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Etiology and characteristics of halitosis in patients of a halitosis centre in Northen Italy.

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ABSTRACT

BACKGROUND*:* As there are few studies in Europe describing characteristics of breath malodor for large groups of patients, this retrospective study was designed to analyse the etiology of halitosis among patients attending a breath malodor centre in Northen Italy.

METHODS: Clinical records of 547 consecutive patients were reviewed and data on self-perceived halitosis, organoleptic scores, volatile sulphur compound (VSC) levels, and oral health condition were extracted and analysed.

RESULTS: The prevalence of intra-oral halitosis was 90.7%. In 21 patients no objective signs of breath malodour could be found. Periodontitis and gingivitis were the main cause of bad breath in 33.9% of subjects and in combination with tongue coating in 55.2%. Only eight subjects have tongue coating as the only cause of halitosis. Ear, nose and throat (ENT)/extra-oral causes were found in 5.2% of the patients. VSC concentrations were lower in the psychogenic halitosis group, whereas no statistically significant differences were detected when comparing intra-oral and extra-oral halitosis except for $(CH_3)_2S$.

CONCLUSION: Psychogenic halitosis is a rare condition among subjects complaining of suffering from bad breath. The most prevalent cause of halitosis is intra-oral, in particular a combination of tongue coating and periodontal disease. Tongue coating is rarely the primary cause of oral malodour.

Keywords: Halitosis – Periodontitis - Self-assessment – Sulfur.

Introduction

Halitosis is a common condition in an adult population characterized by an unpleasant odour in expired air, regardless of its oral or non-oral origin.[1] It is estimated that it occurs approximately in 38.8% of the general population, as reported in a recent systematic review.[2] Hydrogen sulphide (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulphide [$(CH_3)_2S$] constitute approximately 90% of the volatile sulphur compounds (VSCs) in exhaled air and they are probably the major contributors to the objectionable odours in bad breath.[3,4] The potential sources of VSCs are variously located.[5,6] In 85-90% of halitosis the source is in the oral cavity and maleodorants are produced by degradation of sulphur-containing substrates, for example food debris, blood or epithelial cells, by anaerobic Gram-negative bacteria.[5,6] There is general consensus from epidemiologic studies that the dorso-posterior region of the tongue is the primary site of malodour production in the oral cavity.[7-10] In a study from Switzerland one-third of the examined subjects had tongue coating as the predominant cause of oral malodour.[11] In Belgium 43.3% and 18.2% out of 2000 patients attending a halitosis clinic had tongue coating alone or in combination with gingivitis and periodontitis, respectively, as oral source of halitosis.[12] However, some disagreement exists in the literature over to what extent periodontal disease and tongue coating are related. Some Authors suggested that tongue odour might be an important source of odorous compounds, regardless of periodontal conditions, and that tongue coating formation is poorly related to periodontal status.[13,14] In contrast, others observed greater tongue-coating accumulation in periodontitis than in gingivitis[15,16], and significant interactions between periodontitis, degree of tongue coating and severity of halitosis[17].

Approximately 10% of objective halitosis has extra-oral etiology, including ear, nose and throat (ENT) disorders (3%) and upper respiratory tract pathologies (4%).[1,12,18] Other non-oral sources of halitosis include some systemic diseases (e.g. diabetes and kidney diseases),

metabolic or hormonal changes, certain gastrointestinal tract disturbances, medications and carcinomas.[1,6,18] Moreover, multiple causes may be present at the same time and over the course of time the aetiology may shift. In this context, patients suffering from systemic diseases such as diabetes mellitus and rheumatoid diseases are significantly more likely to have periodontitis than healthy controls.[19,20] Thus, it is important to get a proper diagnosis.

Since there is no ideal halitosis diagnostic test, all available evidence sources should be utilized to discriminate between oral and non-oral sources of halitosis, building a clinical picture that allows more confident diagnosis.[21] The primary methods for measuring halitosis are organoleptic evaluation, gas chromatography and sulphide monitoring.[6,18] However, in Europe only few studies documented the characteristics of halitosis in large groups of patients and no one reported data on VCS levels and organoleptic scores to differentiate between oral and extra-oral halitosis.[12,22,23]

As there are no large-scale studies addressing this topic in the adult population in Italy, the aims of the present retrospective study were: 1) to analyse the oral and extra-oral aetiology of halitosis among patients attending a specialized centre in North Italy using Oral Chroma™ Data Manager, organoleptic scores and self-perception of bad breath, 2) to evaluate VSC levels in comparison with clinical diagnosis, and 3) to examine the relationship between oral health status and degree of breath odor.

