Clinical correlates of oral malodour in a population of patients attending a preventive clinic in Pretoria, South Africa

SADJ August 2011, Vol 66 no 7 p326 - p331

O A Ayo-Yusuf: *BDS, MSc (Odont), MPH, PhD,* Department of Community Dentistry, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

T C Postma: *BChD, MChD,* Department of Dental Management Sciences, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

C van Wyk: *Dip OH, MSc (Odont),* Department of Community Dentistry, School of Dentistry, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa.

Corresponding author

O A Ayo-Yusuf: Department of Community Dentistry, School of Dentistry, University of Pretoria; P.O. Box 1266; Pretoria; 0001; South Africa. Tel: 012 319 2514. Fax: 012 323 7616. E-mail: lekan.ayoyusuf@up.ac.za.

ABSTRACT

Aim: This study investigates the occurrence of oral malodour in an adult dental clinic population in Pretoria, South Africa, and the clinical parameters associated with the condition.

Methods: Data collected from new patients (n=896), examined by oral hygiene students under supervision of instructors, between January - October 2004, were retrospectively analysed. Subjects self-reported their medical history and smoking status. Caries experience, plaque index, pocket depths, bleeding on probing (BOP), tongue coating status, and oral hygiene practises were recorded. Malodour was diagnosed using the halimeter (≥120ppb) and an organoleptic measurement (0-5 point scale) of ≥3. Data analysis included chi-square, t-tests and logistical regression.

Results: 15.1% presented with organoleptically-determined malodour and 20.9% presented with malodour detected by the use of the halimeter. Irrespective of the diagnostic tool used, tongue coating, increased plaque levels and BOP were associated with an increased likelihood for oral malodour, while regular flossing reduced the likelihood of presenting with the condition. Periodontitis was associated with oral malodour when applying organoleptic ratings, but not with the halimeter.

Conclusions: Oral malodour prevalence corresponds with values reported in developed countries. Interdental flossing was the most effective self-care practise associated with a reduced likelihood of presenting with malodour. Halimeter performance should be further investigated in relation to varying degrees of severity of periodontal disease.

INTRODUCTION

Oral malodour, also referred to as halitosis or bad breath, is experienced by between 20% and 50% of the general population.[1] Although numerous non-oral sites and many different causes have been suggested as etiologic factors,[2] an estimated 80% to 90% of all bad breath odours originate from the mouth itself, and the tongue in particular.[3,4] Oral malodour has been reported to be caused by the same micro-organisms which cause gingivitis and periodontitis.[5,6] However, it has also been reported that a large proportion of individuals with oral malodour are periodontally healthy.[4] It has thus been proposed that the existence of active gingival inflammation[7] is more important for the production of oral malodour than is the mere presence of deeper periodontal pockets.[8]

It is well accepted that volatile sulphur compounds (VSC)[9] containing hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH) and dimethyl sulphide [$(CH_3)_2S$] are the primary substances responsible for oral malodour.[10] These gases originate from the breakdown of amino acids such as cysteine, cystine, methionine, or peptides, by microbial putrefaction within the oral cavity.[11] Measurement of oral malodour by and large relies on subjective detection of smell by human nose (organoleptic scoring),[9] while the objective measures such as the halimeter, which uses sulphur detectors, have produced varying levels of reliability.[12] The correlation between VSC levels as detected by the halimeter and oral odour smell ranges between r = 0.27[13] and r = 0.66.[12] Nonetheless, the use of the halimeter remains the commonly employed objective measure of oral malodour.

Most of the studies that have have examined oral malodour are from developed nations and have used a wide range of non-uniform criteria.[14] Despite the potential social disability associated with oral malodour,[15] there is limited information on the prevalence and clinical correlates of oral malodour in developing countries. This study was designed to investigate the occurrence and clinical parameters associated with oral malodour in an adult population in a developing country, using the halimeter and organoleptic perception, with the objective of contributing towards a locally relevant and evidence-based protocol for management of the condition.

MATERIALS AND METHODS

Study population

This retrospective cross-sectional study involved a population of all patients aged > 16 years, requiring a routine examination, who visited the Preventive Oral Health Clinic at the School of Dentistry, University of Pretoria, between January and October 2004 (n = 896). The patients were either requesting dental prophylaxis or were referred from other clinical departments for oral hygiene instruction and scaling and polishing. Each participant completed the medical and dental history questionnaire routinely used in the clinic, and signed an informed consent document permitting the use of the information obtained for research purposes. Data extracted for this study excluded personal identifiers. Other information obtained from the dental questionnaire included data on how regular was the use of additional cleaning aids other than tooth-brushing (i.e. floss, mouth rinses and tongue cleaning). Additionally, subjects were asked to report whether they currently smoked, or not.

