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# Validity of a Simple Periodontal Disease Screening Tool in Thai Patients

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## Abstract

**Objectives:** To develop and evaluate the validity of a self-reporting questionnaire for periodontitis in the Thai population.

**Methods:** A cross-sectional analytical study was performed in a group of 300 Thais aged 19-85 years old at the Faculty of Dentistry, Chiang Mai University. Each participant took a questionnaire and received a periodontal status evaluation. Participants were classified into three severity groups using the Centers for Disease Control and Prevention, in partnership with the American Academy of Periodontology (CDC-AAP) criteria. Multivariable ordinal logistic regression analysis was used to achieve the final model. The scoring system was also developed.

**Results:** One hundred patients of each severity group were recruited. Significant predictors in the final model included age, gender, bleeding gums, tooth mobility, dental flossing, dental check-up frequency, diagnosis by a dentist, and individual assessment of periodontitis. The total derived scores identified the severity group of patients into no/mild, moderate, and severe periodontitis. Our model predicted severity groups correctly in 65.7% of patients, while giving an underestimation of 19.3% and an overestimation of 15%. The area under the receiver operating characteristic curves (AuROCs) equal to 0.92 and 0.80 discriminated moderate and severe from no/mild periodontitis, and severe from no/mild and moderate periodontitis, respectively.

**Conclusions:** Our periodontal disease screening tool demonstrates adequate accuracy. Its validity should be evaluated in other populations.

**Keywords:** periodontitis, questionnaire, sensitivity and specificity, Thai

## Introduction

Periodontal disease is an infection and inflammatory condition that affects periodontal tissues. The most common forms of periodontal diseases are gingivitis and periodontitis. Gingivitis is a common or mild form of periodontal disease manifested by inflammation only at the gingiva. Periodontitis, a more severe, irreversible form of periodontal disease, results in the loss of tissues and bones surrounding and supporting the teeth.<sup>(1)</sup> Periodontitis is considered an important cause of tooth loss in adults. Such people are at risk of edentulism, which leads to functional and esthetic impairment that can affect individual physical health and lead to self-esteem problems.<sup>(2)</sup> Since an early stage of periodontitis usually does not present with noticeable symptoms, patients may not realize that they have a problem until they are suffering from an advanced stage of the disease. From 1990 to 2010, approximately 11.2% of the world population suffered from severe periodontitis, which is the sixth most prevalent disease in the world.<sup>(3)</sup> In Thailand, the 8<sup>th</sup> Thai National Oral Health Surveillance, conducted in 2017, reported that the prevalence of periodontitis in adults between 35 and 44 years old was 25.9%, and in the elderly between 60 and 74 years old was 36.3%.<sup>(4)</sup>

Periodontal disease can be prevented by effective daily oral hygiene care, avoiding the risk factors of periodontitis, and undergoing regular professional examination and plaque removal.<sup>(5)</sup> Although the clinical examination is a standard measure and is the most accurate way to detect periodontal disease, it is costly, time-consuming, and resource-demanding. Moreover, dental instruments and dental personnel are mandatory.<sup>(6,7)</sup> More than 60% of Thai adults have never had a dental check-up,<sup>(4)</sup> and thus, their periodontal diseases may be under-detected, which would lead to an increased opportunity of losing teeth from periodontitis.

A self-reported questionnaire could be an interesting alternative tool to assess periodontal disease in a population. It could permit not only painless early detection but would also be easy to use, low-cost, and low-resource.<sup>(7,8)</sup> However, studies in various countries have shown variation in the validity of self-reported periodontal measures.<sup>(7,9)</sup> The divergent validity outcomes regarding self-reporting questionnaires depend on population characteristics and periodontal case definition.<sup>(10)</sup> Neverthe-

less, many studies have been moderate to well valid for self-reported periodontal measurements when combined with demographic variables and risk factors.<sup>(10-15)</sup> In addition, the self-reported questions were written in different languages, such as Japanese<sup>(16)</sup>, Chinese<sup>(17)</sup>, German<sup>(8)</sup>, Portuguese<sup>(15)</sup>, Arabic<sup>(18)</sup>, French<sup>(10)</sup> and Spanish.<sup>(19)</sup> Till now, self-reported measures have never been investigated or validated in Thailand. Moreover, there is no scoring system in existing questionnaires which could predict the severity of the periodontal disease.

Therefore, this study aimed to develop and evaluate the validity of a self-reported questionnaire to screen for periodontitis in a group of Thais attending the Faculty of Dentistry, Chiang Mai University.