Material and Methods

Study design

This study was a retrospective non-interventional clinical study based on sociodemographic, breath odor and clinical documentation collected from patients' records. The study was carried out in accordance with the ethical principles of the World Medical Association Declaration of Helsinki.

Patient selection

Data were retrieved from records of patients who consecutively visited for consultation a breath odor centre (C.I.R. Dental School, Periodontology Department, University of Turin) from January 2012 to December 2017. This is the reference centre for halitosis in Piedmont delivering diagnostic confirmation and therapy. Subjects qualified for participation in the study if they were older than 18 years and were dentate. Pregnant or lactating women and patients taking medications interfering in the VSC production (*e.g.* antidepressants) were excluded.[24]

Data extraction

All data of patients meeting the inclusion criteria were obtained from records review by one operator (L.C.) with a second operator (F.R.) auditing data capture for completeness and accuracy. Data were recorded anonymously and entered into a dataset for statistical analysis.

Data related to medical and dental history and self-perception of halitosis

They included information on socio-demographics, medical history (ENT pathologies, metabolic disorders, upper and lower respiratory tract pathologies, gastrointestinal tract disturbances), lifestyle factors (smoking and diet habits), self-perception of bad breath (type of complaint, intensity and duration of bad breath, use of masking products) and oral hygiene practices (frequency of tooth-brushing, use of interdental devices and tongue scraping).[25]

Data related to objective halitosis

Data on organoleptic and instrumental measurements of breath odor as well as on its aetiology were entered into the database. Organoleptic testing (OLT) and VSC detection were carried out at the first visit by one experienced and trained clinician (E.P.). The intra-examiner reproducibility of OLT was regularly assessed on a 6-month basis. The Cohen's Kappa values were between 0.78 and 0.92, respectively.

Oral malodour evaluation was made between 8:30 and 11:30 hours. Subjects were asked not to eat garlic, onion or spicy food 48 hours prior to their appointment and to abstain from smoking, chewing gum, using any oral rinse and freshener and drinking alcohol or coffee at least 12 h before the visit. On the morning of the appointment they were asked not to use scenting personal products and to brushing their teeth only with water. The intensity of oral molodur was scored on the 0-5 Rosenberg scale, where 0 was given for absence of odor, 1 for barely noticeable odor, 2 for slight malodor, 3 for moderate malodor, 4 for strong malodor and 5 for extremely foul malodor.[26]

The examiner also smelled nasal breath to exclude extra-oral causes.[27] Odor detectable only from the mouth is likely to be of oral or pharyngeal origin, while odor from the nose alone is likely to have an ENT origin. When the odor from the nose and mouth is of similar intensity, a systemic cause of the malodor may be likely.[27] Whenever the medical history and the organoleptic assessment pointed to an extra-oral cause of halitosis, an ENT specialist or an internist/psychiatrist also examined the patients to get a diagnosis. Patients were classified according to the halitosis classification by Miyazaki et al.[28] as modified by Quirynen et al.[12].

The VSC levels were quantified with a portable gas chromatograph (OralChroma^{TM} Abilit Corp., Osaka City, Japan) which measures the concentration of H_2S, CH_3SH and $(CH_3)_2S$. A disposable all-plastic 1-ml syringe was inserted into the patient's mouth for 3 min, and a volume of 0.5 ml of sampled air was injected into the inlet of the device. VSC were analysed authomatically in 8 minutes and the concentration values of the three gases were displayed in parts per billion (ppb). The VSC threshold levels of oral malodour according to the manufacturer's instructions were as follows: $H_2S > 112$ ppb or $CH_3SH > 26$ ppb or $(CH_3)_2S > 8$ ppb.

Data related to oral conditions

For this study the following parameters were evaluated: full mouth plaque score (FMPS), full

mouth bleeding score (FMBS), mean probing depth (PD), mean clinical attachment level (CAL), number of moderate (PD of 4 to 5 mm) and deep pockets (PD ≥ 6 mm), and tongue coating score (TCS). TCS was calculated by multiplying the thickness score (0 = none; 1 = thin, tongue papillae visible; 2 = moderate, tongue papillae invisible; 3 = thick tongue coating) by the area score (0 = none, 1 = <1/3 of the tongue, 2 = 1/3– 2/3 of the tongue, 3 = >2/3 of the tongue).[29] Based on these parameters, patients were retrospectively diagnosed as having healthy conditions, gingivitis or periodontitis. They were classified as having gingivitis if they had FMBS > 10% and no tooth with PD > 3 mm.[30] Based on Page & Eke alghoritm thay were classified as suffering from periodontitis if they had two or more interproximal sites with CAL ≥ 4 mm, or two or more interproximal sites with PD ≥ 5 mm, not on the same tooth.[31]

