Self-perception oral malodor and risk predictors in a group of Thai dental patients

Supawadee Naorungroj[1], Supitcha Talungchit[1], Kaewkwan Tanthai[1], Benjaporn Tantipichiankul[2], Ratirat Klawpai[3], Kanchanit Sittiyuno[4], Keeratirat Aompornnararat[5]

1. Department of Conservative Dentistry, Faculty of Dentistry, Prince of Songkla University.
2. Department of Prosthodontic Dentistry, Faculty of Dentistry, Prince of Songkla University.
3. Dental Department of Sichon Hospital, Nakornsrithammarat.
4. Dental Department of Phipun Hospital, Nakornsrithammarat.
5. Dental Department of Lamthap Hospital, Krabi.

Abstract

This cross-sectional study determined the prevalence of self-perception malodor and associated predictors in a group of Thai dental patients. A self-administered questionnaire, subjective assessment of oral malodor, an oral health examination, and volatile sulfur compounds (VSCs) analysis using a portable gas chromatograph were carried out on 185 dental patients. A multivariate model using multinomial regression, in which the outcome was a dichotomous variable indicating self-perceived oral malodor (mild vs. none and moderate to severe vs. none), was performed.

Approximately 63% of the participants reported having a bad breath experience. There was no significant distributional difference in self-reported oral malodor by gender, education, self-reported medical history, smoking, and tooth brushing. Self-reported oral malodor was positively associated with plaque deposit and gingival inflammation levels, but not with the extension of probing depth, tongue coating, and VSCs concentrations. In a multinomial logistic regression model, compared to reporting no odor detected, female and plaque deposits were significantly associated with increased odds of reporting mild level of malodor (OR = 3.10; 95% CI = 1.23-7.78) and moderate to severe level of malodor (OR =1.82; 95% CI = 1.09-3.03), respectively. In conclusion, self-perceived oral malodor was associated with being female and poor oral hygiene.

Clinical article (J Int Dent Med Res 2022; 15(2): 802-808)

Keywords: Oral malodor, volatile sulfur compounds, oral hygiene, self-reported, plaque.

Received date: 13 March 2022 **Accept date:** 26 April 2022

Introduction

Malodor or halitosis, defined as an offensive or unpleasant odor emanating from the mouth, is a common oral complaint among the general population, affecting interpersonal social communication.[1-4] The prevalence of oral malodor considerably varies between studies due to different methodologies, year of publication, and socioeconomic background of the country.[1, 4-8] A worldwide pooled estimate prevalence of halitosis was 31.8%.[8] However, two studies in Thailand have reported greater self-perceived malodor prevalence (61-71%).[5, 6] Oral malodor was associated with several risk factors such as dry mouth, smoking, dietary habits, and alcohol consumption.[1, 3, 9, 10]

The occurrence of odorous substances can be derived from intra-oral and extra-oral sources. The intra-oral etiology is primarily associated with the by-products of oral bacterial metabolic degradation, especially in periodontal pockets and on the dorsal tongue surface.[4, 11] Plaque deposit and gingival inflammation were associated with oral poor hygiene.[12] Other intra-oral sources contributing to intra-oral malodor included healing wounds, deep caries exposed pulps, prostheses, and fixed orthodontic appliances.[13] Volatile sulfur compounds (VSCs) consisting of hydrogen sulfide, methyl mercaptan, and dimethyl sulfide are the most conspicuous malodorous compounds. Gram-negative and proteolytic nitrate-producing anaerobic bacteria played an essential role in VSCs production.[1, 3, 14]

Corresponding author:
Supawadee Naorungroj
Department of Conservative Dentistry,
Faculty of Dentistry, Prince of Songkla University,
15 Kanjanavanich Rd, Hat Yai, Songkhla, Thailand, 90112.
E-mail address: supawadee.n@psu.ac.th