CLINICAL MEASUREMENTS

Assessment of oral malodour

All of the 14 oral hygiene students who participated in the assessment of oral malodour were trained prior to the study by an expert in the use of the halimeter. As part of routine procedure at the Oral Hygiene Clinic, each patient was evaluated by the attending student by means of an organoleptic oral malodour score, rated as follows: 0= 'no odour'; 1= 'barely noticeable'; 2= 'slight but clearly noticeable'; 3= 'moderate'; 4= 'strong'; and 5= 'extremely strong'.

VSC values were measured using a halimeter (Interscan Corp., Chatsworth, CA, USA). Oral malodour was diagnosed if the average level of two VSC readings was ≥120 parts per billion (ppb) (value suggested by the manufacturer's instruction sheet) and if the organoleptic measurement, using the 0-5 point scale, was ≥2. However, because of the potential for measurement bias from the inexperienced noses of student judges, a narrower definition of oral malodour using an organoleptic score of ≥3 was used during analyses.

Plaque scores

Each tooth was divided into four sites, namely the mesio-buccal-occlusal, disto-buccal-occlusal, mesio-lingual-occlusal, and disto-lingual-occlusal. Plaque-covered surfaces were identified by disclosing all teeth with a proprietary brand of disclosing solution (2 Tone, Young Dental Manufacturing, MO, USA), using a cotton bud. The percentage plaque was calculated by dividing the number of the above-mentioned sites, fully or partially covered with plaque, by the total number of sites examined (teeth present in the mouth multiplied by four).

Probing depths

Full-mouth probing depths (mm) were recorded using a manual UNC probe at six sites per tooth. Guided by previously suggested criteria,[16] study participants were diagnosed as having periodontitis if the number of periodontal probing depths measuring ≥5mm were ≥5% of the total teeth examined.

Bleeding on probing (BOP)

Following probing, BOP was recorded dichotomously as any area in the mouth bleeding on probing, or not.

Table 1: Distribution of organoleptic scores according to gender, oral health-related behaviours and oral health status

		Percentage distribution organoleptic halitosis measurement				
	n	0	1	2	3&4	p-value
	889	31.4	32.1	21.5	15.1	
Sex/gender						
Males	369	20.3	30.9	26.8	22.0	<0.001
Females	520	39.2	32.9	17.7	10.2	
Tongue cleaning						
No	353	25.2	31.7	26.6	16.4	<0.01
Yes	536	35.4	32.3	18.1	14.2	
Floss daily						
No	528	25.4	28.0	25.9	20.6	<0.001
Yes	361	40.2	38.0	15.0	6.9	
Mouth rinse						
No	673	30.8	29.7	22.7	16.8	<0.01
Yes	216	33.3	39.4	17.6	9.7	
Bleed on probing						
No	718	33.0	32.9	20.8	13.4	<0.001
Yes	170	24.1	28.8	24.7	22.4	
Diagnosed periodontitis						
No	797	32.0	33.1	21.2	13.7	<0.001
Yes	42	14.3	16.7	26.2	42.9	
Decayed teeth						
No	521	36.1	33.0	17.5	13.4	<0.001
Yes	368	24.7	30.7	27.2	17.4	
Filled/restored teeth						
No	255	23.5	27.1	25.1	24.3	<0.001
Yes	634	34.5	34.1	20.0	11.4	
Tongue coating						
No	714	34.9	34.5	19.0	11.6	<0.001
Yes	175	17.1	22.3	31.4	29.1	
Smoking						
Non-smokers	637	35.9	31.7	18.5	13.8	<0.001
Smokers	252	19.8	32.9	29.0	18.3	
Sinusitis						
No	694	30.5	30.7	23.3	15.4	
Yes	195	34.4	36.9	14.9	13.8	

Assessment of tongue coating

The accumulation of tongue coating was assessed by visual examination based on a modification of the criteria of Shimizu et al[17] as follows: score 0= 'not visible', 1= 'visible coating' of a part or whole of the tongue with plaque. All the student examiners had been trained using standard colour photographs of the tongue coating.