Statistical analysis

The patient was the statistical unit. Quantitative data were presented as mean and standard deviation, while categorical data as frequencies and percentages. The Kolmogorov-Smirnov test and the visual inspection of their histogram showed that data (except for the number of pathological sites and VSCs) were approximately normally distributed. The Chi-square test was used to examine distributional differences of gender and questionnaire variables. The independent sample *t*-test and the Mann-Whithey U-test were used to examine differences between males and females for age and oral health variables. One-way Kruskal-Wallis test was performed to examine differences in VSC values according to OLT score and aetiology of halitosis. VSC measurement, OLT grading, TCS and oral health data were analysed for correlation using Spearman's correlation coefficient test. All statistical analyses were conducted with the significance level set at $P < 0.05$, and tests were performed using SPSS version 24.0 software (IBM Corporation, Armonk, NY, USA).

Results

Characteristics of the subjects

The records of 547 consecutive patients who complained bad breath and visited the outpatient clinic for breath malodor were reviewed. Due to data deficiency, 43 patients were excluded from the study. A total of 504 subjects, aged between 16 and 90 years, were included in the analysis. Females comprised the 55% of the sample with a mean age of 54.3 ± 16.0 years. Males were younger than females (52.1 ± 14.9 years) but no significant difference in age was detected. Only a small percentage of patients were current smokers (13.5%). About one-third of patients were referred to the halitosis centre by the general practitioner or the dentist, and 14.9% of them were prescribed unnecessary ENT or gastroscopy exams (Table I).

Most of participants had complaints of bad breath for over 3 years, and were aware of the problem through their own perception. About half (53.0%) of patients admitted that halitosis interfered with their family life, and over 40% of them used some masking products to alleviate breath malodor. No statistically significant difference was detected between males and females in any of the parameters analysed except for oral hygiene practices (P = 0.046).

Oral health status

A minority of the study subjects was periodontally healthy, whereas most of them presented plaque-induced gingivitis (44.3%) or periodontitis (49.6%). The mean values of FMPS and FMBS were 51.8 ± 21.7% and 45.9 ± 21.9%, respectively. The highest percentage of subjects had TCS of 2-4 (73%%), and only a minority had no tongue coating (9.3%). Males and females did not differ significantly in any of the oral health parameters (Table II).

Cause of halitosis

Based on the organoleptic test, the prevalence of breath malodor was 95.8%. Only in 21 patients no objective or questionable odor (OLT score 0-1) could be found (psychogenic halitosis). In 90.7% of the cases the halitosis had an intra-oral origin. Periodontitis and gingivitis were determined as the only cause of bad breath in 33.9% of subjects and in

combination with tongue coating in 55.2%. A minority of the patients (1.6%) had tongue coating as the only cause of bad breath. In about 1.4% of the cases, halitosis originated from the ENT region, with tonsillitis and sinusitis the most frequently causes. A gastro-intestinal pathology was identified in approximately 0.8% of the participants (Table III).

Halitosis measurements

Over three-quarters of the patients (75.8%) showed an OLT score ≥ 3. The OLT score was slightly greater in female (3.2 ± 1.1) than in male patients (3.0 ± 1.0), but without statistical significance (P = 0.238). The mean H_2S, CH_3SH and $(CH_3)_2S$ concentrations were 495.5 ± 339.5 ppb, 334.7 ± 245.6 ppb and 101.4 ± 68.4 ppb, respectively. VSC values did not significantly differ with gender (P ≥ 0.116). When data were stratified according to the aetiology of halitosis, VSC concentrations were lower in the psychogenic halitosis group, whereas no statistically significant differences were detected when comparing intra-oral and extra-oral halitosis except for $(CH_3)_2S$ that was detected in higher concentration in ENT and extra-oral halitosis patients (Table IV).

Correlations

As shown in Table V, VSC levels and OLT grading were positively associated ($r \geq 0.652$, $P < 0.001$). OLT scores were also positively associated with FMBS ($r= 0.491$), number of sites with PD ≥ 6 mm ($r = 0.548$), mean PD ($r = 0.321$), and TCS ($r = 0.331$). Significant correlations were also found between H_2S and CH_3SH values and number of deep pocket sites, FMBS and TCS (all $P < 0.01$). A statistically significant correlation was found between TCS, FMBS, and number of deep pocket sites (all $P < 0.01$).