Direct assessment methods for oral malodor include the organoleptic test, gas chromatography, and portable sulfide monitor (Halimeter). To facilitate clinical implementation, portable gas chromatography (i.e., Oral Chroma^{TM}) has been developed to measure sulfur-containing compound levels inside the mouth.[3, 15, 16] Previous clinical studies have demonstrated associations of self-reported malodor with various clinical indicators of periodontal diseases or poor oral hygiene, including pocket depth, gingival bleeding, gingival swelling, plaque deposit, tongue coating,[5-7, 17] and organoleptic test or VSCs concentrations.[3]

The agreement of self-assessment oral malodor with an organoleptic assessment conducted by trained dentists or VSCs was inconsistent and not strong.[9, 18, 19] An accurate diagnosis is essential for decision making and management of oral malodor.[4, 11, 20, 21]

Clinicians need to evaluate its causes using objective measurement and understand patients' perception of breath odor. The present study aimed to determine the prevalence of self-perception malodor and its correlated predictors in a group of Thai dental patients.

Materials and methods

This cross-sectional study was performed after approval by the Ethics Committee of the Faculty of Dentistry (EC5904-17-J-LR). The target population was outpatients who visited the dental student clinic between May 2016-March 2017. Participants who met the following inclusion criteria were eligible for enrollment in the study: male or female aged 35-55 years with a minimum of 20 natural teeth. Participants who had fixed orthodontic appliances; needed prophylactic antibiotic coverage; taken antibiotics or anti-inflammatory medications during the last two months; suffered from a respiratory dysfunction, sinusitis, and tonsilitis; had undergone surgical removal of the impacted tooth in the past week, or had any periodontal treatments in the past two weeks were excluded from the study. A total of 185 participants who met the study inclusion and exclusion criteria gave written informed consent.

All participants completed a standardized self-administered questionnaire concerning health and oral health behaviors, presence or absence of subjective oral malodor symptoms, and related items.[5] The examination was carried out between 7.30-9.00 am. Prior to the assessment, participants were instructed to abstain from using scented personal products, having breakfast, and brushing their teeth for at least 2 hours before the examination. They were also advised to avoid smoking, drinking coffee and alcohol, using oral hygiene products, and chewing gum for at least 12 hours; eating strong-smelling food and drinking at least 24 hours before measurement. Participants were asked to cover their mouth with hands and keep their lips closed for 10 seconds, then exhale briefly with moderate effort through the mouth and instantly smell the expelled air. Subjective oral malodor was assessed using a scale of 0 to 3 as follows: 0 = no odor; 1 = mild odor; 2 = moderate odor; 3 = severe odor.

Following the subjective evaluation of oral malodor, the VSCs of each participant were measured by a portable gas chromatograph (Oral Chroma^{TM} CHM-2, Nissha FIS Inc. Osaka, Japan) according to the manufacturer's instructions. A disposable 1 ml syringe was placed into the oral cavity, and the participants were instructed to nose breathe for 30 seconds while sealing and unventilating the mouth cavity. Following that, the syringe drew 1.0 ml of the air sample, and the collected sample was injected into the Oral Chroma CHM-2. Hydrogen sulfide, methyl mercaptan, and dimethyl sulfide concentration were automatically calculated and recorded. A single trained examiner completed all VSCs measurements.

All participants were examined using a dental mirror and periodontal probe in a dental chair. The number of remaining teeth was recorded. Oral hygiene assessment includes plaque deposit, using Stallard plaque index at buccal and lingual sites.[22] Probing depth was determined at mesiobuccal, mesiolingual, distobuccal, and distolingual areas of all teeth except for the third molars. The condition of gingivae, using the Loe and Silness gingival index, was evaluated at mesial and distal papilla.[23] The presence of tongue coating using the Winkel Tongue Coating index (WTCI) was also evaluated. The dorsum of the tongue was divided into six sections. The coating density of each section was evaluated as follows: no coating = 0; light coating = 1; and heavy coating = 2. The tongue coating value was obtained by the summation of all six scores, ranging from 0-

12.[24] The clinical measurements were made by two calibrated examiners. They were trained and calibrated by and against a 'senior examiner' in a pilot study of 5 subjects. The method of examination and scoring was standardized until inter - examiner reliability (percentage of agreement) exceeded 80% for tongue coating, probing depth, gingival index, and plaque index.

