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*Original Citation:*

*Availability:*

This version is available <http://hdl.handle.net/2318/1765494> since 2020-12-31T08:36:31Z

*Published version:*

DOI:10.23736/S0026-4970.19.04186-4

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# UNIVERSITÀ DEGLI STUDI DI TORINO

*This is an author version of the contribution published on:  
Questa è la versione dell'autore dell'opera:*

Romano F, Pigella E, Guzzi N, Manavella V, Campanelli L, Aimetti M.

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Northern Italy

Minerva Stomatologica 2020;69(3):174-182  
doi:10.23736/S0026-4970.19.04186-4.

*The definitive version is available at:  
La versione definitiva è disponibile alla URL:*

[https://www.minervamedica.it/it/riviste/minerva-stomatologica/articolo.php?](https://www.minervamedica.it/it/riviste/minerva-stomatologica/articolo.php?cod=R18Y2020N03A0174)  
cod=R18Y2020N03A0174

## **Etiology and characteristics of halitosis in patients of a halitosis centre in Northern 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 Northern 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<sub>3</sub>)<sub>2</sub>S.

**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.<sup>1</sup> It is estimated that it occurs approximately in 38.8% of the general population, as reported in a recent systematic review.<sup>2</sup> Hydrogen sulphide (H<sub>2</sub>S), methyl mercaptan (CH<sub>3</sub>SH), and dimethyl sulphide [(CH<sub>3</sub>)<sub>2</sub>S] 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.<sup>3,4</sup> The potential sources of VSCs are variously located.<sup>5,6</sup> 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.<sup>5,6</sup> 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.<sup>7-10</sup> In a study from Switzerland one-third of the examined subjects had tongue coating as the predominant cause of oral malodour.<sup>11</sup> 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.<sup>12</sup> 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.<sup>13,14</sup> In contrast, others observed greater tongue-coating accumulation in periodontitis than in gingivitis<sup>15,16</sup>, and significant interactions between periodontitis, degree of tongue coating and severity of halitosis<sup>17</sup>.

Approximately 10% of objective halitosis has extra-oral etiology, including ear, nose and throat (ENT) disorders (3%) and upper respiratory tract pathologies (4%).<sup>1,12,18</sup> 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.<sup>1,6,18</sup> 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.<sup>19,20</sup> 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.<sup>21</sup> The primary methods for measuring halitosis are organoleptic evaluation, gas chromatography and sulphide monitoring.<sup>6,18</sup> 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.<sup>12,22,23</sup>

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.<sup>24</sup>

### ***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).<sup>25</sup>

### ***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 scented personal products and to brush their teeth only with water. The intensity of oral malodour was scored on the 0-5 Rosenberg scale, where 0 was given for absence of odor, 1 for barely noticeable odor, 2 for slight malodour, 3 for moderate malodour, 4 for strong malodour and 5 for extremely foul malodour.<sup>26</sup>

The examiner also smelled nasal breath to exclude extra-oral causes.<sup>27</sup> 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 malodour may be likely.<sup>27</sup> 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.<sup>28</sup> as modified by Quirynen et al.<sup>12</sup>.

The VSC levels were quantified with a portable gas chromatograph (OralChroma™ Abilit Corp., Osaka City, Japan) which measures the concentration of H<sub>2</sub>S, CH<sub>3</sub>SH and (CH<sub>3</sub>)<sub>2</sub>S. 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 automatically 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<sub>2</sub>S > 112 ppb or CH<sub>3</sub>SH > 26 ppb or (CH<sub>3</sub>)<sub>2</sub>S > 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  $\geq$  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).<sup>29</sup> 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.<sup>30</sup> Based on Page & Eke algorithm they were classified as suffering from periodontitis if they had two or more interproximal sites with CAL  $\geq 4$  mm, or two or more interproximal sites with PD  $\geq 5$  mm, not on the same tooth.<sup>31</sup>

### ***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-Whitney 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  $54.3 \pm 16.0$  years. Males were younger than females ( $52.1 \pm 14.9$  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  $51.8 \pm 21.7\%$  and  $45.9 \pm 21.9\%$ , 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  $\geq 3$ . The OLT score was slightly greater in female ( $3.2 \pm 1.1$ ) than in male patients ( $3.0 \pm 1.0$ ), but without statistical significance ( $P = 0.238$ ). The mean  $H_2S$ ,  $CH_3SH$  and  $(CH_3)_2S$  concentrations were  $495.5 \pm 339.5$  ppb,  $334.7 \pm 245.6$  ppb and  $101.4 \pm 68.4$  ppb, respectively. VSC values did not significantly differ with gender ( $P \geq 0.116$ ). 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  $PD \geq 6$  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 Northern 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.<sup>32</sup> 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.<sup>12,22,23,33</sup>

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.<sup>7,12</sup> 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.<sup>12,23,33</sup>

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.<sup>34</sup> 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.<sup>21,34</sup> Gas chromatography distinguishes between different VSCs and may give additional information

to differentiate between intra- and extra-oral halitosis.<sup>35</sup> In agreement with other reports, we observed a strict correlation between OLT scores and VSC levels as determined by Oral Chroma.<sup>16,36</sup> Particularly, the correlation was stronger for CH<sub>3</sub>SH level than for H<sub>2</sub>S and (CH<sub>3</sub>)<sub>2</sub>S levels. A stronger correlation was also noted between CH<sub>3</sub>SH and number of deep pocket sites, suggesting that CH<sub>3</sub>SH may be the predominant causative factor in intra-oral halitosis.<sup>35,37</sup>