## Materials and Methods

### Study design and sample recruitment

This cross-sectional analytical study used case-control analogue data collection. The study participants were recruited from general patients attending the dental clinic at the Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand, between May and December 2019. The inclusion criteria were: Thais aged > 18 years old able to read and respond to a Thai self-reported questionnaire, and willing to answer the periodontal screening questionnaire. Exclusion criteria were: had fewer than 10 remaining teeth, required antibiotic prophylaxis prior to the periodontal examination, had a history of bleeding disorders, taking medications causing bleeding disorders, had drug-induced gingival overgrowth, was pregnant, and disabled or handicapped. Informed consent was obtained from each subject prior to enrolment. We considered the sample size based on a test of two independent proportions using data from previous studies<sup>(10,12,15)</sup> with a 5% significance level and 80% power. The sample size was estimated to be 100 participants in each group: no/mild, moderate, and severe periodontitis (total n=300). As the determined sample size was 100 subjects per group, every participant who met the inclusion and case definition criteria was included until each severity group reached the required sample size.

The research was approved by the Faculty of Dentistry Human Experimentation Committee, Chiang Mai University, on August 2, 2019 (No. 43/2019).

### Periodontal status measurements

The periodontal status of each participant was examined using a sterile periodontal probe (PCP-UNC 15, Hu-Friedy, Chicago, IL, USA). Probing depth (PD) and clinical attachment level (CAL) were recorded. The full mouth periodontal status of each tooth, excluding third molars and retained roots, was measured in six sites (mesio-buccal, mid-buccal, disto-buccal, disto-palatal/lingual, mid-palatal/lingual, mesio-palatal/lingual). All measurements were performed by a trained resident and two periodontists, who were calibrated prior to the examination. Weighted kappa scores of inter-examiner reliability ranged from 0.87-0.98 and 0.85-0.93, for PD and CAL, respectively.

### The clinical case definition of periodontitis

According to the clinical examination, participants were classified into three groups according to severity, using the definition of periodontitis proposed by the Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC-AAP) Working group.<sup>(20)</sup> The criteria for classification were 1) severe periodontitis: two or more interproximal sites with  $CAL \geq 6$  mm (not on the same tooth) and at least one interproximal site with  $PD \geq 5$  mm; 2) moderate periodontitis: two or more interproximal sites with  $CAL \geq 4$  mm (not on the same tooth) or at least two interproximal sites with  $PD \geq 5$  mm (not on the same tooth); and 3) no/mild periodontitis: neither moderate nor severe periodontitis.

### The self-reported questionnaire development

The self-reported questionnaire was self-administered. Each participant responded to the questionnaire on the visit after the periodontal status was determined by professionals. Due to the question of periodontal disease diagnosis, the participants were not informed about their periodontal status until the questionnaire was completed. The self-reported questions were modified from previous studies.<sup>(6,8,10,12-15,17,18,21)</sup> The questions fell into four categories:

1) Demographic features and risk factors: age, gender, education level, monthly income (<10,000 baht and > 10,000 baht/person/month according to net national income in the year 2018<sup>(22)</sup>), weight, height, alcohol consumption, smoking status and diabetes;

2) Signs and symptoms: bleeding gums, receding gums, tooth mobility, dental calculus, red and swollen gums, food impaction, tooth movement, sore gums, tooth sensitivity, malodor and individual assessment of periodontitis;

3) Oral health care: toothbrushing frequency, dental aids use and mouthwash use;

4) Dental history: dental check-up frequency, tooth loss from periodontitis, diagnosis and recommended treatment of periodontitis by a dentist, history of root planing and history of gum surgery.

### Statistical analyses

All statistical analyses were conducted using STATA software version 14.0 (StataCorp LP, College Station, TX, USA). Means and standard deviations or medians and ranges were used to describe numerical variables. Frequency and percentages were used to describe categorical variables. For univariate analysis, associations between each self-reported question and the clinical definition of periodontitis were evaluated using univariable ordinal logistic regression analysis presented with crude odd ratios (crude OR), with significance set at the 0.05 level. For the final model, multivariable ordinal logistic regression analysis was defined to assess the most predictive set of variables associated with the severity of periodontitis. The predictor variables were retained if they were statistically significant ( $p < 0.05$ ). For the development of the scoring system and cut-off points, each significant  $\beta$ -coefficient was transformed by dividing using the least value of the  $\beta$ -coefficient of the model. Then, the transformed score of each variable was rounded up to the assigned severity score. The total scores and cut-off points were developed and tested for the discriminative capability and predictive validity which were illustrated by the accuracy percentage, the area under the receiver operating characteristic curves (AuROC), the sensitivity, and the specificity.

### Results

A total of 300 participants were classified, based on the CDC-AAP criteria, into three severity groups: no/mild periodontitis (n=100), moderate periodontitis (n=100), and severe periodontitis (n=100). The periodontal parameters of each group are shown in table 1.