Median, maximum, and minimum values were obtained per subject for plaque index, gingival index, and tongue coating scores. Percentage of sites with probing depth greater than 3 mm was calculated. Hydrogen sulfide, methyl mercaptan, and dimethyl sulfide levels were grouped as a binary variable using the cognitive threshold level proposed by the manufacturer of the device, which was <112 *vs.* ≥112 ppb; <26 *vs.* ≥26 ppm; <8 ppb *vs.* ≥8 ppm, respectively. Self-assessment malodor was grouped as none, mild, and moderate to severe. Chi-square tests analyzed bivariate associations between self-perception malodor with nominal, binary, and categorical variables. The non-parametric Kruskal-Wallis test was used to determine differences between groups regarding the plaque index, gingival index, tongue coating index, and %probing depth >3 mm. The correlations of VSCs concentrations with three levels of self-perception malodor and clinical indicators of periodontal disease and oral hygiene were assessed using Spearman's correlation coefficient. Bonferroni adjusted p-value was performed for multiple comparisons. To estimate the adjusted odds ratio (OR) and 95% confidence interval (CI) of self-perceived oral malodor (mild *vs.* none and moderate to severe *vs.* none), multinomial logistic regression was performed. In the model, plaque index, gingival index, tongue coating index, and %probing depth >3 mm variables were categorized into tertiles, and the linearity of these variables was assumed. Potential predictors were included in the model. All statistical analyses were carried out with STATA MP version 16.0 (StataCrop LP, Texas, USA).

Results

Overall self-perception malodor (mild to severe) prevalence among patients seeking dental care was 62.7%, with a prevalence of 26.5% for the moderate to the severe group. The prevalence was not significantly associated with respect to gender, education levels, systemic diseases, smoking, and tooth brushing frequency. Moreover, the cognitive threshold levels of three gases were not correlated with self-reported malodor.

Self - perception malodor was significantly associated with plaque deposit and gingival inflammation levels, but not significantly correlated with the extension of probing depth and tongue coating. However, the highest median value of the extension of probing depth and tongue coating score was observed among those who reported self-perception malodor as moderate to severe (Table 1).

Variables	All	Self-perception malodor			*P-value*
		None n=69	Mild n=67	Moderate-severe n=49	
Gender					
Male	62 (33.5)	29 (46.8)	17 (27.4)	16 (25.8)	0.119
Female	123 (66.5)	40 (32.5)	50 (40.7)	33 (26.8)	
Education levels					
≤16 years	64 (34.6)	19 (29.7)	23 (35.9)	22 (34.4)	0.148
>16 years	121 (65.4)	50 (41.3)	44 (36.4)	27 (22.3)	
Systemic diseases*					
Yes	40 (21.6)	15 (37.5)	16 (40.0)	9 (22.5)	0.775
No	145 (78.4)	54 (37.2)	51 (35.2)	40 (27.6)	
Smoking					
Current/Past	28 (15.1)	10 (35.7)	11 (39.3)	7 (25.0)	0.934
Never	157 (84.9)	59 (37.6)	56 (35.7)	42 (26.7)	
Tooth brushing per day					
≤2 times	11 (5.9)	6 (54.5)	2 (18.2)	3 (27.3)	0.370
>2 times	174 (94.1)	63 (36.2)	65 (37.4)	46 (26.4)	
Hydrogen sulfide					
<112 ppb	94 (50.8)	34 (36.2)	35 (37.2)	25 (26.6)	0.941
≥112 ppb	91 (49.2)	35 (38.4)	32 (35.2)	24 (26.4)	
Methyl mercaptan					
<26 ppb	100 (54.0)	39 (39.0)	39 (39.0)	22 (22.0)	0.318
≥26 ppb	85 (46.0)	30 (35.3)	28 (32.9)	27 (31.8)	
Dimethyl sulfide					
<8 ppb	35 (18.9)	13 (37.1)	12 (34.3)	10 (28.6)	0.944
≥8 ppb	150 (81.1)	56 (37.3)	55 (36.7)	39 (26.0)	
%Probing depth >3 mm*	1.9(61.2, 0)	1.8 (52.7, 0)	1.8 (46.4, 0)	3.6 (61.2, 0)	0.059
Plaque index*	1.4(2.9, 0.3)	1.3(2.4, 0.3)	1.4 (2.6, 0.5)	1.6 (2.9, 0.5)	0.022
Gingival index*	1.5(2.9, 0.4)	1.4(2.3, 0.4)	1.5(2.6, 1.1)	1.5(2.9, 1.2)	0.027
Tongue coating*	6 (12, 0)	6 (12, 0)	6 (12, 3)	7 (12, 3)	0.614

