CURRENT METHODS FOR HALITOSIS DIAGNOSIS AND THE IMPACT OF COVID-19 PANDEMIC: AN INTERNATIONAL SURVEY

Isabelle Laleman[1,2] & Jesica Dadamio[3]

[1] Department of Periodontology and Oral Surgery, Faculty of Medicine, University of Liège, Liège, Belgium

[2] Dental Biomaterials Research Unit (d-BRU), Faculty of Medicine, University of Liège, Liège, Belgium

[3] Department of Periodontology and Oral Health Sciences, Katholieke Universiteit Leuven, Belgium.

Corresponding author:

Isabelle Laleman

isabelle.laleman@chuliege.be

Service de parodontologie, chirurgie bucco-dentaire et chirurgie implantaire,

Bât. B-35 Médicine dentaire,

C.H.U, Sart Tilman,

Liège 4000,

Belgium.

Abstract

Halitosis specialists can be found all over the world, but very little is known about how they approach patients with halitosis complaints. Therefore, this web-based questionnaire study tried to reach as many of them to gain insight in their methods and tools used to diagnose the condition. Since this study was carried out in the aftermath of the COVID-19 pandemic, its impact was also examined.

This survey encompassed 19 questions interrogating the responders' profile; their diagnostic process in general; the methods and tools used to examine the breath; and the impact of COVID-19 on them. It was accessible online from May till October 2022.

Eighty halitosis professionals from 19 different countries replied. Their answers showed that the community behind the field of halitosis seems to be largely driven by oral health professionals. The respondents had been active in this niche for on average 12 years in consultations (41%), research (23%) or a combination (36%). To achieve a diagnosis 96% believed a thorough history is a must and 94% felt that a breath odor examination (instrumental and/or organoleptically) was necessary. The Halimeter® was the most common instrument used for breath odor analysis. There was a large variation in the organoleptic examination regarding the calibration and number of judges and the specific odors sources that were assessed (i.e. mouth odor versus nose odor). Less variation was noted on the rating scale used: 87% made use of the 6-point odor strength scale. For those that performed organoleptic examinations COVID-19 forced them to modify their examination (20%) or to stop performing it (67%).

This international survey showed that there isn't a consensus between specialists on how the diagnosis of halitosis should be carried out. However, a common thread can be noted: thoroughly interviewing the patients and examining the breath odor are of upmost importance.

Keywords:

Halitosis, bad breath, diagnosis, questionnaire

Acknowledgments:

The authors thank Bruno Carvalho and João Paulo Pinto for their translation of the questionnaire into Portuguese.

Introduction

Halitosis is an unpleasant odor in expired air with an intensity beyond a socially acceptable level originating from oral and/or non-oral sources (Yaegaki & Coil, 2000). The most common causes (80-90%) of bad breath can be found in the oral cavity (Quirynen et al., 2009), in those cases we speak of intra-oral halitosis. Most often this is the result of the bacterial degradation of proteins present in e.g. saliva and tongue coating by Gram-negative anaerobic bacteria. During this process unpleasant smelling volatile sulfur compounds (VSC's such as hydrogen sulfide and methyl mercaptan), are produced (Tonzetich, 1977; Tonzetich & Carpenter, 1971; Tonzetich & Kestenbaum, 1969). The most common extra-oral causes of bad breath can be found in the ear-nose-throat region and the gastrointestinal tract (Quirynen et al., 2009).

The diagnosis of halitosis is a complex process, requiring a stepwise approach as described by the latest consensus conferences on this subject (Renvert et al., 2020; Seemann et al., 2014). It encompasses the medical, dental and halitosis history. This is followed by a clinical examination within the knowledge domain and skills of the clinician. For a dental professional this entails an assessment of the oral hygiene and oral health (including the tongue). Finally, the breath odor should be assessed (Renvert et al., 2020; Seemann et al., 2014). The latter can be done based on an organoleptic examination and/or an instrumental assessment of the odorous compounds present in breath. A combination is preferred as both have their advantages and shortcomings (Seemann et al., 2014). For example, our nose can detect many more different smells than these machines (Greenman et al., 2014). However, the organoleptic method depends on several variables, e.g. the mood, gender, odor detection spectrum and threshold of the odor judge and is difficult to standardize (sampling method and scale). Drawbacks of instrumental examinations are, amongst others, the cost of the devices and the limited number of odors they can detect (mainly sulfur gasses) (Laleman et al., 2014).

Although the diagnostic protocol mentioned above was published almost a decade ago (Seemann et al., 2014), it is difficult to estimate to what extent this protocol is followed in day-to-day clinical practice. To our knowledge specific investigations focusing on the diagnosis of halitosis in general dental practices and specialized halitosis consultations are lacking. The data we have from general dental practices on this subject are based on few questionnaire studies with a broader scope than only diagnosis (Buunk-Werkhoven et al., 2015; Elsenberg et al., 2022; Harmouche et al., 2021). The most pertinent finding in relation to the diagnosis of halitosis is that in more than 80% of the dental offices -in the Netherlands- there is no protocol in place for the diagnosis and treatment of halitosis (Buunk-Werkhoven et al., 2015; Elsenberg et al., 2022). The information we have from specialized halitosis consultations is fragmented and based on what is reported in the "material and methods" sections of cross-sectional studies of patients with halitosis complaints (Bornstein et al., 2009; Hauenstein et al., 2023; Quirynen et al., 2009).

