-test, [b]Mann-Whitney U test, *Indicates significant relationship

Similar multivariate analysis results were found when the association between the type of plaque and dental caries was analyzed using logistic regression (Table 2). The crude ORs indicated that strong acid producing plaque was associated with caries compared with children without caries. After adjustment for age, amount of saliva, and using fluoride-containing products, the adjusted OR was still significantly associated with dental caries.

To identify the type of plaque that best predicted caries outcome, ROC curves were generated for the type of plaque with caries present. The AUC was 0.677 (Figure 2). The sensitivity, specificity, and accuracy of the plaque gel test was 78.4%, 44%, and 64.8%, respectively. Therefore, there is strong experimental basis for using the type of plaque to identify caries-risk schoolchildren.

Table 2 Logistic Regression Analyses of Factors Associated with caries in the Model.

Variables	B	SE	Estimated adjusted OR	95% CI	p
Age	0.002	0.08	1.00	0.86 - 1.17	0.981
Mature plaque	1.20	0.67	3.32	0.89 - 12.40	0.075
Strong acid producing plaque	1.56	0.72	4.75	1.16 - 19.46	0.031*
Saliva flow rate 0.7-1.0 ml/min	0.57	0.47	1.77	0.71 – 4.42	0.220
Saliva flow rate < 0.7 ml/min	1.20	0.50	3.31	1.25 – 8.80	0.016*
Receiving fluoride	0.71	0.45	2.03	0.84 – 4.91	0.116

* indicates significant relationship

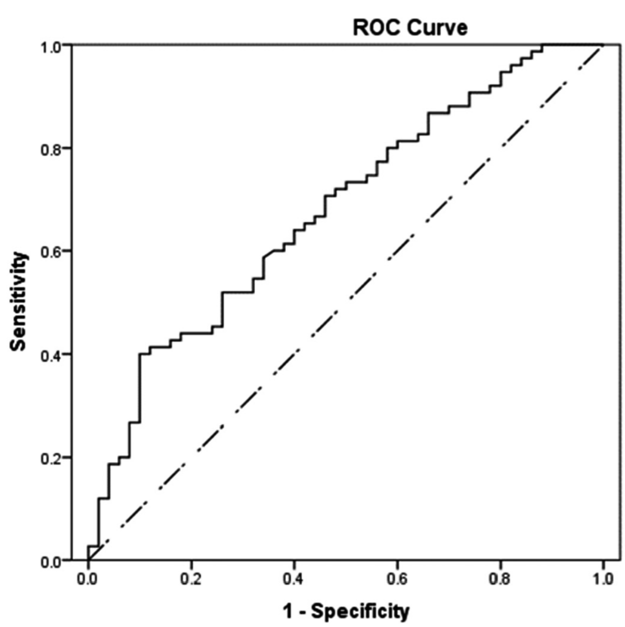

Figure 2 Area under the Curve (AUC) for Dental Caries = 0.677

Discussion

The results indicated that over 60% of children had cavitated caries. This finding of a high prevalence of caries existing in a population of young Thai schoolchildren is alarming. However, our prevalence results correspond with those reported in the 8th Thailand National Oral Health Survey that found a prevalence of 52.3% and 62.4% among those aged 12 and 15 years, respectively [11]. However, the high caries prevalence in young Thai schoolchildren in the present study suggests that perhaps some extraordinary factors play important roles in the caries etiology of this population, such as the low flow rate and low saliva buffering capacity.

The results indicated that girls had a higher prevalence and severity of caries compared with boys, which was consistent with the findings of Lukacs [12], Doyal and Naidoo [13], and Ferraro and Vieira [14]. The higher caries prevalence in girls may be due to different salivary composition and flow rate, and dietary habits [14]. Our results demonstrated that girl students snacked more frequently during the day, similar to other study findings [15]. However, the differences in snacking between the sexes in our study were not significant.

The present study found that the type of plaque and saliva flow rate were associated with caries in our population. The multivariate analysis revealed that strong acid producing plaque was strongly associated with dental caries (OR = 4.75). This result corroborated the findings of Pearce et al. [16] and Walsh [17]. The type of plaque found in our study reflected the three phases of plaque biofilm development. Amina et al. found that supragingival plaque was composed mainly of gram-positive aerobic, particularly *Mutans streptococci* and *Lactobacilli* [18], while strong acid producing plaque had an increased percentage of gram negative anaerobic bacteria [3]. Therefore, strong acid producing plaque metabolizes dietary fermentable carbohydrates, mainly free sugar resulting in the acidification of the biofilm which in turn may lead to acid induced tooth demineralization [17]. Thus, strategies to control caries include effective oral hygiene practices to reduce biofilm development, and adoption of a low-sugar diet to restrict periods of acidic challenge to the teeth.