Table 1. Study characteristics, health behaviors, and clinical periodontal health (n =185).

*Median (maximum, minimum)

Chi-square tests were used to analyze bivariate associations between self-perception malodor with socio-demographic, medical health, and health behaviors. Kruskal-Wallis tests were used to test the associations between self-perception malodor with clinical variables.

Table 2 presents the correlation between VSCs concentrations with clinical indicators of periodontal health and oral hygiene status. All clinical indicators were significantly associated with hydrogen sulfide. While methyl mercaptan was correlated with clinical indicators of oral hygiene and gingival inflammation, none of the clinical indicators were correlated with dimethyl sulfide.

In multinomial logistic regression model, female was more likely to report self-perception malodor than male (OR = 3.10; 95% CI = 1.23-7.78 for mild level; OR = 2.11; 95% CI = 0.81-5.50). Increased tertiles of plaque deposit were significantly associated with increased odds of reporting moderate to severe levels of malodor (OR =1.82; 95% CI = 1.09-3.03). Similarly, the increase in tertiles of %probing depth > 3mm, gingival index, and tongue coating scores increased the odds of reporting greater severity of self-perception malodor. However, a statistically significant difference was not observed. (Table 3).

Variables	Volatile sulfur compounds		
	Hydrogensulfide	Methylmercaptan	Dimethylsulfide
Self-perception malodor	0.009 *P-value = 0.902*	0.058 *P-value = 0.433*	0.061 *P-value = 0.407*
%Probing depth >3 mm	0.251 *P-value =* ***0.006***	0.190 *P-value = 0.097*	-0.022 *P-value = 0.097*
Plaque index	0.236 *P-value =* ***0.012***	0.260 *P-value =* **0.003**	-0.048 *P-value = 1.000*
Gingival index	0.274 *P-value =* ***0.002***	0.259 *P-value =* **0.004**	-0.025 *P-value = 1.000*
Tongue coating score	0.247 *P-value =* ***0.007***	0.225 *P-value =* ***0.021***	0.083 *P-value = 1.000*

Table 2. Associations of volatile sulfur compound concentrations with clinical self-perception malodor and clinical periodontal health parameters.

Values: Spearman's correlation coefficient (R). Bonferroni adjusted p-value was performed for multiple comparisons.

Variables	Self-perception malodor			
	Mild *vs.* None	*P-value*	Moderate to severe *vs.* None	*P-value*
Female vs. Male	3.10 (1.23, 7.78)	0.016	2.11 (0.81, 5.50)	0.125
>16 years *vs.* ≤ 16 years	0.69 (0.31, 1.51)	0.351	0.55 (0.24, 1.27)	0.163
Current/ past smoking vs. never	2.95 (0.90, 9.65)	0.073	1.54 (0.43, 5.48)	0.508
Tooth brushing > 2 vs.≤ 2 times per day	3.51(0.61,20.22)	0.160	2.19 (0.46, 10.38)	0.323
Systemic diseases	1.13 (0.49, 2.61)	0.780	0.89 (0.34, 2.35)	0.812
%Probing depth > 3 mm	1.00 (0.60, 1.67)	0.996	1.16 (0.65, 2.08)	0.607
Plaque index	1.30 (0.82, 2.06)	0.264	1.82 (1.09, 3.03)	0.022
Gingival index	1.11 (0.67, 1.85)	0.687	1.20 (0.68, 2.12)	0.536
Tongue coating score	0.87 (0.56, 1.33)	0.511	1.03 (0.65, 1.63)	0.907

Table 3. Multinomial logistic regression model for self-perception malodor.