Up to now, knowledge about the diagnosis of halitosis in day-to-day practice is thus scarce. Specific surveys to investigate how this happens in specialized halitosis consultations all over the world have not yet been done to the best of our knowledge.

The aim of this survey was to gather practice-based information about diagnostic strategies used in specialized halitosis consultations worldwide. Methods, tools, and machines used for the diagnosis of bad breath were examined based on a questionnaire. Furthermore, we explored the impact that the COVID-19 pandemic had on the daily operation of halitosis consultations and the ongoing research.

Materials and methods

This web-based questionnaire study was initiated to gain insight into the diagnostic strategies used in specialized halitosis consultations worldwide. Due to the nature of the study, the Ethical Committee of the *CHU de Liège* (Liège, Belgium) ruled that no permission from an Ethical Committee was required to initiate it. Participation was anonymous and voluntary. Completion of the questionnaire was considered as consent from the respondents to the use of these data. This was clearly stated before the first question of the survey.

Questionnaire

The questionnaire was provided in three different languages (English, Portuguese, and Spanish) and encompassed 19 questions. The first six questions served to outline the profile of the respondents. The next two were questions about the diagnostic process in general. This was followed by two specific questions about the instrumental examination of breath odor. The eight following questions delved deeper into the organoleptic examination. These questions were only displayed for those performing this type of examination. The last question examined the influence of COVID-19. The complete questionnaire can be found as an online appendix (**online appendix 1**). Eighteen questions were multiple choice or multiple answer questions, for the first it was only allowed to select one answer and for the latter multiple answers were permitted. To collect as much information as possible, "other" was almost always a possible option. When this response was selected, it allowed to further explain this answer in a text field. The last question was an open question where the participants were encouraged to extensively describe their answer in a free text. **Table 1** describes the questions in more detail.

The questionnaire was pre-tested by piloting the instrument with colleagues of both authors, specialized in halitosis research, to ensure the clarity and relevance of the items. Feedback from this expert group facilitated the refinement of the questionnaire.

Sample and procedure

The survey was carried out with the aid of the online program “SurveyMonkey” (https://www.surveymonkey.com). The software assures data confidentiality and prevents multiple participation. It was put online on the 4th of May 2022 and was taken offline the 31st October of the same year. Colleagues active in the field of halitosis (both clinically and/or scientifically) from all over the world were targeted to answer this questionnaire. Personal contacts of the authors active in this field and the corresponding authors of recent (the last 5 years) articles on this subject indexed in PubMed were invited by email to answer this survey. Additionally, authors with studies in this field that were registered on https://clinicaltrials.gov/ and whose contact details were available were also contacted. Finally, the link to the questionnaire was dispersed by the Associação Brasileira de Halitose (ABHA) amongst their members and was shared on a Facebook page for halitosis professionals (https://www.facebook.com/groups/658324850955802).

Statistical analysis

Answers were downloaded to an excel spreadsheet to allow them to be used for the descriptive statistics. The report included all the answers independently of the status of completion of the forms (fully or partially). Mean, standard deviation and range were calculated to present the results of continuous variables. Non-continuous variables were presented as percentages. Results will be accompanied by the total number of answers to account for “blanks” answers as well as for those that were conditioned to a previous yes/no answer (i.e. questions 12 to 18 could only be completed by those answering “yes” to question 11). Comparisons by means of statistical test were beyond the scope of the report.

Results

Due to the way this questionnaire was distributed, it is impossible to calculate the exact response rate. During the 6 months this questionnaire was online, halitosis professionals from 19 different countries filled in and submitted 80 forms.

Most of the answers came from professionals in the American (42/80, 52.5%) and European (21/80, 26.3%) continents. This was left blank in 11 forms. There were slightly more female responders (42vs34) (**Figure 1**).

The distribution according to the profession of the respondents can be found in **Figure 2**. The largest group of respondents were oral health professionals, namely dentists and oral hygienists (71/80, 88.8%). They had been active in the field of bad breath from 1 to more than twenty years, with an average of 12 years (±8.0y). Most of them (76/80, 95.0%) are currently active in the field, with four of them having ceased their activity. The relation between type of activity and the year's active in the field of halitosis of the responders is pictured in **Figure 3**.

Most responders (33/80, 41.3%) indicated to work with halitosis patients in a clinical setting, but not to be involved in research. Eighteen (22.5%) respondents reported only conducting research in this field, while the remaining 29 (36.3%) combined clinical and research activities.

An oral health professional (dentist/dental specialist or oral hygienist) was chosen by all except one of the responders as the best person to diagnose halitosis (79/80, 98.9%). One respondent indicated an ENT doctor as the ideal person to diagnose halitosis. Eight of the 79 chose an oral health professional using the option "other". They did so mainly to demonstrate that they did not think it was possible to select just one answer to this question. Three of them answered here along the lines that the specialist's diploma does not matter, but that a special training in this field is more important.

Regarding the multiple answer question about the examinations that were deemed necessary for the diagnosis of halitosis most of the responders (70/79, 88.6%) chose to include all the health history options given in the questionnaire: medical, dental and halitosis specific. Fifty-seven (72.2%) would also add the details of the patient's diet. Three responders (3.8%) would not record any patient history. The evaluation of breath odor was considered necessary by 74 responders (93.7%). A combination of organoleptic and instrumental methods was chosen by 48 specialists (60.8%). More detailed information can be found in **Figure 4**. Within the 18 people that indicated "other" the answer that came back there most often (by 7 responders) were salivary tests such as salivary production and pH determinations. Three responders additionally suggested psychological profiling of the patients. Cysteine challenge, microbiology of the oral cavity, imaging and blood tests were each reported once.