**Table 1:** Periodontal status of the study participants according to periodontal case definition

Variables	Total sample (n=300)	Periodontal case definition (CDC-AAP)			p-value
		Mild (n=100)	Moderate (n=100)	Severe (n=100)	
Average remaining teeth (min-max)	26.14 (11-32)	26.82 (17-32)	25.68 (11-32)	25.91 (12-32)	0.057
Average PPD ( $\pm$ SD)	2.59 $\pm$ 0.58	2.31 $\pm$ 0.40	2.48 $\pm$ 0.39	2.99 $\pm$ 0.68	<0.001
<b>Percentage of sites with PPD (mean <math>\pm</math> SD)</b>					
≥ 3 mm	42.28 $\pm$ 28.77	14.58 $\pm$ 17.56	47.68 $\pm$ 22.15	64.57 $\pm$ 19.87	<0.001
≥ 4 mm	10.51 $\pm$ 14.50	0.80 $\pm$ 1.85	5.90 $\pm$ 6.55	24.83 $\pm$ 16.28	<0.001
≥ 5 mm	4.93 $\pm$ 9.11	0.07 $\pm$ 0.34	1.38 $\pm$ 2.07	13.34 $\pm$ 11.76	<0.001
≥ 6 mm	2.42 $\pm$ 5.51	0.04 $\pm$ 0.25	0.34 $\pm$ 0.67	6.88 $\pm$ 7.81	<0.001
<b>Percentage of teeth with PPD (mean <math>\pm</math> SD)</b>					
≥ 3 mm	11.74 $\pm$ 5.75	5.87 $\pm$ 5.12	13.84 $\pm$ 3.70	15.50 $\pm$ 2.45	<0.001
≥ 4 mm	4.59 $\pm$ 4.82	0.59 $\pm$ 1.24	3.61 $\pm$ 3.02	9.57 $\pm$ 4.18	<0.001
≥ 5 mm	2.41 $\pm$ 3.58	0.05 $\pm$ 0.20	1.04 $\pm$ 1.42	6.13 $\pm$ 3.88	<0.001
≥ 6 mm	1.28 $\pm$ 2.40	0.02 $\pm$ 0.14	0.27 $\pm$ 0.51	3.54 $\pm$ 3.05	<0.001
Average CAL ( $\pm$ SD)	2.78 $\pm$ 0.84	2.28 $\pm$ 0.56	2.63 $\pm$ 0.64	3.42 $\pm$ 0.85	<0.001
<b>Percentage of sites with CAL (mean <math>\pm</math> SD)</b>					
≥ 3 mm	47.17 $\pm$ 31.40	12.00 $\pm$ 15.04	56.32 $\pm$ 20.33	73.19 $\pm$ 17.93	<0.001
≥ 4 mm	19.43 $\pm$ 21.08	1.20 $\pm$ 3.11	17.13 $\pm$ 12.98	39.95 $\pm$ 19.94	<0.001
≥ 5 mm	9.21 $\pm$ 13.54	0.19 $\pm$ 0.77	5.12 $\pm$ 6.15	22.32 $\pm$ 15.57	<0.001
≥ 6 mm	4.58 $\pm$ 8.53	0.03 $\pm$ 0.18	1.49 $\pm$ 2.46	12.22 $\pm$ 11.13	<0.001
<b>Percentage of teeth with CAL (mean <math>\pm</math> SD)</b>					
≥ 3 mm	12.10 $\pm$ 5.55	5.56 $\pm$ 4.27	14.80 $\pm$ 2.69	15.94 $\pm$ 1.49	<0.001
≥ 4 mm	6.70 $\pm$ 5.61	0.77 $\pm$ 1.73	7.20 $\pm$ 3.74	12.15 $\pm$ 3.50	<0.001
≥ 5 mm	3.75 $\pm$ 4.29	0.14 $\pm$ 0.52	2.78 $\pm$ 2.43	8.32 $\pm$ 3.76	<0.001
≥ 6 mm	2.07 $\pm$ 3.09	0.12 $\pm$ 0.10	0.91 $\pm$ 1.13	5.28 $\pm$ 3.40	<0.001

All participants responded to all of the questions. The entire sample had a mean age of 46 $\pm$ 15 years (ranging from 19 to 85 years) with 60.67% of females. The majority of the sample had a high level of education (58.67% of bachelor's degree or more) and 68.33% had a monthly income > 10,000 baht/person/month. The average Body Mass Index (BMI) of participants was approximately 24 kg/m<sup>2</sup>. In addition, 15.33% of patients reported alcohol consumption, 3.33% were current smokers and 9% were diabetic. (Table 2, Category I).

Table 2 shows that almost all variables were associated with the severity of periodontitis.