Multinomial logistic regression was performed. Adjusted odd ratios (OR) and 95% confident intervals (CI) of self-perceived oral malodor (mild *vs.* none and moderate to severe *vs.* none) were calculated.

Discussion

Oral malodor seems to pose an oral health problem among Thai dental outpatients, primarily due to oral hygiene and periodontal disease. The current study's findings also support earlier reports, indicating that perceived oral malodor is weakly correlated with clinical parameters and VSC levels measured by portable gas chromatography.[25]

There are epidemiological data on halitosis prevalence.[1, 24, 25] A previous study in Thailand using a self-administered questionnaire reported that about 61% of adult patients seeking dental care concerned about oral malodor.[6] The prevalence of self-assessment malodor in this study, which used the hand-on-mouth technique, is 63%, which is consistent with the previous study. However, the prevalence is lower compared to another study in Thai pregnancy women using the same technique (71%).[5] Bad breath problem in pregnant women, that is more pronounced, may be due to hormonal change, increasing susceptibility to gingivitis; less use of dental service; and improper oral hygiene care.[5]

As expected, hydrogen sulfide and methyl mercaptan showed positive correlation with clinical indicators for poor oral hygiene or periodontal disease in bivariate analyses. However, strong associations were not observed among these parameters with was consistent with previous investigations.[20, 21] Malodorous chemical compounds, hydrogen sulfide and methyl mercaptan as byproducts of microbial amino acid metabolism, are common causes of oral-derived malodor. An increased in those sulfide levels suggests oral hygiene problem. On the other hand, dimethyl sulfide, known as the primary volatile sulfur compound in extra-oral or blood borne halitosis, is uncommon. The causes included respiratory disorders, gastrointestinal diseases, metabolic disorders, and medications.[3,26]

The results of this study are consistent with earlier research that reported a positive correlation between increased hydrogen sulfide levels with greater extension of probing depth, plaque deposit, gingival inflammation, and tongue coating.[3,20,27] Among healthy individuals without halitosis and no periodontal disease, the tongue is a common source for VSCs production.[19] Effective tongue cleaning has been shown to minimize halitosis.[28,29] Methyl mercaptan levels at high concentrations could indicate periodontitis.[3,27] However, in the present study, a significant association between methyl mercaptan levels and probing depth was not observed. During the early stages of periodontal disease, the sensor device may be unable to detect low methyl mercaptan concentration. While a previous study demonstrated that among oral pathologic halitosis patients, the greater extend of periodontal pockets was associated with higher total VSC levels and organoleptic

scores. In that study, periodontal pocket depth was considered as a reliable predictor for oral malodor treatment outcome.[20] (Figure 1).

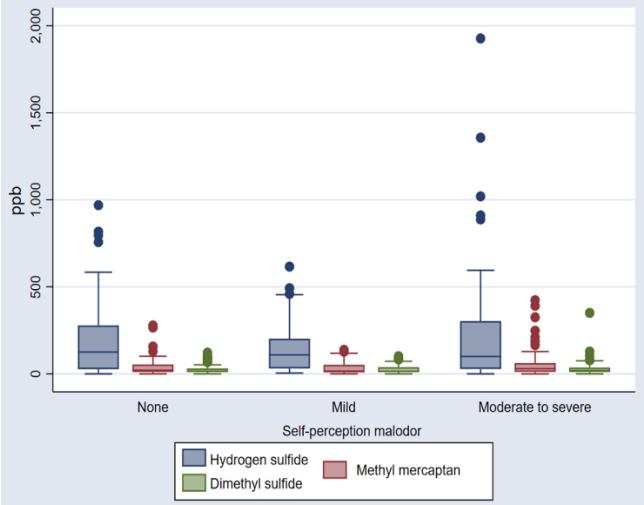

Figure 1. Self-perception malodor and volatile sulfur compounds concentrations.