Table 2 summarizes the answers regarding the devices the respondents used in their practice/research facilities and the ones they wished to be able to have. Over three quarters of the responders owned at least one portable device (61/79, 77.2%), with the Halimeter® (Interscan Corporation, USA) being the most common one (42/61, 68.9%), followed by the OralChroma™ (Fis Inc, Japan) (35/61, 57.4%). Six (9.8%) of the responders used gas chromatography. For the specialists that chose "other", two responders conducted the measurements by means of a HaliSens® (Analytical Innovations, Germany). A "halitometer", a "multi-gas detector" and e-Nose accounted for one answer each.

When asked about their wishes for devices under ideal conditions (no money or logistic limitations) nine out of the 17 responders that did not have any type of device would like to have one (or two).

Three of them would choose to have an OralChroma™ CHM-2, three would opt for an OralChroma™ CHM-1, one would purchase the HalimeterPlus® and one would like to have a gas chromatograph. Two responders would like to purchase multiple devices: one the OralChroma™ CHM-2 together with a Halimeter® and the other one the OralChroma™ CHM-2 with a gas chromatograph. Only one of the 17 did not seem to consider them necessary. Seven fields were left blank.

An evaluation of the breath by organoleptic measurements in daily practice was performed by 78.7% of the responders (59/75). Five specialists left this question unanswered. People doing this examination were trained by an experienced judge (38/75) or using volatile odor compounds (VOCs) (14/75). Details can be found in **Figure 5**. For the responses under "Other", specific training courses and self-trained accounted for 4 and 8 answers each. Being "calibrated" and having a specialty in stomatology accounted each for 1 answer.

In a clinical setting, the organoleptic evaluation was performed by one judge in approximately 50% of the consultations (28/52, 53.4%) and in 40.4% by two of them (21/52, 40.4%). The highest number of judges present was 3 (5.8%). Two answers were left blank. For research purposes, half of the respondents reported the presence of two judges (18/34, 52.9%) and an additional 23.5% the presence of three judges (8/34). In 7 research settings the evaluations were performed by one judge (20.6%). One answer reported the use of a panel of 12 judges. Details about the number of odor judges in clinical and research settings can be seen in **Figure 6**.

"Nose odor" and "mouth odor after closing the mouth for 1-3 minutes" were the odors used for the organoleptic exam by two third of the responders (each 36/54, 66.7%). Additionally, 31 (57.4%) specialists scored the mouth odor when exhaling and 12 (22.2%) when letting the patient count. The assessment of the smell of the tongue coating was reported by 18 participants (33.3%). Concerning the answer "other": "[assessing the] floss odor", "mouth odor when blowing (light blowing as if blowing out a birthday candle)" and "assessing pulmonary [air]" were each reported once.

The 6-point organoleptic scale rating odor strength, popularly known as the Rosenberg scale, was used as scoring tool by 47 out of 54 specialists (87.0%) (Rosenberg et al., 1991). Two respondents (3.7%) reported using another odor strength scale but did not specify which one. Further, three specialists (5.6%) used the distance malodor scale (Bornstein et al., 2019). Three people answered "other" in order to report their own method "develop[ed] according to the degree of perception, nasal and/or buccal and degree of propagation (we use it in the training course we teach)" or using the "1 to 5 Duarte Conceicao"(Conceicao M et al., 2020) and the "Vieira e Falcão organoleptic scale" (Vieira et al., 2010).

In a quarter of the breath evaluations a privacy screen was used (16/54, 25%). The negative pressure method was used by 6 (11.1%) of the responders. One respondent mentioned a self-made device with borosilicate glass.

Eighty-seven percent (47/54) of the people using the organoleptic evaluation reported this was affected during the COVID-19 pandemics forcing them to stop performing it (36/54, 66.7%) or having to modify their examination (11/54, 20.4%) (**Figure 7**). Those who chose the latter, reported reducing the frequency of the test, increasing the distance at which the test was performed or switching to the negative pressure method. One respondent specified that the patient should "emit a jet of slow, soft and dray air" and that the organoleptic exam was carried out at a distance of 20 cm. Finally, two specialists stated that a negative PCR test for COVID-19 within 24 hours prior to the examination was required.

Sixty-four respondents answered to the open question about how COVID-19 impacted the halitosis consultation and/or the research activities. Four respondents reported not being affected by the pandemic. One of these clarified this by indicating that the organoleptic score was never part of his/her protocol.

The answer that came back most often (30 times) was the fact that the organoleptic score could no longer be performed. However, eight of these respondents already literally mention that they have started doing this again at the time of completing the questionnaire. Whilst others mention that they resorted to alternative organoleptic methods (negative pressure/Kim method, distance scale, …) or still rely solely on the instrumental assessment and/or (extended) questionnaires. Alternative ways to perform the organoleptic evaluations were implemented including the "use of mouth mask" during breath evaluations, "standing side by side and not in front of the patient" (to avoid direct contact with expired air) or performing the test to selected patients (i.e. those where extra-oral halitosis was suspected or only if VSCs readings were not elevated). Six respondents mentioned that all research activities were stopped.