The role of saliva in protecting against caries development was evaluated in this study. The multivariate analysis revealed that a saliva flow rate of less than 0.7 ml/min was strongly associated with dental caries (OR = 3.31). The saliva flow rate of less than 0.7 ml/min in subjects with active caries (33.3%) was significantly higher compared with those without active caries (16%) ($p<0.05$). These results indicate that a low salivary flow rate may be a sign of caries activity, corresponding with the findings of several studies [19-21]. Saliva influences oral health and plays an important role in tooth demineralization and remineralization. The saliva functions as a cleansing solution and a lubricant by constantly bathing the teeth and oral mucosa, hence lack of its secretion contributes to the disease process [22]. The buffer capacity of saliva can raise a low salivary pH to normal pH. Moreover, the calcium and phosphate in saliva are ion reservoirs, which are essential for the remineralization of initial carious lesions [19,20].

Attempts to predict future caries activity have been previously conducted [21,23-25]. The risk indicators studied included saliva flow rate, buffering capacity, pH, and calcium and phosphate concentrations, *Mutans streptococci* counts in saliva, past caries experience, tooth morphology, and dietary habits and other sociodemographic data [5,16,26,27]. Several studies showed that the predictive power of several variables were higher than single predictors using multiple regression techniques [25]. This is a reasonable finding as caries is a multifactorial disease.

Caries risk assessment is regarded with increasing importance by dental public health planners. Dental preventive treatments are costly and it is inappropriate or not feasible to apply them to the whole population. In the school-aged population in Thailand, approximately 30–36% of 12-15-year-old children had untreated caries [11]. Accurate methods of identifying ‘at risk’ individuals at an early age for specific preventive measures are needed.

Multifactorial modeling has been used to increase caries risk assessment accuracy and a useful caries risk assessment program should be one with high simplicity, sensitivity, and specificity (sensitivity + specificity > 160%) [25]. Our analysis showed a high sensitivity combined with low specificity (78.4%/44%), however, with the tradeoff between the simplicity and accuracy, this method may be practical and useful for screening children, especially in communities where regular dental screening for schoolchildren is uncommon and/or costly.

The present study indicated that the type of plaque and saliva flow rate had a strong relationship with caries activity in schoolchildren. Moreover, our result showed that plaque disclosing agent was effective in identifying pathological plaque, which is similar to previous studies showing using three-tone plaque disclosing agent as one of the chairside adjuvants in caries risk assessment and may be effective in improving oral hygiene among schoolchildren at their home [28,29]. These results re-emphasize the importance of determining the type of plaque, such as its acid production ability and bacterial polysaccharide content, which are markers of caries activity. However, to extrapolate the findings of this study, studies involving a larger sample size are required.

Despite the rich data emerging from this study, limitations exist. The data regarding brushing/snacking behaviors was self-reported, thus, its accuracy might be uncertain and recall bias may exist. Although the findings from this study may not be generalizable to other groups, such as in rural schools, they likely provide an accurate representation of schoolchildren in the urban area.

Conclusions

The study indicates that determining the type of plaque is useful for identifying caries risk in schoolchildren. Using plaque disclosing gel might be practical and useful for screening caries-risk schoolchildren.

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References

1. Marsh P, Nyvad B. Dental Caries. The disease and its clinical management. Copenhagen: Blackwell Munksgaard; 2003.
2. Pisarnturakit PP, Detsomboonrat P. Microbial and Behavioral Determinants of Dental Caries in Permanent Dentition among Thai Schoolchildren. *Southeast Asian J Trop Med Public Health* 2017; 48: 912-25.
3. Chetrus V, Ion IR. Dental plaque-classification, formation, and identification. *International Journal of Medical Dentistry* 2013; 17: 139-43.
4. Marsh PD. Are dental diseases examples of ecological catastrophes? Microbiology 2003; 149: 279-94.
5. Piwat S, Hassan H, Kjeang T, Lindehag J, Wedin H, et al. Site-specific dental plaque pH in 13-year-old Thai schoolchildren. *Clin Oral Investig* 2015; 19: 2179-86.
6. GC corporation GC Tri Plaque ID Gel™ a new perspective on biofilms to improve oral hygiene and motivation. 2011. "http://www.gcamerica.com/products/preventive/GC_Tri_Plaque_ID/index.php". Accessed 14 July 2017.
7. Datta D, Kumar R, Narayanan A, Selvamary L, Sujatha A. Disclosing solutions used in dentistry. *World J Pharm Res* 2017; 6: 1648-56.
8. GC Europe Tri plaque ID Gel. 2016. "https://www.gceurope.com/products/triplaqueidgel/". Accessed Jun 02 2016.
9. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. Multivariate Data Analysis. sixth edition ed. Upper Saddle River, New Jersey, United States of America: Pearson Education, Inc.; 2006.
10. Tayanin GL Simplified Oral hygiene index (Greene and Vermilion, 1964). " https://www.mah.se/CAPP/Methods-and-Indices/Oral-Hygiene-Indices/Simplified-Oral-Hygiene-Index--OHI-S/". Accessed Mar 20 2017.
11. Bureau of Dental Health, Department of Health, Ministry of Public Health. Report of the Eighth National Oral Health Survey 2017. Bangkok: Samcharoen Panich (Bangkok) Co.Ltd; 2018.
12. Lukacs JR. Sex differences in dental caries experience: clinical evidence, complex etiology. *Clin Oral Investig* 2011; 15: 649-56.
13. Doyal L, Naidoo S. Why dentists should take a greater interest in sex and gender. *Br Dent J* 2010; 209: 335-7.