VSCs level had a poor correlation with the levels of self-assessed oral malodor, which was in line with previous studies that self-perception oral malodor was less reliable than objective assessment.[9,18,19,25] This could be explained that there was a difficulty for individuals to assess their own breath[25] or a limitation of equipment. Other malodorous gaseous molecules associated with halitosis were not detected, including volatile short-chain fatty acids, alcohols, and nitrogen-containing compounds.[3] Moreover, the discrepancy may be influenced by sampling procedure. In this study, because each sample was obtained by a single examiner, this is unlikely to be a cause.

Persons' experience, stressful situation, personality traits, and gender affect how one perceived odor.[2,3,20] Gender was a significant factor in self-reported oral malodor in the present study. After controlling for covariates, female was about 3 times and 2 times more likely than male to report mild and moderate to severe oral malodor, accordingly. However, no significant difference between gender was found for moderate to severe oral malodor perception. Our finding is in agreement with previous studies examining dental patients that females were more concerned about bad breath and they tended to report having oral malodor.[30, 31] In contrast to a study in dental students that male perceived oral malodor more than female students. A possible explanation was that female students may be more embarrassed about oral malodor compared to males.[27] Additional investigation may be necessary to determine this conflicting association between gender and oral malodor.

Halitosis treatment requires not only professional dental care but also psychological support, as it has a direct effect on an individual's well-being and quality of life[4]. In some cases that complain of oral malodor, but causes are unidentified or not related to level of self-perceived oral malodor. Halitophobia may be diagnosed when a patient continues to believe that he or she has halitosis, despite reassurance, treatment, and counseling.[1,2]

The perception of bad breath also influences care-seeking behavior and attitudes toward of oral health-promotion activities. It is reasonable to suppose that dental patients might be more concerned about periodontal disease than the general population.[32] Individuals may have a more poor perception of their oral health than their counterparts. Besides being females, the tendency toward reporting a mild level of oral malodor was also observed prominently among those with more frequent tooth brushing (OR = 3.51; 95% CI = 0.61-20.22) and those with a lower tongue coating score (OR = 0.87; 95% CI = 0.56-1.33), even though statistical significance was not revealed. Additional research is required to explore the factors that influence oral malodor perception in Thai people.

The objective measurement of bad breath is essential for clinical diagnosis, management of halitosis and building a trust with patients. Several methods have been used to detect oral malodor including direct and indirect methods. The primary reference standard for the detection of oral malodor is organoleptic test, which requires experienced dentist and relies on human senses. Clinical studies supported that organoleptic test is a gold standard for oral malodor assessment as it shows significant correlation with periodontal parameters or VSCs levels.[21,33] Although this method is simple, the major disadvantages are the poor inter-and intra-examiner reliability and reproducibility.[3,34,35] Also, it may not be accepted by the patients, especially by those suffering from psychogenic halitosis. Gas chromatography is a gold standard of measurement of oral malodor; however, it is a laboratory-based and an expensive equipment.

That is not suitable for a clinical use. Two instruments, commonly used in practice to detect sulphur-containing compound level inside the mouth, are the Halimeter® and the Oral Chroma™. Portable sulfur monitor (Halimeter®) measures the total concentration of sulfur compounds, while Oral Chroma™ based on a gas chromatograph detects and discriminates the three components of VSCs.[3,35,36] A new portable device, the Breath-Alert™, which measures VSCs and hydrocarbon gas, has recently demonstrated a good diagnostic accuracy.[16] There have been significant correlations reported between organoleptic assessments and the Halimeter®, the Oral Chroma™ [21], or the Breath-Alert™.[16] The present study confirmed that using Oral Chroma™ CHM-2, a new model, provided a reliable and comprehensive chair-sided assessment of VSCs concentration in clinic.

The present study is not without limitations. The dental hospital was chosen for this study because it provides facilities necessary for a high-quality oral health examination, even though the dental patients cannot be generalized to the entire population. Their characteristics may differ from those of the general population as discussed previously. It is possible that dental patients might have a more negative perception of their oral health than general population.[32] The current study is exploratory in nature and employs a cross-sectional design using a convenience sample of dental patient. Further investigation utilizing probability sampling among the Thai population is required to conduct an in-depth analysis of the factors influencing of oral malodor perception.