Five respondents answered that the mask wearing increased the patients' self-awareness of their bad breath. And one mentioned that the stress caused by the pandemic increased the number of patients with halitosis complaints and one other expressed concern about patients being "left alone" during this period.

Discussion

This survey showed that there is a wide variation concerning the diagnostic process of bad breath odor amongst dental specialist from (mostly) the American and European continent. Most of them agree on the importance of a thorough anamnesis and the usefulness of assessing breath odor. But opinions differ on how the latter should be done.

A questionnaire study was chosen as the research design because our goal was to reach a large sample size and collect quantitative data from diverse geographic regions. However, when interpreting the results, it is important to consider the potential biases inherent to this study design, such as responder bias and the limitations of predefined questions. Additionally, one has to take into consideration the possible bias introduced by the methods used to contact the responders, certainly contacting personal contacts by the authors, who themselves work in the field of oral health. In addition, the questionnaire was also distributed through a specific halitosis organization and through a specific Facebook page. This makes calculating a response rate impossible.

Out of the responses collected, it seems mostly oral health specialists are behind the halitosis community. In the same fashion, they consider their peers as the best suited to diagnose the condition. This is not surprising considering that most of the underlying causes can be found in the oral cavity with tongue coating and periodontal diseases being the most common culprits (Hauenstein et al., 2023; Quirynen et al., 2009).

The wide range of years in which professionals have been involved in this topic shows that it is still interesting for the new generations. Even though most of the responders reported to be involved in dedicated consultations, there was a clear connection between clinical settings and research activities as reflected on the fact that one third of the professionals were involved in both domains.

Although clinicians from 19 different countries around the world answered this questionnaire, they mainly represent the European and South and North American colleagues. A limited number of respondents from Asia were reached and only one from Africa on to our knowledge no one from Oceania. In future surveys more efforts should be made to obtain data from some locations that might be underrepresented in this report like Middle East and Africa.

Most of the professionals agreed on the anamnesis as an important step in the diagnosis of halitosis. General medical and dental questionnaires were combined with halitosis and dietary-specific questions. In a similar way, the evaluation of the breath odor was deemed as necessary by over 90% of the responders. While some respondents believe that only instrumental examination is sufficient, for others the same was valid with respect to the organoleptic examination. However, more than half were in favor of combining (both of) them.

Despite their high acquisition costs, most of the responders had at least one device to their disposal for breath evaluation. While these devices are small, very easy to use and able to provide results within minutes, their ability to detect malodor compounds in breath samples is (mostly) limited to VSCs. It is known that the volatile compounds contributing to the breath odor also include amines (cadaverine and putrescine), indole and skatole; and chain fatty acids (Drabińska et al., 2021; Van den Velde et al., 2009). Moreover, none of the individual compounds resembles the smell of the breath of those suffering from halitosis. This limitation could be solved, by using more complex technologies as gas chromatography and e-Noses. Their high costs, the technique's complexity and the non-immediate availability of the results make these less suitable for clinical settings. This is also

reflected in the answers collected where gas chromatography and e-Nose were almost exclusively used in research units and always reported accompanied with at least one portable device.

The Halimeter® and OralChroma™ were the devices reported most by the responders. To the best of our knowledge these are also the only machines from which numerous peer reviewed reports from different groups have validated their utility. However, as shown by a recent systematic review, the pooled correlation coefficients between Halimeter® and OLS, and OralChroma™ and OLS reach 0.65 and 0.69 (95% ICs) respectively (Szalai et al, 2023). This should be seen in the light of the fact that the devices only examine a limited number of the compounds responsible for the bad breath.

Next to the well-known Halimeter® and OralChroma™, few other devices were mentioned. The HaliSens device is, similar to the Halimeter®, a portable sulfur detector with a chemical sensor. To the best of our knowledge clinical data validating the use of this device has not been published yet, even though its use has been mentioned in recent literature (Cerri et al., 2023). In the same fashion reports about the use of a "portable industrial multi-gas detector", said to be able to detect breath volatiles other than VSCs, are limited (Aydin et al., 2016; Aydin & Gunay, 2022).

The organoleptic evaluation, a controversial "gold standard", was extensively used by the responders. It provides valuable information that up to now no device can reproduce. However, the evaluation is not free of subjectivity and its accuracy might relay on the judges experience.

Within those performing the evaluation, most of them reported having been trained by an experienced judge. Only a minority of subjects had the chance to attend training sessions/courses involving the use of VOCs as part of it. Self-training was not an exception to the answers. Geographical limitations and a rather small size of experts in the field make this logistically challenging. It is very common in halitosis practices that new "judges" are trained by accompanying experienced judges during appointments. In accordance, almost half of the dedicated consultations reported employing 2 judges during appointments. Following the same logic, research protocols make use of more judges in order to increase the value of the determination.

Next to the lack of standardization of the organoleptic method, one of its biggest limitations is the embarrassment that some patients experience during the examination. A privacy screen or the negative pressure (NP) method described by Kim and colleagues can overcome such problem. While the installation of a screen poses some logistic difficulties, the NP method can be easily implemented. An extra advantage of this procedure is that two or more judges can assess the (exact) same breath sample and therefore reducing the variability between evaluations. Consecutive samples are assumed to be comparable but by no means are identical.