Discussion

The aim of the present retrospective study was to analyse the aetiology and characteristics of bad breath in a large group of patients with a primary complaint of halitosis and to examine the relationship between degree of breath odor and oral health status.

Data from 504 Caucasian patients attending a specialized centre in Northen Italy was examined.

The present findings suggest that psychogenic halitosis is a rare condition among subjects complaining halitosis. The most prevalent cause of halitosis is intra-oral, in particular a combination of tongue coating and periodontal disease. Tongue coating alone is rarely the primary cause of oral malodor.

To the best of our knowledge this is the first study in which the aetiology and characteristics of halitosis were studied for a group of patients as large as this in Italy. A previous investigation by Settineri et al. recruited 1502 patients attending dental clinics of Messina and Reggio Calabria for dental consultation and analysed the relationship between self-reported halitosis and emotional state.[32] The presence of halitosis was not determined objectively. So far, data on the aetiology of halitosis in large groups of dental patients are restricted to Switzerland, Germany and Belgium.[12,22,23,33]

In the current study, slightly more women than men visited the halitosis centre. It has been already reported that women seem to be more willing to consult healthcare professionals about their breath odor problems than men.[7,12,] Of note, only one-third of people visiting the center were referred by the primary care practitioners or the dentists and about 15% of them were prescribed unnecessary ENT or gastroscopy exams. These findings support previous data from Europe in which health care professionals seem not adequately informed about diagnosis and treatment of halitosis.[12,23,33]

The bad breath level was objectively determined by measuring the 3 major oral-malodor related VSCs using a portable gas chromatography, as an adjunct to the organoleptic test.[34] Despite its subjective nature, the organoleptic test is still considered to be the primary indicator of halitosis as it reflects the everyday situation when halitosis is detected.[21,34] Gas chromatography distinguishes between different VSCs and may give additional information

to differentiate between intra- and extra-oral halitosis.[35] In agreement with other reports, we observed a strict correlation between OLT scores and VSC levels as determined by Oral Chroma.[16,36] Particularly, the correlation was stronger for CH_3SH level than for H_2S and $(CH_3)_2S$ levels. A stronger correlation was also noted between CH_3SH and number of deep pocket sites, suggesting that CH_3SH may be the predominant causative factor in intra-oral halitosis.[35,37]

In 90.7% of the patients an intra-oral halitosis was diagnosed. Periodontitis and gingivitis were diagnosed as the only cause of bad breath in 33.9% of subjects and in combination with tongue coating in 55.2%. Only eight subjects (1.6%) have tongue coating as the only cause of oral malodor. In a Swiss clinical study, tongue coating was found as the only factor contributing to oral malodor in 84.7% of 465 patients visiting a halitosis clinic.[23] In other large-scale studies from Belgium tongue coating and periodontal conditions were the main factors related to halitosis.[12,22] Gingivitis and periodontitis accounted for approximately 60% of the oral factors and the tongue for the other 40%.[12,22]

In contrast, in a study of 2,672 patients, from Japan, Miyazaki et al. found that tongue coating was the main cause of oral malodor in the younger cohorts, whereas periodontal diseases along with tongue coating in the older cohorts.[7] In a recent epidemiological population-based study on 744 adults periodontitis and tongue coating were found to exert a synergistic contribution to oral malodor.[17] Among individuals with severe periodontitis the odds ratio of having halitosis increased from 2.95 to 20.77 when considering low and high TCS.[17] As studies do not have a standardized evaluation protocol, it is difficult to obtain exact data on the halitosis-related parameters. Diagnostic criteria for gingivitis and periodontitis in the literature are largely variable.[38] In the current study patients were diagnosed as gingivitis if having FMBS >10% and no sites with PD >3 mm.[30] The diagnosis of moderate and severe periodontitis was made according to the CDC/AAP case definition for population-based

surveillance of periodontitis.[31] In the above mentioned investigations diagnostic criteria for gingivitis and periodontitis were not clearly defined.[12,22,23] Of note, only 7.74% of the patients included in the current study were < 30 years of age, whereas in the study by Quirynen et al. almost 4% of the patients were under the age of 15.[12] Thus, it is not possible to rule out that the role of tongue coating was underestimated in the population we examined.