Conclusions

In summary, self-perceived oral malodor was found to be substantially linked with being female, plaque accumulation, and gingival inflammation. Detection of VSCs concentration could be useful for evaluating the degree of an issue in particular patients.

Acknowledgements

The present study was funded by Faculty of Dentistry, Prince of Songkla University. The authors thank to staffs in dental hospital and patients participated in this study.

Declaration of Interest

The authors have no conflict of interest to declare.

References

1. Wu J, Cannon RD, Ji P, Farella M, Mei L. Halitosis: prevalence, risk factors, sources, measurement and treatment - a review of the literature. Aust Dent J 2020;65(1):4-11.
2. Eli I, Baht R, Koriat H, Rosenberg M. Self-perception of breath odor. J Am Dent Assoc 2001;132(5):621-6.
3. van den Broek AM, Feenstra L, de Baat C. A review of the current literature on aetiology and measurement methods of halitosis. J Dent 2007;35(8):627-35.
4. Renvert S, Noack MJ, Lequart C, Roldán S, Laine ML. The Underestimated Problem of Intra-Oral Halitosis in Dental Practice: An Expert Consensus Review. Clin Cosmet Investig Dent 2020;12:251-62.
5. Naorungroj S, Hunsrisakhun J, Talungchit S. Oral hygiene status, self-reported oral malodor, oral hygiene practices, and oral health knowledge: A cross-sectional study in a group of Muslim Thai pregnant women. Journal of International Oral Health 2018;10(5):229-36.
6. Youngnak-Piboonratanakit P, Vachirarojpisan T. Prevalence of self-perceived oral malodor in a group of thai dental patients. J Dent (Tehran) 2010;7(4):196-204.
7. Faria SFS, Costa FO, Silveira JO, Cyrino RM, Cota LOM. Self-reported halitosis in a sample of Brazilians: Prevalence, associated risk predictors and accuracy estimates with clinical diagnosis. J Clin Periodontol 2020;47(2):233-46.
8. Silva MF, Leite FRM, Ferreira LB, et al. Estimated prevalence of halitosis: a systematic review and meta-regression analysis. Clin Oral Investig 2018;22(1):47-55.
9. Aimetti M, Perotto S, Castiglione A, Ercoli E, Romano F. Prevalence estimation of halitosis and its association with oral health-related parameters in an adult population of a city in North Italy. J Clin Periodontol 2015;42(12):1105-14.
10. Kauss AR, Antunes M, Zanetti F, et al. Influence of tobacco smoking on the development of halitosis. Toxicol Rep 2022;9:316-22.
11. Izidoro C, Botelho J, Machado V, et al. Periodontitis, Halitosis and oral-health-related quality of life-A cross-sectional study. J Clin Med 2021;10(19):4415.
12. Wulandari P, Kusdhany LS, Masulili SLC, Puspitadewi SR, Baziad A. The relationship between tooth loss and gingival status with oral hygiene in postmenopausal women. Journal of International Dental and Medical Research 2021;14(3):1057-63.
13. Sinjari B, Murmura G, Caputi S, et al. Use of Oral Chroma™ in the assessment of volatile sulfur compounds in patients with fixed protheses. Int J Immunopathol Pharmacol 2013;26(3):691-7.
14. Hampelska K, Jaworska MM, Babalska Z, Karpiński TM. The Role of Oral Microbiota in Intra-Oral Halitosis. J Clin Med 2020;9(8):2484.
15. Choi KY, Lee BS, Kim JH, et al. Assessment of volatile sulfur compounds in adult and pediatric chronic tonsillitis patients receiving tonsillectomy. Clin Exp Otorhinolaryngol 2018;11(3):210-15.
16. Guedes CC, Bussadori SK, Garcia ACM, et al. Accuracy of a portable breath meter test for the detection of halitosis in children and adolescents. Clinics (Sao Paulo) 2020;75:e1764.
17. Mumghamba EG, Manji KP, Michael J. Oral hygiene practices, periodontal conditions, dentition status and self-reported bad mouth breath among young mothers, Tanzania. Int J Dent Hyg 2006;4(4):166-73.
18. Dudzik A, Chomyszyn-Gajewska M, Łazarz-Bartyzel K. An Evaluation of Halitosis using Oral Chroma™ Data Manager, Organoleptic Scores and Patients' Subjective Opinions. J Int Oral Health 2015;7(3):6-11.