The scoring methods seemed to be more comparable between responders with an overwhelming majority of the judges using the 6-point organoleptic scale rating odor strength, or Rosenberg scale (Rosenberg et al., 1991). Here the observer evaluates the breath quality at fixed distance from the patient, in contrast with the "distance malodor" scale proposed by Bornstein or Vieira (Bornstein et al., 2009; Vieira et al., 2010). More recently, in the context of COVID-19 pandemic, Duarte Conceicao presented an alternative to the evaluation to minimize the aerosol contact (Conceicao M et al., 2020). The authors suggested using a flame to train the patient to achieve a slow flow of air during the organoleptic evaluation. Such modification could allow the organoleptic judge to perform the test while reducing the risk of spreading diseases.

Breath samples of air exhaled via the nose and mouth are the starting point of a differential diagnosis between intra-oral and extra-oral causes of halitosis, therefore their report as the most common practice was to be expected. Assessing the smell of a sample of tongue coating or floss wire could

help to assign causality to the malodor detected. Saliva incubation methods and assessing the smell of dry saliva after licking the dorsal side of the hand or the wrist have been published (Quirynen et al., 2003). Care should be taken when patients and non-experienced health workers perform this evaluation, as it can be misleading. Dry saliva poses a less agreeable smell by nature and might be misinterpreted as pathological.

COVID-19 represented an unprecedented challenge for humanity. In 2020 the complete health care system was turned upside down and the field of halitosis was no exception. The measures taken to prevent COVID-19 infections had a profound impact on the way health professionals approached patients. The natural close contact between patients and caregivers was suddenly turn into a hazard situation. The organoleptic evaluation is a rather intimate evaluation as judges come as close as 10-15cm from the patients' face and poses the risk of aerosol exposure/micro-drops of saliva. It is therefore not surprising that COVID-19 changed the outlook on this examination greatly and drove changes in both clinical and research activities. First there were the interruptions of consultations during lock down periods, and later the virus threat introduced changes in the protocols. The responders relayed more on extended questionnaires, complaints from close contacts (relatives and friends) and VSCs readings. Those that continued with the examination reported implementing Concenciao's approach or performing them only on selected occasions.

COVID-19 pandemic affected greatly the dedicated consultations, especially the organoleptic test. As the situation returned to the normality, and contrary to what could be expected, it seems that judges returned to make use of it. The advantage of this information seems to outgrow the fear of disease spread/contagiousness.

This study showed that despite the many differences, there are also many similarities in the diagnostic process of halitosis around the world. Concerning the specialized halitosis consultations it seems logical that everyone adapts their process to their logistical and financial possibilities. However, in terms of research, a global consensus would facilitate the comparison between future studies in this field.

Concluding remarks

With responses from 19 countries, the data in this manuscript provides a snapshot of the current situation in Europe and America. There is no full consensus on halitosis diagnosis strategies among the (mostly) dental specialists surveyed; however, they all agreed that thoroughly interviewing patients and examining breath odor are of utmost importance. Organoleptic evaluation remains a preferred tool and the use of commercially available portable devices is also widespread. Considering the strengths and limitations of each, it is clear why their use is more complementary than exclusive.

Bibliography

Aydin, M., & Gunay, I. (2022). Cysteine challenge test as a novel diagnostic tool to distinguish oral halitosis. *Australian Dental Journal*, *n/a*(n/a), Article n/a. https://doi.org/10.1111/adj.12884

Aydin, M., Özen, M. E., Evlice, B., Ferguson, M., & Uzel, İ. (2016). A new measurement protocol to differentiate sources of halitosis. *Acta Odontologica Scandinavica*, *74*(5), 380–384. https://doi.org/10.3109/00016357.2016.1163732

Bornstein, M. M., Kislig, K., Hoti, B. B., Seemann, R., & Lussi, A. (2009). Prevalence of halitosis in the population of the city of Bern, Switzerland: A study comparing self-reported and clinical data. *European Journal of Oral Sciences*, *117*(3), 261–267. https://doi.org/10.1111/j.1600-0722.2009.00630.x

Buunk-Werkhoven, Y. A. B., Buls, J. G., Osinga, E., & Bruers, J. J. M. (2015). Diagnosis and treatment of patients with halitosis by dental hygienists and dentists in the Netherlands. *International Dental Journal*, *65*(2), 65–70. https://doi.org/10.1111/idj.12145

Cerri, N., Saccardin, F., Ortiz, V., & Filippi, A. (2023). The effects of various types of lozenges on halitosis: A crossover clinical trial. *Swiss Dental Journal*, *133*(133), 652–660.

Chatterjee, C., Kumar Padhi, B., Kumar, V., & Aryal, S. (2023). Mask-mouth syndrome: A looming oral health concern. *International Journal of Surgery (London, England)*, *109*(3), 616–617. https://doi.org/10.1097/JS9.0000000000000211

Conceicao M, Marocchio L, & Giudice F. (2020). *Diagnostic technique for assessing halitosis origin using oral and nasal organoleptic tests, including safety measures post Covid-19*. *2*, 1–19.