In Category I: Demographic features and risk factors, there were four variables, which included age, gender, smoking status, and diabetes, which were associated with the severity of periodontitis. The proportions of patients with severe periodontitis were higher in older, male, current-smoker, and diabetic patients.

In Category II: Signs and symptoms, only one variable (tooth sensitivity) was not associated with the severity of periodontitis. The proportions of participants with signs and symptoms of periodontitis were higher in the severe periodontitis group than those in the moderate and no/mild groups.

In Category III: Oral health care, two variables (toothbrushing frequency and dental flossing) were associated with the severity of periodontitis.

In Category IV: Dental history, all variables were associated with the severity of periodontitis. The proportions of participants with a history of tooth loss from periodontitis, diagnosis and recommended treatment of periodontitis by a dentist, and those receiving periodontal treatment in the past were higher in the severe periodontitis group than in other groups.

**Table 2:** Response to the self-reported questionnaire for the screening of periodontitis

Variable	Total sample (n=300)	Periodontal case definition (CDC-AAP)			Crude OR (95% CI)	p value
		No/mild (n=100)	Moderate (n=100)	Severe (n=100)		
<b>Category I: Demographic features and risk factors</b>						
<b>Age (%)</b>						
<40 years	36.67	73	20	17	1.00	
40-54 years	26.00	21	32	25	4.85 (2.70-8.72)	<0.001
>54 years	37.33	6	48	58	12.85 (7.25-22.79)	<0.001
Mean (±SD)	46±15	35±12	53±14	52±12		
<b>Gender (%)</b>						
Female	60.67	75	61	46	1.00	
Male	39.33	25	39	54	2.54 (1.64–3.94)	<0.001
<b>Education level (%)</b>						
Primary school	12.66	6	21	11	1.55 (0.84-2.85)	0.158
High school	28.67	26	25	35	1.53 (0.95-2.49)	0.082
≥Bachelor's degree	58.67	68	54	54	1.00	
<b>Monthly income (%)</b>						
≤10,000 baht	31.67	21	40	34	1.55 (1.00-2.41)	0.052
>10,000 baht	68.33	79	60	66	1.00	
Median (IQR)	15,000 (14,790)	15,000 (8,488)	15,000 (19,000)	15,000 (20,250)		
<b>BMI (%)</b>						
Low (<25 kg/m <sup>2</sup> )	68.33	66	69	70	1.04 (0.64-1.70)	0.854
Normal (25-30 kg/m <sup>2</sup> )	24.67	22	27	25	1.00	
High (>30 kg/m <sup>2</sup> )	7.00	12	4	5	0.41 (0.17-1.00)	0.050
Mean (±SD)	23.64±0.24	23.66±4.53	23.66±3.75	23.62±4.05		
<b>Alcohol consumption (%)</b>						
Never	69.33	69	74	65	1.00	
Former	15.33	13	12	21	1.58 (0.86-2.89)	0.137
Current	15.33	18	14	14	0.85 (0.47-1.54)	0.601
<b>Smoking status (%)</b>						
Never	84.67	92	86	76	1.00	
Former	12.00	8	10	18	2.23 (1.15-4.35)	0.018
Current	3.33	0	4	6	4.30 (1.27-14.57)	0.019
<b>Diabetes (%)</b>						
No	91.00	100	90	83	1.00	
Yes	9.00	0	10	63	4.80 (2.19-10.50)	<0.001
<b>Category II: Signs and symptoms</b>						
<b>Bleeding gums (%)</b>						
No	54.67	61	66	37	1.00	
Yes	45.33	39	34	63	2.11 (1.38-3.24)	<0.001
<b>Receding gums (%)</b>						
No	58.67	73	62	41	1.00	
Yes	41.33	27	38	59	2.78 (1.80-4.31)	<0.001
<b>Tooth mobility (%)</b>						
No	62.33	93	62	32	1.00	
Yes	37.67	7	38	68	8.94 (5.43-14.73)	<0.001
<b>Dental calculus (%)</b>						
No	23.57	34	25	12	1.00	
Yes	76.33	66	75	88	2.51 (1.52-4.14)	0.001