Dental caries experience

The DMFT Index was also recorded according to the standard guidelines.[18]

After the completion of the examination, all of the above-mentioned clinical findings were confirmed, corrected and signed off by an experienced clinician.

Table 2: Tongue coating in relation to halitosis, periodontal status and oral health-related behaviours

	n	% Tongue coating	
		No	Yes
Halitosis 1			
Halimeter<120	428	88.6	11.4*
Halimeter≥120	128	78.1	21.9
Halitosis 2			
Organoleptic<3	755	83.6	16.4*
Organoleptic≥3	134	61.9	38.1
Periodontal disease			
No	803	81.0	19.0
Yes	42	69.0	31.0
Bleeding upon probing			
No	725	80.1	19.9
Yes	170	82.4	17.7
Tongue cleaning			
No	356	76.7	23.3*
Yes	540	83.0	17.0
Daily flossing			
No	534	77.7	22.3*
Yes	362	84.5	15.5
Use of mouth rinse			
No	677	79.9	20.1
Yes	231	77.9	22.1
Smoking			
No	642	85.51	14.49*
Yes	254	67.72	32.28
Sinusitis			
No	698	80.2	19.8
Yes	198	81.3	18.7

* Chi^2 - statistically significant at P<0.05

STATISTICAL ANALYSIS

All analyses were performed using the commercially available statistical package SPSS, Version 13. The data were expressed as mean ± standard deviation (SD) for all continuous variables and group differences were tested using independent t-tests. Categorical variables were analysed using chi-square tests. The Pearson correlation co-efficient was utilised to measure the correlation between halimeter and organoleptic oral malodour scores. Two multiple logistic regression models were constructed to determine the independent association of each clinical parameter with a diagnosis of oral malodour (as previously defined). The clinical parameters listed in Table 1 were entered as covariates together with age into the models. Covariates which recorded a low significance of association (p≥0.25) were subsequently dropped from the respective models. As has been mentioned, smokers were excluded from analyses involving the halimeter, in accord with the protocol for the use of the instrument.

RESULTS

Most of the study participants were middle-aged females, the sample having a mean (±SD) age of 39.9 (±16.8) years (range 16-91 years). All the study participants reported brushing at least once daily. Sixty percent of the sample reported regular tongue cleaning, 40% flossed daily, and 24% reported regular use of a mouth rinse. Of the study participants, 19% were diagnosed with BOP, 5% had periodontal pockets of ≥5mm on more than 5% of their teeth, 20% presented with a tongue coating, 41% had decayed teeth, and 71% had at least one filled tooth. The mean number of decayed- and filled teeth was 1.1 (±2.3) and 5.2 (±5.7), respectively. Of the participants, 29% reported to be a current smoker. The mean plaque score was 46.1% (±21.0) with a mean halimeter reading of 103.3 (±187.8). The mean plaque index score of those who flossed daily was significantly lower than that of those who did not practise daily flossing (41.1 vs. 49.5; p<0.05). None of the other clinical parameters showed a significant relation with the plaque index score.

Table 3: Multivariate logistic regression model for significant predictors of malodour

	Organoleptic ≥3 OR (95% CI)	Halimeter ≥120 OR (95% CI)
Age	-	0.99 (0.97-1.00)*
Female/male (1)	0.50 (0.33-0.75)*	-
Daily flossing/not (1)	0.36 (0.22-0.60)*	0.54 (0.33-0.88)*
Plaque score (continuous variable on a scale; 0-100)	1.02 (1.01-1.03)*	1.01 (1.00-1.02)*
Tongue coating/none (1)	2.57 (1.66-4.00)*	2.37 (1.35-4.18)*
Periodontitis/not (1)	3.45 (1.70-6.97)*	1.94 (0.81-4.65)
Bleed on probing/not (1)	1.46 (0.91-2.33)*	1.82 (1.08-3.04)*
Sinusitis	-	0.52 (0.27-1.01)
Diabetes	0.37 (0.10-1.40)	0.43 (0.11-1.64)

Independent variables with p>0.25 were dropped from the models *p<0.05

Organoleptically, 21.5% suffered from 'slight but clearly noticeable' malodour, while only 15.1% of the subjects presented with a moderate to strong oral malodour (Table 1). Using the halimeter, 20.9% of subjects registered a reading greater than or equal to 120 ppb. There was a modest, but significant correlation between halimeter readings and organoleptic scores (Pearson's r = 0.39; p<0.01).