Drabińska, N., Flynn, C., Ratcliffe, N., Belluomo, I., Myridakis, A., Gould, O., Fois, M., Smart, A., Devine, T., & Costello, B. D. L. (2021). A literature survey of all volatiles from healthy human breath and bodily fluids: The human volatilome. *Journal of Breath Research*, *15*(3). https://doi.org/10.1088/1752-7163/abf1d0

Elsenberg, C. P. M., Sidiqi, S., & Buunk-Werkhoven, Y. A. B. (2022). Halitosis, what experiences and methods apply Dutch dental hygienists. *International Journal of Dental Hygiene*, *20*(2), 219–224. https://doi.org/10.1111/idh.12554

Greenman, J., Lenton, P., Seemann, R., & Nachnani, S. (2014). *Organoleptic assessment of halitosis for dental professionals—General recommendations*. *8*(1), 017102. https://doi.org/10.1088/1752-7155/8/1/017102

Harmouche, L., Reingewirtz, Y., Tuzin, N., Lefebvre, F., Davideau, J.-L., & Huck, O. (2021). Knowledge and Management of Halitosis in France and Lebanon: A Questionnaire-Based Study. *Journal of Clinical Medicine*, *10*(3), Article 3. https://doi.org/10.3390/jcm10030502

Hauenstein, C., Ortiz, V., & Filippi, A. (2023). A retrospective analysis of patients suffering from halitosis over a 17-year period. *Swiss Dental Journal*, *134*(3).

Laleman, I., Dadamio, J., Geest, S. D., Dekeyser, C., & Quirynen, M. (2014). *Instrumental assessment of halitosis for the general dental practitioner*. *8*(1), 017103. https://doi.org/10.1088/1752-7155/8/1/017103

Quirynen, M., Dadamio, J., Van den Velde, S., De Smit, M., Dekeyser, C., Van Tornout, M., & Vandekerckhove, B. (2009). Characteristics of 2000 patients who visited a halitosis clinic. *Journal of Clinical Periodontology*, *36*(11), 970–975. https://doi.org/10.1111/j.1600-051X.2009.01478.x

Quirynen, M., Zhao, H., Avontroodt, P., Soers, C., Pauwels, M., Coucke, W., & van Steenberghe, D. (2003). A salivary incubation test for evaluation of oral malodor: A pilot study. *Journal of Periodontology*, *74*(7), 937–944. https://doi.org/10.1902/jop.2003.74.7.937

Renvert, S., Noack, M. J., Lequart, C., Roldán, S., & Laine, M. L. (2020). The Underestimated Problem of Intra-Oral Halitosis in Dental Practice: An Expert Consensus Review. *Clinical, Cosmetic and Investigational Dentistry*, *12*, 251–262. https://doi.org/10.2147/CCIDE.S253765

Rosenberg, M., Septon, I., Eli, I., Bar-Ness, R., Gelernter, I., Brenner, S., & Gabbay, J. (1991). Halitosis measurement by an industrial sulphide monitor. *Journal of Periodontology*, *62*(8), 487–489. https://doi.org/10.1902/jop.1991.62.8.487

Seemann, R., Conceicao, M. D., Filippi, A., Greenman, J., Lenton, P., Nachnani, S., Quirynen, M., Roldan, S., Schulze, H., Sterer, N., Tangerman, A., Winkel, E. G., Yaegaki, K., & Rosenberg, M. (2014). Halitosis management by the general dental practitioner—Results of an international consensus workshop. *Journal of Breath Research*, *8*(1), Article 1.

Tonzetich, J. (1977). Production and origin of oral malodor: A review of mechanisms and methods of analysis. *Journal of Periodontology*, *48*(1), 13–20. https://doi.org/10.1902/jop.1977.48.1.13

Tonzetich, J., & Carpenter, P. A. (1971). Production of volatile sulphur compounds from cysteine, cystine and methionine by human dental plague. *Archives of Oral Biology*, *16*(6), 599–607. https://doi.org/10.1016/0003-9969(71)90063-x

Tonzetich, J., & Kestenbaum, R. C. (1969). Odour production by human salivary fractions and plaque. *Archives of Oral Biology*, *14*(7), 815–827. https://doi.org/10.1016/0003-9969(69)90172-1

Van den Velde, S., van Steenberghe, D., Van Hee, P., & Quirynen, M. (2009). Detection of odorous compounds in breath. *Journal of Dental Research*, *88*(3), 285–289. https://doi.org/10.1177/0022034508329741

Vieira, C. N., Falcão, D. P., Faber, J., & Nunes, F. de P. (2010). Avaliação da condição periodontale da presença de biofilme lingual como indicadores de risco para halitose. *2010*, *20*(2), 53.

Yaegaki, K., & Coil, J. M. (2000). Examination, classification, and treatment of halitosis; clinical perspectives. *Journal (Canadian Dental Association)*, *66*(5), 257–261.

Tables

Table 1: Overview of the questions of the survey

1. I am currently active in: …	Open question
2. To which gender identity do you most identify?	MCQ
3. What is your profession?	MCQ
4. When did you graduate?	Open question
5. From when (until when) are/were you active in the field of halitosis?	Open question
6. What do/did you specifically do in the field of halitosis?	MAQ
7. In general, who is the best person to diagnose halitosis according to you?	MCQ
8. In your opinion, which exams are necessary for a correct diagnosis of halitosis?	MAQ
9. Which devices do/did you have in your consultation/research lab to evaluate the breath?	MAQ
10. Which devices would you like for your consultation/research if there were no financial/logistical limitations?	MAQ
11. Do/did you do an organoleptic measurement(s)?	MCQ
12. Was your organoleptic scoring method affected because of COVID-19?	MCQ
13. How were you trained?	MAQ
14. If you do/did organoleptic measurement(s) in a clinical environment with how many organoleptic judges are/were you in general?	MCQ
15. If you do/did organoleptic measurement(s) for research purpose with how many organoleptic judges are/were you in general?	MCQ
16. Which odours do you score during your organoleptic exam?	MAQ
17. If you perform an organoleptic examination, which scale do/did you use?	MAQ
18. Do you use special methods for organoleptic scoring?	MAQ
19. How did COVID-19 change your halitosis practice/research?	Open question