<b>Red and swollen gums (%)</b>						
No	65.33	81	72	43	1.00	
Yes	34.67	19	28	57	3.84 (2.41-6.13)	<0.001
<b>Food impaction (%)</b>						
No	48.67	58	56	32	1.00	
Yes	51.33	42	44	68	2.21 (1.45-3.38)	<0.001
<b>Tooth movement (%)</b>						
No	64.00	75	67	50	1.00	
Yes	36.00	25	33	50	2.31 (1.48-3.60)	0.001
<b>Sore gums (%)</b>						
No	65.67	80	71	46	1.00	
Yes	34.33	20	29	54	3.30 (2.08-5.24)	<0.001
<b>Tooth sensitivity (%)</b>						
No	34.00	39	38	25	1.00	
Yes	66.00	61	62	75	1.59 (1.03-2.47)	0.065
<b>Malodor (%)</b>						
No	35.00	51	27	27	1.00	
Yes	65.00	49	73	73	2.29 (1.46-3.60)	<0.001
<b>Do you think you have periodontitis? (%)</b>						
No	63.00	87	66	36	1.00	
Yes	37.00	13	34	64	6.00 (3.72-9.67)	<0.001
<b>Category III: Oral hygiene care</b>						
<b>Toothbrushing frequency (%)</b>						
1 time/day	4.00	2	5	5	3.18 (1.05-9.62)	0.042
2-3 times/day	82.00	62	75	78	2.20 (1.33-3.65)	0.002
>3 times/day	4.00	36	20	17	1.00	
<b>Toothpick use (%)</b>						
No	68.67	60	76	70	1.44 (0.91-2.27)	
Yes	31.33	40	24	30	1.00	0.056
<b>Dental flossing (%)</b>						
No	49.33	31	53	64	2.77 (1.80-4.26)	
Yes	50.67	69	47	36	1.00	<0.001
<b>Single tuft use (%)</b>						
No	91.33	92	93	89	1.00	
Yes	8.67	8	7	11	1.35 (0.63-2.87)	0.662
<b>Proxabrush use (%)</b>						
No	82.00	85	85	76	0.62 (0.36-1.08)	
Yes	18.00	15	15	24	1.00	0.093
<b>Mouthwash use (%)</b>						
Never/ Sometimes	81.33	88	79	77	0.59 (0.34-1.00)	
>1 times/day	18.67	12	21	23	1.00	0.049
<b>Category IV: Dental history</b>						
<b>Dental check-up frequency (%)</b>						
<1 times/year	40.67	30	37	55	2.22 (1.44-3.42)	
≥1 times/year	59.33	70	63	45	1.00	0.001
<b>Extraction from periodontitis (%)</b>						
No	74.00	94	77	51	1.00	
Yes	26.00	6	23	49	6.21 (3.66-10.55)	<0.001
<b>Dentist told you that you have periodontitis (%)</b>						
No	68.33	90	72	43	1.00	
Yes	31.67	10	28	57	5.91 (3.60-9.71)	<0.001

<b>Dentist told you that you have pocket depth or bone loss (%)</b>						
No	77.33	91	79	62	1.00	
Yes	22.67	9	21	38	3.66 (2.16-6.20)	<0.001
<b>Dentist told you that you need periodontal treatment (%)</b>						
No	75.00	92	82	51	1.00	
Yes	25.00	8	18	49	6.28 (3.64-10.84)	<0.001
<b>Root planing in the past (%)</b>						
No	82.33	91	84	72	1.00	
Yes	17.67	9	16	28	2.76 (1.56-4.87)	0.002
<b>Gum surgery in the past (%)</b>						
No	90.00	97	89	84	1.00	
Yes	10.00	3	11	16	2.93 (1.44-5.97)	0.005
<b>Denture wearing (%)</b>						
No	81.67	91	79	75	1.00	
Yes	18.33	9	21	25	2.20 (1.28-3.77)	0.006

### Predictive model development

Multivariable ordinal logistic regression analysis was performed to obtain the final predictive model. The set of variables in the final model with significant predictive ability for the severity of periodontitis consisted of age 40-54 years (OR=3.63, 95% CI=1.91-6.90,  $p<0.001$ ), age >54 years (OR=9.13, 95% CI=4.74-17.56,  $p<0.001$ ), male (OR=1.93, 95% CI=1.14-3.26,  $p=0.014$ ), bleeding gums (OR=1.92, 95% CI=1.13-3.25,  $p=0.016$ ), tooth mobility (OR=4.82, 95% CI=2.72-8.55,  $p<0.001$ ), patients who thought they had periodontitis (OR=2.31, 95% CI=1.27-4.21,  $p=0.006$ ), patients who did not use dental floss (OR=2.18, 95% CI=1.29-3.66,  $p=0.003$ ), dental check-up < 1 time/year (OR=1.93, 95% CI=1.14-3.28,  $p=0.015$ ), and periodontitis diagnosis by a dentist (OR=2.73, 95% CI=1.44-5.16,  $p=0.002$ ) (Table 3).