19. Kameyama A, Ishii K, Tomita S, et al. Correlations between perceived oral malodor levels and self-reported oral complaints. Int J Dent 2015;2015:343527.
20. Tanaka M, Anguri H, Nishida N, et al. Reliability of clinical parameters for predicting the outcome of oral malodor treatment. J Dent Res 2003;82(7):518-22.
21. Vandekerckhove B, Van den Velde S, De Smit M, et al. Clinical reliability of non-organoleptic oral malodour measurements. J Clin Periodontol 2009;36(11):964-9.
22. Stallard RE, Volpe AR, Orban JE, King WJ. The effect of an antimicrobial mouth rinse on dental plaque, calculus and gingivitis. J Periodontol 1969;40(12):683-94.
23. Loe H, Silness J. Periodontal disease in Ppregnancy. I. Prevalence and severity. Acta Odontol Scand 1963;21:533-51.
24. Winkel EG, Roldán S, Van Winkelhoff AJ, Herrera D, Sanz M. Clinical effects of a new mouthrinse containing chlorhexidine, cetylpyridinium chloride and zinc-lactate on oral halitosis. A dual-center, double-blind placebo-controlled study. J Clin Periodontol 2003;30(4):300-6.
25. Bornstein MM, Kislig K, Hoti BB, Seemann R, Lussi A. Prevalence of halitosis in the population of the city of Bern, Switzerland: a study comparing self-reported and clinical data. Eur J Oral Sci 2009;117(3):261-7.
26. Bollen CM, Beikler T. Halitosis: the multidisciplinary approach. Int J Oral Sci 2012;4(2):55-63.
27. Rani H, Ueno M, Zaitsu T, Furukawa S, Kawaguchi Y. Factors associated with clinical and perceived oral malodor among dental students. J Med Dent Sci 2015;62(2):33-41.
28. Gonçalves ACS, Martins MCN, Paula BL, et al. A new technique for tongue brushing and halitosis reduction: the X technique. J Appl Oral Sci 2019;27:e20180331.
29. van den Broek AM, Feenstra L, de Baat C. A review of the current literature on management of halitosis. Oral Dis 2008;14(1):30-9.
30. Al-Ansari JM, Boodai H, Al-Sumait N, et al. Factors associated with self-reported halitosis in Kuwaiti patients. J Dent 2006;34(7):444-9.
31. Romano F, Pigella E, Guzzi N, Aimetti M. Patients' self-assessment of oral malodour and its relationship with organoleptic scores and oral conditions. Int J Dent Hyg 2010;8(1):41-6.
32. Blizniuk A, Ueno M, Zaitsu T, Kawaguchi Y. Association between self-reported and clinical oral health status in Belarusian adults. J Investig Clin Dent 2017;8(2):1-6.
33. Grover HS, Blaggana A, Jain Y, Saini N. Detection and measurement of oral malodor in chronic periodontitis patients and its correlation with levels of select oral anaerobes in subgingival plaque. Contemp Clin Dent 2015;6(Suppl 1):S181-7.
34. Kim DJ, Lee JY, Kho HS, et al. A new organoleptic testing method for evaluating halitosis. J Periodontol 2009;80(1):93-7.
35. Zürcher A, Laine ML, Filippi A. Diagnosis, Prevalence, and Treatment of Halitosis. Current Oral Health Reports 2014;1(4):279-85.
36. Salako NO, Philip L. Comparison of the use of the Halimeter and the Oral Chroma™ in the assessment of the ability of common cultivable oral anaerobic bacteria to produce malodorous volatile sulfur compounds from cysteine and methionine. Med Princ Pract 2011;20(1):75-9.