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.<sup>23</sup> In other large-scale studies from Belgium tongue coating and periodontal conditions were the main factors related to halitosis.<sup>12,22</sup> Gingivitis and periodontitis accounted for approximately 60% of the oral factors and the tongue for the other 40%.<sup>12,22</sup>

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.<sup>7</sup> In a recent epidemiological population-based study on 744 adults periodontitis and tongue coating were found to exert a synergistic contribution to oral malodor.<sup>17</sup> Among individuals with severe periodontitis the odds ratio of having halitosis increased from 2.95 to 20.77 when considering low and high TCS.<sup>17</sup> 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.<sup>38</sup> In the current study patients were diagnosed as gingivitis if having FMBS >10% and no sites with PD >3 mm.<sup>30</sup> The diagnosis of moderate and severe periodontitis was made according to the CDC/AAP case definition for population-based

surveillance of periodontitis.<sup>31</sup> In the above mentioned investigations diagnostic criteria for gingivitis and periodontitis were not clearly defined.<sup>12,22,23</sup> 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.<sup>12</sup> 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.<sup>8,11,16,39</sup> 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.<sup>6,10</sup> Presence and proportion of specific periodontopathogens in tongue coating are closely associated with severity of periodontal conditions.<sup>13,40</sup> Yet, non-surgical periodontal treatment and mechanical cleaning of the tongue are an effective method for significantly reducing VSCs and OLT scores.<sup>41,42</sup> In this context, the application of chemotherapeutic agents may further enhance the ability of mechanical instrumentation in reducing subgingival biofilm.<sup>43</sup>

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.<sup>1,6,44</sup> It is worth noting that higher  $(\text{CH}_3)_2\text{S}$  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.<sup>12,23,33</sup> The Halimeter has more limitations, especially in diagnosis of extra-oral halitosis. It is most sensitive for  $\text{H}_2\text{S}$ , then for  $\text{CH}_3\text{SH}$  and  $(\text{CH}_3)_2\text{S}$ . It underestimates  $\text{CH}_3\text{SH}$  by about 31% but it markedly underestimates  $(\text{CH}_3)_2\text{S}$  concentrations by 70%.<sup>45</sup>

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.<sup>39</sup>

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

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.<sup>12,23,33</sup> Among the factors that cause psychogenic halitosis there are an increasing number of advertisements for oral hygiene products and the individual emotional state.<sup>12,33</sup> 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.<sup>12,23</sup> 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 complaint experienced dental anxiety and emotional stress.<sup>32</sup> 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.<sup>33</sup>

### **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 thorough 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  $\text{CH}_3)_2\text{S}$ . 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.

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

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

<b>Variables</b>	<b>Male N. = 227</b>	<b>Female N. = 277</b>	<b>Population N. = 504</b>	<b>P value</b>
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.

	<b>Male</b>	<b>Female</b>	<b>Population</b>
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 <sub>s</sub> (ppb)		
		H <sub>2</sub> S	CH <sub>3</sub> SH	(CH <sub>3</sub> ) <sub>2</sub> S
<b>Gender</b>				
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)
<b>OLT</b>				
0-1	21	27.0 (22.2) <sup>a</sup>	15.8 (19.5) <sup>a</sup>	10.9 (11.3) <sup>a</sup>
2-3	315	316.3 (170.3) <sup>b</sup>	206.2 (121.8) <sup>b</sup>	71.3 (34.7) <sup>b</sup>
4-5	168	890.2 (218.7)	615.4 (174.7)	168.2 (67.6)
<b>Cause of halitosis</b>				
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) <sup>c</sup>
Extra-oral	19	526.5 (243.2)	307.3 (183.1)	162.1 (58.6) <sup>c</sup>
Psychogenic halitosis	21	27.0 (22.2) <sup>c</sup>	15.8 (19.5) <sup>c</sup>	10.9 (11.3) <sup>c</sup>
<b>Average</b>		495.5 (339.5)	334.7 (245.6)	101.4 (68.4)

<sup>a</sup>Significant difference (P < 0.001) with respect to 2-3 and 4-5 OLT values.

<sup>b</sup>Significant difference (P < 0.001) with respect to 4-5 OLT values.

<sup>c</sup>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 <sub>s</sub>		
		H <sub>2</sub> S	CH <sub>3</sub> SH	(CH <sub>3</sub> ) <sub>2</sub> S
OLT	1	0.792 <sup>a</sup>	0.881 <sup>a</sup>	0.652 <sup>a</sup>
FMBS	0.491 <sup>a</sup>	0.402 <sup>a</sup>	0.379 <sup>b</sup>	0.213
PD	0.321 <sup>b</sup>	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 <sup>a</sup>	0.516 <sup>a</sup>	0.494 <sup>a</sup>	0.268
TCS	0.331 <sup>b</sup>	0.355 <sup>b</sup>	0.321 <sup>b</sup>	0.187

FMBS Full-Mouth Bleeding Score, PD probing depth, TCS tongue coating score.

<sup>a</sup>P < 0.001 <sup>b</sup>P < 0.01