### Scoring system and cut-off points

Each  $\beta$ -coefficient was divided by the least value of the  $\beta$ -coefficient of the model (e.g., bleeding gums: 0.65) to obtain the transformed score. Then, each transformed score was rounded up or down to the nearest 0.5. For our predictive model, the derived item scores ranged from 0 to 3.5 and the total score ranged from 0 to 13 (Table 3). The total score was calculated in each group of patients with no/mild, moderate, and severe periodontitis. The median (Interquartile range: IQR) total scores in each group were 2 (2), 5.5 (3.25), and 8.5 (3.5), respectively.

To obtain the most effective cut-off points, we calculated the performance of scores which were the most correctly predicted and least over or underestimation from

several cut-off points that are likely to be able to differentiate each disease severity group.

The most effective cut-off points for our predictive model were scores 4.5 and 7. Total scores less than 4.5 correctly predicted no/mild periodontitis in 85 patients (28.3%) with an underestimation in 29 patients (9.7%). Total scores from 4.5 to 7 correctly predicted moderate periodontitis in 45 patients (15%) with an underestimation in 29 patients (9.7%) and an overestimation in 10 patients (3.3%). Total scores greater than 7 correctly predicted severe periodontitis in 67 patients (22.3%) with an overestimation in 35 patients (11.7%) (Table 4).

Overall, these cut-off points predicted periodontal status correctly in 197 patients (65.7%) with an underestimation in 58 patients (19.3%) and an overestimation in 45 patients (15%). The obtained scores discriminated

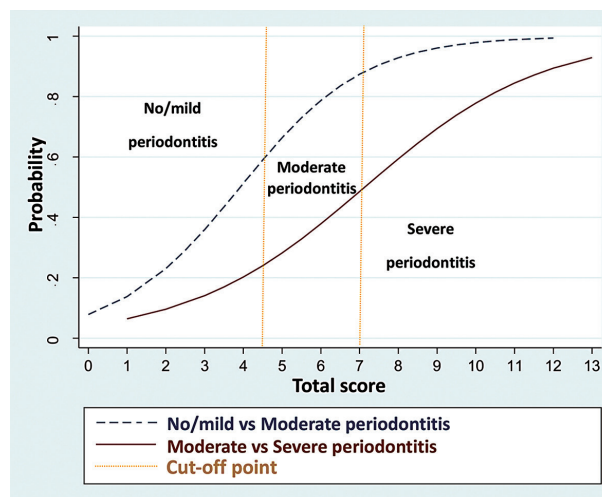


Figure 1: Discrimination of periodontitis severity scores.

**Table 3:** Significant predictors of periodontitis severity and assigned scores

Predictor variable	Adjusted OR	95% CI	p value	β-coefficient	Transformed Score	Assigned Score
<b>Age</b>						
<40 years	1					0
40-54 years	3.63	1.91-6.90	<0.001	1.29	1.98	2.0
>54 years	9.13	4.74-17.56	<0.001	2.21	3.4	3.5
<b>Gender</b>						
Female	1					0
Male	1.93	1.14-3.26	0.014	0.66	1.02	1
<b>Bleeding gums</b>						
No	1					0
Yes	1.92	1.13-3.25	0.016	0.65	1	1
<b>Tooth mobility</b>						
No	1					0
Yes	4.82	2.72-8.55	<0.001	1.57	2.42	2.5
<b>Do you think you have periodontitis?</b>						
No	1					0
Yes	2.31	1.27-4.21	0.006	0.84	1.29	1.5
<b>Dental flossing</b>						
No	2.18					1
Yes	1	1.29-3.66	0.003	0.78	1.2	0
<b>Dental check-up frequency</b>						
<1 times/year	1.93					1
≥1 times/year	1	1.14-3.28	0.015	0.66	1.02	0
<b>Dentist told you that you have periodontitis.</b>						
No	1					0
Yes	2.73	1.44-5.16	0.002	1.00	1.54	1.5

**Table 4:** Predicted periodontitis severity and predictive validity

Predicted periodontitis severity	Total score	Periodontal case definition (CDC-AAP)			Predictive validity		
		No/mild (n=100)	Moderate (n=100)	Severe (n=100)	Over (%)	Correct (%)	Under (%)
No/mild (n=114)	<4.5	85	25	4	-	85 (28.3)	29 (9.7)
Moderate (n=84)	4.5-7	10	45	29	10 (3.3)	45 (15)	29 (9.7)
Severe (n=102)	>7	5	30	67	35 (11.7)	67 (22.3)	-
				Total	45 (15.0)	197 (65.7)	58 (19.3)

among the three severity groups of periodontitis, as shown in figure 1.