In agreement with previous studies, we observed a strong correlation between TCS and severity of periodontal disease.[8,11,16,39] Microbiological studies suggest that periodontal disease-associated bacteria, mainly bacteria of the red complex, are capable of producing large amounts of VSCs and that tongue and periodontal pockets are the main habitat from which they can be isolated.[6,10] Presence and proportion of specific periodontopathogens in tongue coating are closely associated with severity of periodontal conditions.[13,40] Yet, non-surgical periodontal treatment and mechanical cleaning of the tongue are an effective method for significantly reducing VSCs and OLT scores.[41,42] In this context, the application of chemotherapeutic agents may further enhance the ability of mechanical instrumentation in reducing subgingival biofilm.[43]

The second most common cause of halitosis is the ENT region (1.4%), followed by the gastrointestinal tract (0.8%). These percentages lie in the same range reported in the literature.[1,6,44] It is worth noting that higher $(CH_3)_2S$ levels were detected in mouth air from extra-oral than intra-oral halitosis patients. Previous studies used the Halimeter for VSC measuring and did not stratify data by causes of bad breath.[12,23,33] The Halimeter has more limitations, especially in diagnosis of extra-oral halitosis. It is most sensitive for H2S, then for CH_3SH and $(CH_3)_2S$. It underestimates CH_3SH by about 31% but it markedly underestimates $(CH_3)_2S$ concentrations by 70%.[45]

In contrast to other studies, the frequency of patients with psychogenic halitosis was low (4.2%) and had slightly decreased when compared to a previous study from the same centre.[39]

As previously reported, the perception of malodor varies in culturally diverse populations.[46] Percentages of halitophobic patients ranged between 16% and 38.5% depending on the country.[12,23,33]

In agreement with data from other breath malodor consultations, we found a higher proportion of women in the group without any objective sign of bad breath.[12,23,33] Among the factors that cause psychogenic halitosis there are an increasing number of advertisements for oral hygiene products and the individual emotional state.[12,33] Of note, the percentage of subjects using masking products to combat bad breath was lower in the present study than that reported in other European countries.[12,23] We did not examine psychological factors related to the emotional state. However, Settineri et al. emphasized that 36% and 45% of Italian people with a primary halitosis compliant experienced dental anxiety and emotional stress.[32] Due to the role of anxiety and emotional factors in odor perception, organoleptic and instrumental examinations should be complemented with personality tests to evaluate self-reported halitosis.[33]

Conclusions

This is the larger database in Italy reporting data on the aetiology and characteristics of patients with a primary halitosis complaint. Although most of the cases originated from the oral cavity, 10% of the patients had nonoral causes or suffered from psychogenic halitosis. Differential diagnosis between oral and extra-oral halitosis is of utmost importance. This can be done by considering the underlying systemic conditions of the patients, by comparing mouth breath with nose breath and by carrying out a through clinical examination. The instrumental analysis is useful to detect the VSC quantitatively and to correlate them to the intensity of bad breath. However, VCS profile may not be different between oral and extra-oral halitosis except for higher intensity of $CH_3)_2S$. Presenting objective features such as Oral Chroma readings is also useful to discriminate between genuine and psychogenic halitosis

and may be beneficial to those patients whose complaint is not based on objective clinical findings.

Conflicts of interest: The authors declare that they have no conflict of interest.

REFERENCES

1. Rösing CK, Loesche W. Halitosis: an overview of epidemiology, etiology and clinical management. Braz Oral Res 2011;25:466-71.

2. Silva MF, Leite FRM, Ferreira LB, Pola NM, Scannapieco FA, Demarco FF, *et al.* Estimated prevalence of halitosis: a systematic review and meta-regression analysis. Clin Oral Invesr 2018;22:47-55.

3. Tonzetich J. Direct gas chromatographic analysis of sulphur compounds in mouth air in man. Arch Oral Biol 1971;16:587-97.

4. Van den Velde S, van Steenberghe D, Van Hee P, Quirynen M. Detection of odorous compounds in breath. J Dent Res 2009;88:285-9.

5. Tonzetich J. Production and origin of oral malodour: a review of mechanisms and methods of analysis. J Periodontol 1977;48:13-20.

6. Scully C, Greenman J. Halitology (breath odour: aetiopathogenesis and management). Oral Dis 2012;18:333-45.

7. 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.

8. Liu XN, Shinada K, Chen XC, Zhang BX, Yaegaki K, Kawaguchi Y. Oral malodour-related parameters in the Chinese general population. J Clin Periodontol 2006;33:31-6.

9. Calil C, Liberato FL, Pereira AC, de Castro Meneghim M, Goodson JM, Groppo FC. The

relationship between volatile sulphur compounds, tongue coating and periodontal disease. Int J Dent Hyg 2009;7:251-5.