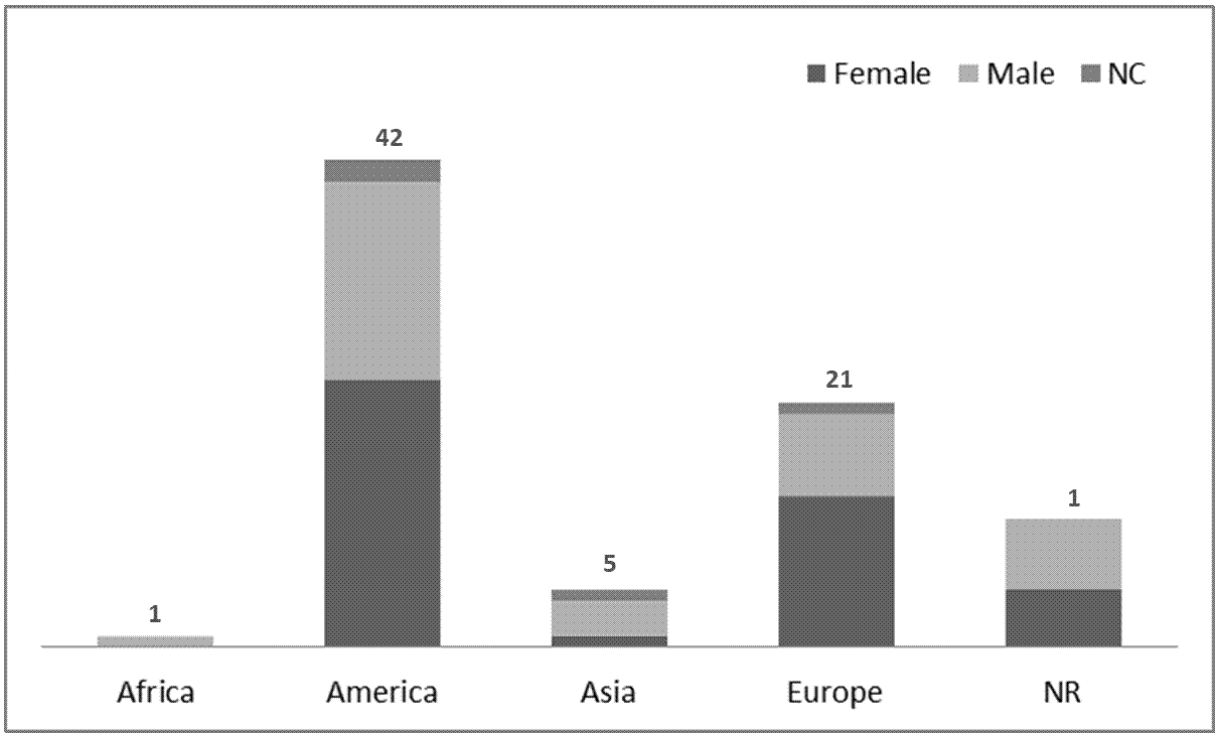
MCQ: multiple choice question (with the possibility to select only one answer), MAQ: multiple answer question (with the possibility to select different answers)

Table 2: Devices owned and wished for by the responders.

Device	Already owns it (yes/no)	Would keep it (yes/no)	Would like to get it (yes/no)	Would like to upgrade it
Halimeter®	38/42	7/31	2/40	8
Halimeter® PLUS/BLU	7/73	2/5	9*/64	/
OralChroma™ CHM-1	17/63	3/14	10/53	11
OralCHroma™ CHM-2	25/55	13/12	25*/30	/
Gas chromatography	6/74	4/2	17/57	/
HaliSens	2/78	1/1	0/78	/
e-Nose	1/79	0/1	0/79	/
Multi-gas detector	1/79	1/0	0/79	/
Halitometer	1/79	0/1	0/79	/

(*) upgrades included

Figures



NR: not reported, NC: non-confirming

Figure 1: Distribution of the respondents based on gender and continent.

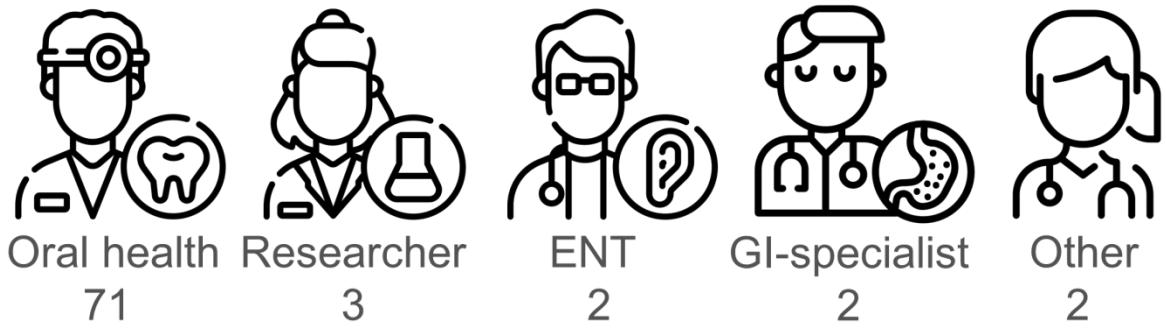


Figure 2: Distribution of the respondents based on their profession (figure created based on icons from Freepik)