### Predictive validity

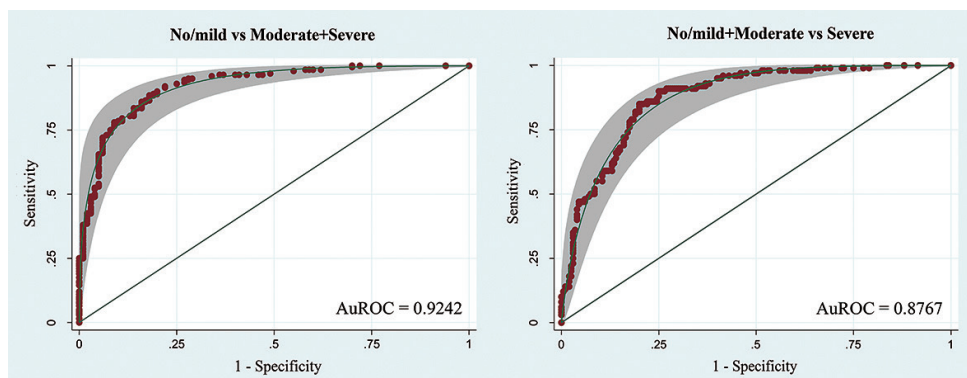
Our predictive tool discriminated moderate and severe periodontitis from no/mild periodontitis with an AuROC of 0.92 (95% CI;0.89-0.96), with the specificity of 85%, and the sensitivity of 85.5%. To distinguish severe periodontitis from no/mild and moderate periodontitis, the value of the AuROC was 0.88 (95% CI;0.84-0.92) with the

specificity of 83.5%, and the sensitivity of 67% (Figure 2).

### Discussion

The prediction of periodontitis based on a set of self-reported questions has been demonstrated to be more accurate than those based on a single question.<sup>(7,23,24)</sup> For this reason, we employed this method combined with demographic and risk factors in this study. In order to create a set of predictive model questions, multivariable ordinal logistic regression was performed. Among eight





**Figure 2:** AuROC for periodontitis case definition purposed by CDC-AAP. (Left: AuROC for moderate and severe periodontitis, Right: AuROC for severe periodontitis)

significant variables in our final model, age and tooth mobility were the most influential factors in predicting the severity of periodontitis.

Among demographic variables, age and gender were the only two significant variables included in our final model. These two variables were also included in previous predictive models.<sup>(6,11,12,14,17)</sup> Moreover, age and gender were identified as the risk indicators in the Thai study group according to the study by Torrungruang *et al.*,<sup>(25)</sup> The results of our study assure that the combination of demographic features in the predictive model can improve the accuracy of the model as shown in previous studies.<sup>(7,23,24)</sup>

As for signs and symptoms, bleeding gums and tooth mobility were two self-reported variables that can predict the severity of periodontitis. Particularly for tooth mobility, our statistical analysis showed that the adjusted odds ratio for the severity of periodontitis was 4.82 (95%CI = 2.72-8.55), which reinforces the strong influence of this variable. According to a systematic review by Abbood *et al.*,<sup>(9)</sup> tooth mobility was a highly accurate predictor for severe periodontitis defined by the CDC-AAP criteria. In addition, tooth mobility is a good indicator of severe periodontitis, as it is a simple clinical feature that both dentists and patients can correctly identify.<sup>(7,15,26)</sup> As such, it was not surprising that this predictor would regularly remain in the predictive model for periodontitis in various studies.<sup>(10,14,17)</sup> From the results of our study, bleeding gums were also a good predictor, as reported by previous studies.<sup>(11,16,21)</sup> However, one should realize that a sign of bleeding gums is not always associated with chronic periodontitis but indicates active gingivitis.<sup>(27)</sup>

In our present study, dental flossing was the only variable in the oral hygiene care category that predicted the severity of periodontitis. This result is in line with the study conducted by Cepeda *et al.*,<sup>(28)</sup> which proved the association between dental flossing and a low prevalence of periodontitis in an American population. Moreover, this variable has also been included in many final models.<sup>(6,14,15)</sup>

In the dental history category, the influential variables were dental check-up frequency, diagnosis by a dentist, and individual assessment of periodontitis. To answer these questions effectively, the participants must have had dental examinations in the past.<sup>(7,9)</sup> In this study, only 6.33% of patients had never received any dental services. Therefore, most patients were expected to be able to report their dental history efficiently in our study. This factor probably accounts for the existence of these variables in our final model.

Smoking and diabetes are certain risk factors for periodontitis, as confirmed by previous studies<sup>(27,29-32)</sup> In our findings, both smoking and diabetes had a statistically significant correlation with the severity of periodontitis only in the univariable analysis model. Perhaps, this is due to the low incidence of smokers and diabetics in our study population, causing our model to be underpowered in predicting the disease. In fact, the result was similar to the study of Cyrino *et al.*,<sup>(15)</sup> in a Brazilian population.