10. Van Tornout M, Dadamio J, Coucke W, Quirynen M. Tongue coating: related factors. J Clin Periodontol 2013;l40:180-5.

11. 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;117:261-7.

12. Quirynen M, Dadamio J, Van den Velde S, De Smit M, Dekeyser C, Van Tornout M, *et al*. Characteristics of 2000 patients who visited a halitosis clinic. J Clin Periodontol 2009;36:970-5.

13. Apatzidou AD, Bakirtzoglou E, Vouros I, Karagiannis V, Papa A, Konstantinidis A. Association between oral malodour and periodontal disease-related parameters in the general population. Acta Odontol Scand 2012;71:189-95.

14. Tsai CC, Chou HH, Wu TL, Yang YH, Ho KY, Wu YM, *et al.* The levels of volatile sulphur compounds in mouth air from patients with chronic periodontitis. J Periodontal Res 2008;43:186-93.

15. Yaegaki K, Sanada K. Volatile sulphur compounds in mouth air from clinically healthy subjects and patients with periodontal disease. J Periodontal Res 1992;27:233-8.

16. Pham TA, Ueno M, Shinada K, Kawaguchi Y. Factors affecting oral malodour in periodontitis and gingivitis patients. J Investing Clin Dent 2012;3:284-90.

17. 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;42:1105-14.

18. Bollen CM, Beikler T. Halitosis: the multidisciplinary approach. Int J Oral Sci 2012;4:55-63.

19. Chapple Il, Genco R, Working group 2 of joint EFP/AAP workshop. Diabetes and periodontal diseases: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. J Clin Periodontol 2013;40(Suppl 14):S106-12.

20. Isola G, Williams RC, Lo Gullo A, Ramaglia L, Matarese M, Iorio-Siciliano V, *et al.* Risk association between scleroderma disease characteristics, periodontitis, and tooth loss. Clin Rheumatol 2017;36:2733-41.

21. Seemann R, Conceicao Md, Filippi A, Greenman J, Lenton P, Nachnani S, *et al.* Halitosis management by the general dental practitioner – results of an international consensus workshop. J Breath Res 2014;8:017101.

22. Delanghe G, Ghyselen J, van Steenberghe D, Feenstra L. Multidisciplinary breath-odour clinic. Lancet 1997;350:187.

23. Zürcher A, Filippi A. Findings, diagnoses and results of a halitosis clinic over a seven year period. Schweiz Monatsschr Zahnmed 2012;122:205-16.

24. Donaldson AC, Riggio MP, Rolph HJ, Bahìgg J, Hodge PJ. Clinical examination of subjects with halitosis. Oral Dis 2007 13;63-70.

25. Yaegaki K, Coil JM. Clinical application of a questionnaire for diagnosis and treatment of halitosis. Quintessence Int 1999;30:302-6.

26. Rosenberg M, McCulloch CA. Measurement of oral malodour: current methods and future prospects. J Periodontol 1992;63:776-82.

27. Porter SR, Scully C. Oral malodour (halitosis). BMJ 2006;333:632-5.

28. Murata T, Yamaga T, Iida T, Miyazaki H, Yaegaki K. Classification and examination of halitosis. Int Dent J 2002;52(Suppl 3):181-6.

29. 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. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;91:531-4.

30. Chakraborty S, Tewari S, Sharma RK, Narula SC. Effect of non-surgical periodontal therapy on serum ferritin levels: an interventional study. J Periodontol 2014;85:688-96.

31. Page RC, Eke PI. Case definitions for use in population-based surveillance of periodontitis. J Periodontol 2007;78(Suppl 7):1387-99.

32. Settineri S, Mento C, Gugliotta SC, Saitta A, Terranova A, Trimarchi G, *et al.* Self-reported halitosis and emotional state: impact on oral conditions and treatments. Health Qual Life Outcomes 2010;8:34.

33. Seemann R, Bizhang M, Djamchidi C, Kage A, Nachnani S. The proportion of pseudohalitosis patients in a multidisciplinary breath malodour consultation. Int Dent J 2006; 56:77-81.

34. Dadamio J, Laleman I, De Geest S, Vancauwenberghe F, Dekeyser C, Coucke W, *et al.* Usefulness of a new malodour-compound detection portable device in oral malodour diagnosis. J Breath Res 2013;7:046005.

35. Tangerman A, Winkel EG. Intra- and extra-oral halitosis: finding of a new form of extra-oral blood-borne halitosis caused by dimethyl sulphide. J Clin Periodontol 2007;34:748-55.