In a bivariate analysis, being female was significantly associated with lower organoleptic rating of oral malodour. Furthermore, regular tongue cleaning, daily flossing and an increased number of filled teeth were also significantly associated with lower organoleptic ratings of oral malodour (Table 1). In addition, the use of mouth rinse was significantly associated with reduced levels of oral malodour, while the presence of BOP and decayed teeth, as well as smoking was associated with higher organoleptic ratings. Irrespective of the measurement method, oral malodour was significantly associated with presence of a tongue coating (Table 2).

Table 3 contains the multivariate results for non-smokers only, so as to make the two explanatory models comparable. After controlling for potential confounding factors, being female and being of a younger age was associated with reduced likelihoods of presenting with oral malodour using organoleptic measurement and the halimeter respectively (Table 3). Daily flossing remained

associated with a reduced likelihood of presenting with oral malodour while an increased plaque index score, the presence of a tongue coating, and BOP were associated with an increased likelihood of oral malodour. In particular, daily flossing was associated with 64% and 46% lower probability of being diagnosed with oral malodour using organoleptic rating and halimeter, respectively. It is however pertinent to note that periodontitis was no longer significantly associated with a diagnosis of oral malodour using the halimeter after controlling for BOP, but the condition remained significantly associated with organoleptic oral malodour scores ≥3.

DISCUSSION

This study showed that about one in five South Africans attending the preventive oral health clinic in Pretoria may have experienced oral malodour. This finding is consistent with the oral malodour prevalence previously reported for the general population in developed countries.[1,8] Also consistent with the literature,[19-21] this study showed that the presence of a tongue coating, increased plaque levels and BOP are risk indicators for the occurrence of oral malodour.

The literature indicates that the association between periodontitis and oral malodour remains ambiguous.[19,22-24] In the current study periodontitis was associated with oral malodour when determined by organoleptic scoring, but not with oral malodour measured by means of the halimeter. This finding suggests that the malodour gasses of periodontal disease origin in this sample were not significantly detected by the halimeter and might be explained by the low prevalence of diagnosed periodontitis and/or the halimeter's relatively lower sensitivity to detect methyl mercaptan compared with other VSCs like hydrogen sulphate.[25] Gas chromatography analyses has shown that methyl mercaptan is the main cause of perceptible oral malodour.[26] Methyl mercaptan is predominantly produced by *Porphyromonas gingivalis* in patients suffering from periodontitis.[11,27] Hence the methyl mercaptan/hydrogen sulphide ratio increases with increasing pocket depth or severity of periodontal disease.[5,6,10,28] It is therefore possible that the differences in detection of malodour by halimeter and by organoleptic rating observed in this study and the inconsistencies observed in other studies[19,22-24] may be related to the differences in the clinical severity of periodontal disease in the study populations. Variation in the diagnostic criteria used could also explain the discrepancies in results. The fact that periodontitis is associated with gingival inflammation[29] and with BOP, may explain why the halimeter measurement of malodour was not significantly associated with periodontitis when BOP was controlled for.

Recent literature reviews suggests that regular self-care oral hygiene practices such as brushing, and interdental flossing are effective in reducing oral malodour.[21,30] Oral rinses provide a short term benefit,[31] but some others containing a high concentration of alcohol might exacerbate oral malodour.[32] Tongue cleaning has also been suggested as being beneficial in reducing halitosis.[21,30] Although the current study confirms the importance of plaque control, especially through daily flossing, no support could be found to indicate that tongue cleaning (as reportedly practised by the study population) and the use of oral rinses are significant independent determinants of oral malodour. It should however be noted that the lack of significant association may be a result of reporting bias, considering these were self-reported practices. Nevertheless, others have suggested that tongue cleaning without the addition of mouth rinse may not be effective in reducing oral malodour.[33]

Previous research found that compared with males, females may be more anxious about bad breath and are generally more likely to seek care, especially when experiencing oral malodour.[34-35] This might explain the significant association between being female and the reduced occurrence of oral malodour, as well as the predominant female population in the current study, despite the fact that males and females have equal access to the preventive clinic in Pretoria.