Globally, the predictive ability of self-reported models has been determined by values of the sensitivity, specificity, and AuROC. According to the validity classification of the self-assessment model proposed by Nelson *et al.*,<sup>(32)</sup> the predictive ability was evaluated using

values of the sensitivity and specificity, which were defined as low (<60%), moderate (60-79%), or high ( $\geq 80\%$ ). In addition, Swets<sup>(33)</sup> assessed the model performance based on the AuROC, which was defined as low (0.5-0.7), moderate (0.7-0.9), or high ( $>0.9$ ). Referring to the aforementioned studies, some other studies<sup>(10,12-15,19)</sup> usually obtained the AuROC of the predictive model in a range of 0.79-0.94. Regarding the specificity and sensitivity, while one value was moderate or high, the other was low or moderate. In this study, when using the above criteria, the periodontitis screening model was found to have high accuracy in discriminating moderate and severe periodontitis from no/mild periodontitis with an AuROC of 0.92 (95% CI=0.89-0.96), with a specificity of 85% and a sensitivity of 85.5%. The ability of the predictive model to discriminate severe periodontitis from no/mild and moderate periodontitis was fair with an AuROC of 0.88 (95% CI=0.84-0.92), with the specificity of 83.5%, and the sensitivity of 67%. It can be noted that the model has a higher validity in predicting moderate and severe periodontitis than severe periodontitis. This result is consistent with our focus on using the model to screen the disease in patients from the early stages of the disease. This can lead to an in-time treatment process that reduces the rate of tooth loss from periodontitis.

Our study has strengths and limitations. For strengths, firstly, this study provided a methodology for evaluating the disease using the widely accepted CDC-AAP criteria for epidemiological research in periodontitis.<sup>(34)</sup> These criteria were combined with full-mouth examination at six sites of teeth, which is the “gold standard” measurement.<sup>(35)</sup> In addition, the periodontal assessments were performed by a trained dentist and calibrated by two periodontists. All of these helped to reduce the chance of misdiagnosis. Secondly, in the study, several question variables relating to periodontitis were applied to identify a set of good predictors effectively. Moreover, to our knowledge, this is the first periodontitis predictive model in a Thai population that implements the scoring system alongside applicable recommendations. Meanwhile, for limitations, the study population was who received dental care at the Faculty of Dentistry, which is considered a convenient sample. Our samples may not represent the Thai population as a whole. More than half of the participants had high education and income level, and nearly all of them

had dental care experience before participating in this study. Prevalence of smoking and having diabetes were low, which were acknowledged as strong risk factors for periodontitis. Thus, the final model may be influenced, and the generalizability of the study results may be limited.

The periodontitis screening model that we have developed may be utilized as a clinical disease screening tool, or for the epidemiological surveillance of periodontitis. In order to achieve external validity, a similar study in a more extensive and diverse population should be conducted. Moreover, this model should be further analyzed for its usage in other populations.

### Clinical implications

Our main objective was to develop a simple screening tool for patients to conduct a preliminary periodontitis evaluation for themselves. To achieve this goal, a scoring system was developed. It predicted the severity of periodontitis with 65.7% accuracy, underestimated (false negative) by 19.3%, and overestimated (false positive) by 15%. The false negative should be as low as possible in order to warn patients with periodontitis. However, patients in each severity group should be given suitable but different recommendations as follows:

1) No/mild periodontitis (scores<4.5): Patients in this group tend to have little or no noticeable symptoms of periodontitis. Even so, regular individual oral hygiene is still necessary. Visiting the dentist twice a year for plaque removal and oral check-up are also needed. In addition, treatment planning for this group is usually not complicated, and a high success rate of treatment is to be expected,

2) Moderate periodontitis (scores 4.5-7): Patients in this group may need to be treated by a periodontist. They need not only scaling and root planing, but maybe also periodontal surgery. Assessment of risk factors for periodontitis is recommended. After complete treatment, the patients are highly recommended to see a periodontist according to their individual needs, in order to maintain good periodontal status,

3) Severe periodontitis (scores>7): Patients in this group should immediately see a periodontist to assess the periodontal condition and to receive proper treatment, due to the possibility of tooth loss. Most of such patients require complex treatment procedures or even a plan for denture placement.

## Conclusions

Our periodontal disease screening tool demonstrates adequate accuracy and represents a promising tool for predicting periodontitis in a Thai study group. The predictive model has high accuracy in discriminating between moderate and severe periodontitis. We have identified age and tooth mobility as the most powerful question variables in the model. Our developed scoring system shows the potential to classify patients into three severity groups of periodontitis, as defined by the CDC-AAP criteria. The validation of this model should be further investigated in a more extensive and diverse population.

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## Conflicts of interest

The authors declare no conflicts of interest.

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