36. Takeuchi H, Machigashira M, Yamashita D, Kozono S, Nakajima Y, Miyamoto M, *et al.* The association of periodontal disease with oral malodour in a Japanese population. Oral Dis 2010;16:702-6.

37. 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.

38. Silva MF, Cademartori MG, Leite FRM, López R, Demarco FF, Nascimento GG. Is periodontitis associated with halitosis? A systematic review and meta-regression analysis. J Clin Periodontol 2017;44:1003-9.

39. Romano F, Nigella 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;8:41-6.

40. Amou T, Hinode D, Yoshioka M, Grenier D. Relationship between halitosis and periodontal disease-associated bacteria in tongue coatings. Int J Dent Hyg 2013 12:145-51.

41. Van der Sleen MI, Slot DE, Van Trijffel E, Winkel EG, Van der Weijden GA. Effectiveness of mechanical tongue cleaning on breath odor and tongue coating: a systematic review. Int J Dent Hyg 2010;8:258-68.

42. Deutcher HCD, Derman SHM, Barbe AG, Seeman R, Noack MJ. The effect of professional tooth cleaning or non-surgical periodontal therapy on halitosis in patients with periodontal diseases. A systematic review. Int J Dent Hyg 2018;16:36-47.

43. Isola G, Matarese G, Williams RC, Iorio Siciliano V, Alibrandi A, Cordasco G, *et al.* The effects of a disseccant agent in the treatment of chronic periodontitis: a randomized, controlled clinical trial. Clin Oral Invest 2018;22:791-800.

44. Tangerman A, Winkel EG. Extra-oral halitosis: an overview. J Breath Res 2010;4:017003.

45. Furne J, Majerus G, Lenton P, Springfield J, Levitt DG, Levitt MD. Comparison of volatile sulfur compound concentrations measured with a sulphide detector vs. gas chromatography. J Dent Res 2002;81:140-3.

46. Rayman S, Almas K. Halitosis among racially diverse populations: an update. Int J Dent Hyg 2008;6:2-7.

Table I. General characteristics of patients who visited the halitosis centre by gender.

Variables	Male N.=227	Female N.=277	Population N.= 504	P value
Age, years	52.1 ± 14.9	54.3 ± 16.0	53. 3 ± 15.5	0.114
Smoking				0.492
Current smokers	28 (41.2%)	40 (58.8%)	68 (13.5%)	
No/past smokers	199 (45.6%)	237 (54.4%)	436 (86.5%)	
Duration of halitosis				0.976
<1	3 (42.9%)	4 (57.1%)	7 (1.4%)	
1-3	42 (44.2%)	53 (55.8%)	95 (18.8%)	
3-5	159 (46.9%)	180 (53.1%)	339 (67.3%)	
>5	23 (36.5%)	40 (63.5%)	63 (12.5%)	
Source of complaint				0.163
Patient himself	69 (46.0%)	81 (54.0%)	150 (29.8%)	
Patient himself and others	150 (46.0%)	176 (54.0%)	326 (64.7%)	
Only others	8 (28.8%)	20 (71.4%)	28 (5.5%)	
Negative impact of halitosis				0.861
No impact	23 (46.9%)	26 (53.1%)	49 (9.7%)	
Social life	80 (42.6%)	108 (57.4%)	188 (37.3%)	
Family life	124 (46.4%)	143 (53.6%)	267 (53.0%)	
Daily oral hygiene practice				0.046
Only brushing	95 (41.5%)	134 (58.5%)	229 (45.4%)	
Brushing + Flossing	44 (42.7%)	59 (57.3%)	103 (20.4%)	
Brushing + Tongue scraper	38 (43.7%)	49 (56.3%)	87 (17.3%)	
Brushing + Flossing + Tongue scraper	50 (58.8%)	35 (41.2%)	85 (16.9%)	
Diet				0.581
No preference	92 (44.9%)	113 (55.1%)	205 (40.7%)	
Preference to meat	22 (41.5%)	31 (58.5%)	53 (10.5%)	
Preference to spicy food	91 (48.2%)	98 (51.8%)	189 (37.5%)	
Preference to sugar food	22 (38.6%)	35 (61.4%)	57 (11.3%)	
Use of masking products				0.386
Nothing	127 (43.4%)	163 (56.6%)	290 (57.5%)	
Mouthrinse	59 (51.3%)	56 (48.7%)	115 (22.8%)	
Toffee/Chewingum	35 (40.7%)	51 (59.3%)	86 (17.1%)	
Both	6 (46.2%)	7 (53.8%)	13 (2.6%)	

Data are expressed as number of subjects (proportion).

Table II. Oral health status of patients who visited the halitosis centre by gender.