The major limitations of this study are the cross-sectional study design and the utilisation of a non-representative population sample under clinical training circumstances. It should also be noted that this sample comprises a majority of dentally aware adults who may have demanded dental services elsewhere in the past, as reflected in the relatively high average number of dental restorations, as well as the high frequency of interdental flossing, tongue scraping, and the use of oral rinses. This might explain the protective effect of filled teeth on oral malodour. It has indeed been established that adults with more access to dental care in South Africa have more filled teeth than those who do not.[36]

The reliability of the data collected by oral hygiene students was ensured by the double-checking and signing off of every detail on the dental record by an experienced supervising clinician. Some measurement bias, however, cannot be excluded since it could not always be determined whether the patients had complied with the instructions pertaining to the protocol for breath sampling using the halimeter. Lastly, the data presented is dated, but the associations reported are not likely to have changed with time. Furthermore, the study was conducted at a time when the halimeter was routinely used in the clinic. The strength of this study is the use of an objective measure of halitosis along with a subjective measure, while controlling for several clinical parameters in a relatively large sample of adults. Despite the limitations, this study provides useful information on clinical correlates of oral malodour in a dental clinic population within a developing country.

CONCLUSIONS

Although further studies are indicated, the results of this study indicate that the prevalence of oral malodour in this dental clinic sample falls within the range previously reported for populations in developed countries. However, the study findings in relation to halimeter measurements highlight the need to further investigate the performance of the halimeter instrument in relation to varying degrees of severity of periodontal disease.

Oral conditions, namely the presence of a tongue coating, poor plaque control, BOP and periodontitis were identified as risk

indicators of oral malodour. Plaque control, particularly daily flossing was identified as an important intervention to reduce oral malodour in the studied population.

Declaration: No conflict of interest.