14. Ferraro M, Vieira AR. Explaining gender differences in caries: a multifactorial approach to a multifactorial disease. *Int J Dent* 2010; 2010: 649643.
15. Sgan-Cohen HD, Bajali M, Eskander L, Steinberg D, Zini A. Dental Caries Status, Socio-Economic, Behavioral and Biological Variables among 12-Year-Old Palestinian School Children. *J Clin Pediatr Dent* 2015; 39: 331-5.
16. Pearce EI, Dong YM, Yue L, Gao XJ, Purdie GL, et al. Plaque minerals in the prediction of caries activity. *Community Dent Oral Epidemiol* 2002; 30: 61-9.
17. Walsh LJ. Dental plaque fermentation and its role in caries risk assessment. Paper presented at: International Dentistry SA (Australasian Edition), 2006.
18. Hoceini A, Khelil NK, Ben-Yelles I, Mesli A, Ziouani S, et al. Caries-related factors and bacterial composition of supragingival plaques in cariesfree and caries active Algerian adults. *Asian Pac J Trop Biomed* 2016; 6: 720-26.
19. Prabhakar A, Dodawad R, Os R. Evaluation of Flow Rate, pH, Buffering Capacity, Calcium, Total Protein and Total Antioxidant Levels of Saliva in Caries Free and Caries Active Children-An In Vivo Study. *Int J Clin Pediatr Dent* 2009; 2: 9-12.
20. Preethi BP, Reshma D, Anand P. Evaluation of Flow Rate, pH, Buffering Capacity, Calcium, Total Proteins and Total Antioxidant Capacity Levels of Saliva in Caries Free and Caries Active Children: An In Vivo Study. *Indian J Clin Biochem* 2010; 25: 425-8.
21. Sakeenabi B, Hiremath SS. Dental caries experience and salivary Streptococcus mutans, lactobacilli scores, salivary flow rate, and salivary buffering capacity among 6-year-old Indian school children. *J Int Soc Prev Community Dent* 2011; 1: 45-51.
22. Animireddy D, Reddy Bekkem VT, Vallala P, Kotha SB, Ankireddy S, et al. Evaluation of pH, buffering capacity, viscosity and flow rate levels of saliva in caries-free, minimal caries and nursing caries children: An in vivo study. *Contemp Clin Dent* 2014; 5: 324-8.
23. Koch G. Importance of early determination of caries risk. Int Dent J 1988;38(4):203-10.
24. Johnson NW. Concluding perspectives and future directions. Cambridge, New York: Cambridge University; 1991.
25. Stamm JW, Disney JA, Beck JD. The University of North Carolina caries risk assessment study: Final results and some alternative modelling approaches. Rochester: University of Rochester; 1993.
26. Klock B, Krasse B. Effect of caries-preventive measures in children with high numbers of S. mutans and lactobacilli. *Scand J Dent Res* 1978; 86: 221-30.
27. Russell JI, MacFarlane TW, Aitchison TC, Stephen KW, Burchell CK. Prediction of caries increment in Scottish adolescents. *Community Dent Oral Epidemiol* 1991; 19: 74-7.
28. Jayanthi M, Shilpapriya M, Reddy VN, Elangovan A, Sakthivel R, et al. Efficacy of three-tone disclosing agent as an adjunct in caries risk assessment. *Contemp Clin Dent* 2015; 6: 358-63.
29. Nagashima Y, Shigeishi H, Fukada E, Amano H, Urade M, et al. Self-check with plaque disclosing solution improves oral hygiene in schoolchildren living in a children's home. *Arch Public Health* 2018; 76: 50.