Variables	Male N. = 227	Female N. = 277	Population N. = 504	*P* value
FMPS (%)	50.2 ± 21.6	53.1 ± 21.9	51.8 ± 21.7	0.137
FMBS (%)	44.2 ± 21.4	47.2 ± 23.1	45.9 ± 21.9	0.134
PD (mm)	3.1 ± 1.0	3.0 ± 0.9	3.0 ± 1.0	0.238
N. sites with PD 4-5 mm	13.6 ± 16.4	12.6 ± 16.7	13.0 ± 16.6	0.500
N. sites with PD ≥ 6 mm	5.1 ± 9.5	4.9 ± 8.5	5.0 ± 9.0	0.803
TCS	3.5 ± 1.9	3.6 ± 2.0	3.6 ± 1.9	0.568
Area score	1.9 ± 0.7	1.8 ± 0.6	1.9 ± 0.6	0.103

Data are expressed as the mean ± SD.

FMPS full-mouth plaque score, *FMBS* full-mouth bleeding score, *PD* probing depth, *TCS* tongue coating score.

Table III. Etiology of halitosis.

	Male		Female		Population
Intra-oral	93.0 %		88.8%		90.7%
Gingivitis/Periodontitis	81	(35.7%)	90	(32.5%)	33.9%
Tongue coating	3	(1.3%)	5	(1.8%)	1.6%
Combination	127	(56.0%)	151	(54.5%)	55.2%
ENT	0.8%		1.8%		1.4%
Tonsillitis	2	(0.8%)	2	(0.7%)	0.8%
Sinusitis	0	(0%)	2	(0.7%)	0.4%
Rhinitis	0	(0%)	1	(0.4%)	0.2%
Extra-oral	2.6%		4.7%		3.8%
Gastro-intestinal	1	(0.4%)	3	(1.1%)	0.8%
Medication	1	(0.4%)	0	(0%)	0.2%
Hormonal	0	(0%)	1	(0.4%)	0.2%
Combined	4	(1.8%)	9	(3.2%)	2.6%
Psychogenic halitosis	8	(3.6%)	13	(4.7%)	4.2%

Table IV. Volatile sulphur compounds (VSCs) distribution by gender, organoleptic grading (OLT) and cause of halitosis.

Parameter	N	Mean VSC_s (ppb)		
		H_2S	CH_3SH	$(CH_3)_2S$
Gender				
Male	227	474.9 (343.7)	315.7 (240.3)	99.4 (72.4)
Female	277	512.5 (335.8)	350.2 (249.2)	103.1 (64.9)
OLT				
0-1	21	27.0 (22.2)[a]	15.8 (19.5)[a]	10.9 (11.3)[a]
2-3	315	316.3 (170.3)[b]	206.2 (121.8)[b]	71.3 (34.7)[b]
4-5	168	890.2 (218.7)	615.4 (174.7)	168.2 (67.6)
Cause of halitosis				
Intra-oral	457	515.6 (336.5)	350.6 (243.9)	102.2 (53.3)
ENT	7	501.9 (282.3)	324.3 (229.0)	158.1 (60.6)[c]
Extra-oral	19	526.5 (243.2)	307.3 (183.1)	162.1 (58.6)[c]
Psychogenic halitosis	21	27.0 (22.2)[c]	15.8 (19.5)[c]	10.9 (11.3)[c]
Average		495.5 (339.5)	334.7 (245.6)	101.4 (68.4)

[a]Significant difference ($P < 0.001$) with respect to 2-3 and 4-5 OLT values.
[b]Significant difference ($P < 0.001$) with respect to 4-5 OLT values.
[c]Significant difference ($P < 0.001$) with respect to other causes of halitosis.

Table V. Pearson correlations between organoleptic score (OLT), volatile sulphur compounds (VSCs) and oral conditions**.**

Parameter	OLT	VSC_s		
		H_2S	CH_3SH	$(CH_3)_2S$
OLT	1	0.792[a]	0.881[a]	0.652[a]
FMBS	0.491[a]	0.402[a]	0.379[b]	0.213
PD	0.321[b]	0.117	0.109	0.099
N. sites with PD 4-5 mm	0.119	0.088	0.041	0.090
N. sites with PD ≥ 6 mm	0.548[a]	0.516[a]	0.494[a]	0.268
TCS	0.331[b]	0.355[b]	0.321[b]	0.187

FMBS Full-Mouth Bleeding Score, *PD* probing depth, *TCS* tongue coating score.
[a]$P < 0.001$ [b]$P < 0.01$