REFERENCES

1. Klokkevold PR. Oral malodour: A periodontal perspective. *J Calif Dent Assoc* 1997; **25**: 153-9.
2. Messad DV. Oral and non-oral sources of halitosis. *J Calif Dent Assoc* 1997; **25**: 127-31.
3. Tonzetich J. Production and origin of oral malodour: A review of mechanisms and methods of analysis. *J Periodontol* 1977; **48**:13-20.
4. Lee CH, Kho HS, Chung SC, Lee SW, Kim YK. The relationship between volatile sulfur compounds and major halitosis-inducing factors. *J Periodontol* 2003; **74**: 32-7.
5. Yaegaki K, Sanada K. Biochemical and clinical factors influencing oral malodour in periodontal patients. *J Periodontol* 1992a; **23**: 783-9.
6. Coil JM, Tonzetich J. Characterisation of volatile sulphur compounds production at individual gingival crevice in humans. *J Clin Dent* 1992; **3**: 97-103.
7. Morita M, Wang HL. Relationships between sulcular sulphide levels and oral malodour in subjects with periodontal disease. *J Periodontol* 2001; **72**: 79-84.
8. Miyazaki H, Sakao S, Katoh Y, Takehara T. Correlation between volatile sulphur compounds and certain oral health measurements in the general population. *J Periodontol* 1995; **66**: 679-84.
9. Greenman J. Rosenberg M. Proceedings of the Sixth International Conference on Breath Odour. *Oral Dis* 2005; **11** (Suppl 1): 5-6.
10. Yaegaki K, Sanada K. Volatile sulfur compounds in mouth air from clinically healthy subjects and patients with periodontal disease. *J Periodontal Res* 1992b; **27**: 233-8.
11. Persson S, Claesson R, Carlsson J. The capacity of subgingival microbiota to produce volatile sulfur compounds in human serum. *Oral Microbiol Immunol* 1989; **4**: 169-72.
12. Oho T, Yoshida Y, Shimazaki Y, Yamashita Y, Koga T. Characteristics of patients complaining of halitosis and the usefulness of gas chromatography for diagnosing halitosis. *Al Surg Oral Med Oral Pathol Oral Radiol Endod* 2001; **91**: 531-4.
13. Delanghe G, Ghyselen J, Feenstra L, van Steenberghe D. Experiences of Belgian multidisciplinary breath odour clinic. In: Bad breath, a multidisciplinary approach, eds. van Steenberghe D, Rosenburg M pp. 199-208. Leuven: Leuven University Press: 1996
14. Iwanicka-Grzegorek E, Michalik J, Kepa J, Wierzbicka M, Aleksinski M, Pierzynowska E. Subjective patients' opinion and evaluation of halitosis using halimeter and organoleptic scores. *Oral Dis* 2005; **11**: 86-8.
15. Hine MK. Halitosis. *J Am Dent Assoc* 1957; **55**: 37-46.
16. Bergström J. Tobacco smoking and risk for periodontal disease. *J Clin Periodontol* 2003; **30**: 107-13.
17. Shimizu T, Ueda T, Sakurai K. New method for evaluation of tongue-coating status. *J Oral Rehabil* 2007; **34**(6): 442-7.
18. World Health Organisation. Oral health surveys: Basic methods. 1997; 4th edition, p. 41-46. Geneva. World Health Organisation.
19. Bosy A, Kulkarni GV, Rosenberg M, McCulloch CA. Relationship of oral malodour to periodontitis: Evidence of independence in discrete subpopulations. *J Periodontol* 1994; **65**: 37-46.
20. De Boever EH, Loesche WJ. Assessing the contribution of anaerobic microflora of the tongue to oral malodour. *J Am Dent Assoc* 1995; **126**: 1384-93.
21. Porter SR, Scully C. Clinical review. Oral Malodour (halitosis). *Br Med J* 2006; **333**: 632-5.
22. Figueiredo LC, Rosetti EP, Marcantonio E Jr, Marcantonio RA, Salvador SL. The relationship of oral malodour in patients with or without periodontal disease. *J Periodontol* 2002; **73**: 1338-42.
23. Sharma NC, Galustians HJ, Qaquish J, Galustians A, Rustogi KN, Petrone ME, et al. The clinical effectiveness of a dentifrice containing triclosan and a copolymer for controlling breath odour measured organoleptically twelve hours after tooth brushing. *J Clin Dent* 1999; **10**: 131-4.
24. Tanaka M, Anguri H, Nonaka A, Kataoka K, Nagata H, Kita J, *et al*. Clinical assessment of oral malodour by the electronic nose system. *J Dent Res* 2004; **83**: 317-21.
25. Furne J, Majerus G, Lenton P, Springfield J, Levitt DG, Levitt MD. Comparison of volatile sulphur compound concentrations measured with a sulphide detector vs. gas chromatography. *J Dent Res* 2002; **81**: 140-3.
26. Awano S, Koshimune S, Kurihara E, Gohara K, Sakai A, Soh I, *et al*. The assessment of methyl mercaptan, an important clinical marker for the diagnosis of oral malodour. *J Dent* 2004; **32**: 555-9.
27. Tanaka M, Yamamoto Y, Kuboniwa M, Nonaka A, Nishida N, Maeda K, *et al*. Contribution of periodontal pathogens on tongue dorsa analyzed with real-time PCR to oral malodour. *Microbes Infect* 2004; **6**: 1078-83.
28. Hamlet SM, Cullinan MP, Westerman B, Lindeman M, Bird PS, Palmer J, *et al*. Distribution of Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis and Prevotella intermedia in an Australian population. *J Clin Periodontol* 2001; **28**: 1163-71.
29. Ratcliff PA, Johnson PW. The relationship between oral malodour, gingivitis and periodontitis. *J Periodontol* 1999; **70**: 485-9.
30. Quirynen M, Zhao H, van Steenberghe D. Review of the treatment strategies for oral malodour. *Clin Oral Investig* 2002; **6**: 1-10.
31. Bosy A. Oral malodour: Philosophical and practical aspects. *J Can Dent Assoc* 1997; **63**: 196-201.
32. Rosenberg M. Clinical assessment of bad breath: current concepts. *J Am Dent Assoc* 1996; **127**: 475-82.
33. Quirynen M, Zhao H, Soers C, Dekeyser C, Pauwels M, Coucke W, *et al*. The impact of periodontal therapy and adjunctive effect of antiseptics on breath odour-related outcome variables: a double-blind randomized study. *J Periodontol* 2005; **76**: 705-12.
34. Almas K, Al-Hawish A, Al-Khamis W. Oral hygiene practises, smoking habit, and self-perceived oral malodour among dental students. *J Contemp Dent Pract* 2003; **4**: 77-90.
35. Rosenberg M, Leib E. Experiences of an Israeli malodour clinic. In: Bad breath: Research perspectives, ed. Rosenberg M., 1995; pp. 137-48. Tel Aviv: Ramot Publishing.
36. Van Wyk PJ. National Oral Health Survey – South Africa 1988/89. A report of the first National Survey of South Africa. 1994: 72-92. Pretoria. Department of Health.

EOWS080811CMD