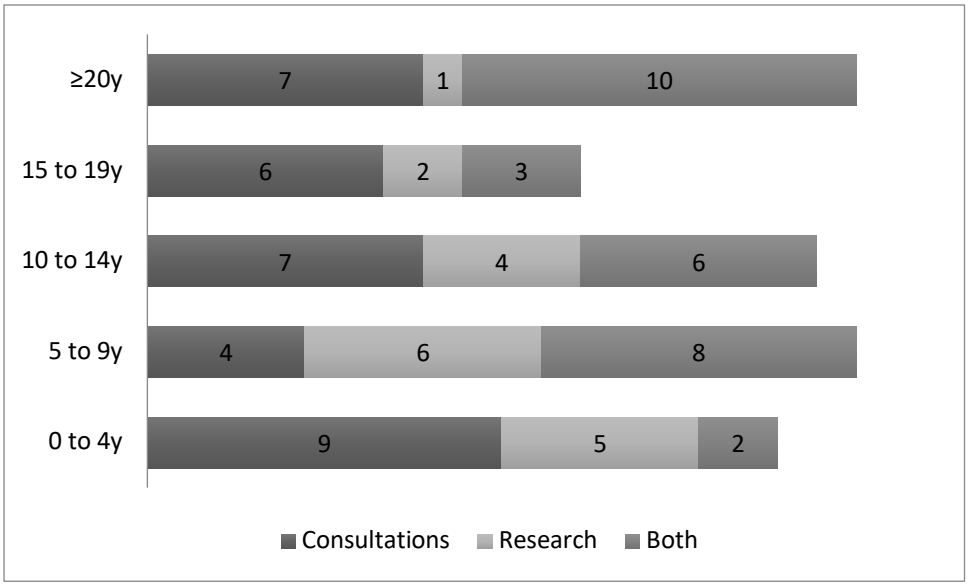


Figure 3: Year's active in the field of halitosis and the type of activity in this field

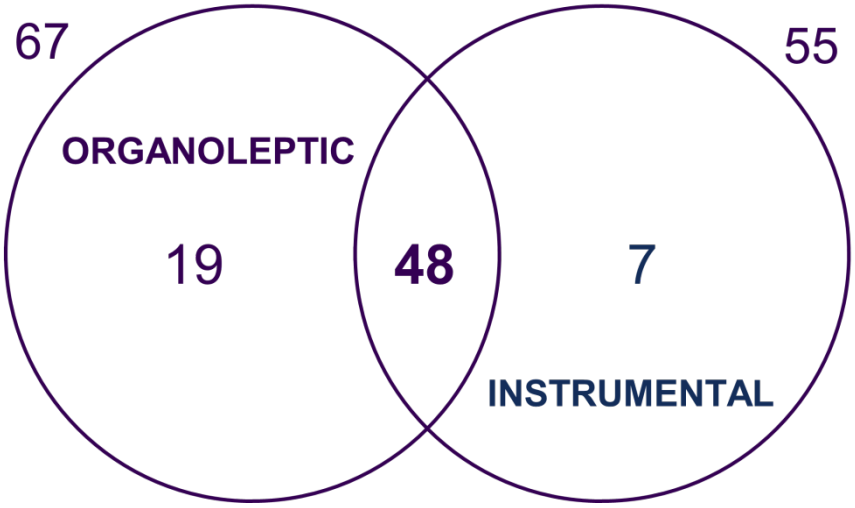


Figure 4: How bad breath is measured.

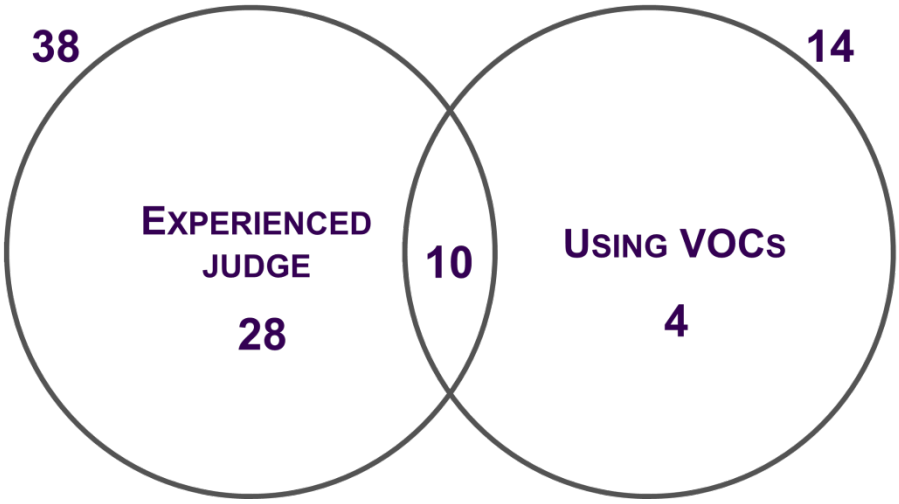


Figure 5: Training for organoleptic examination

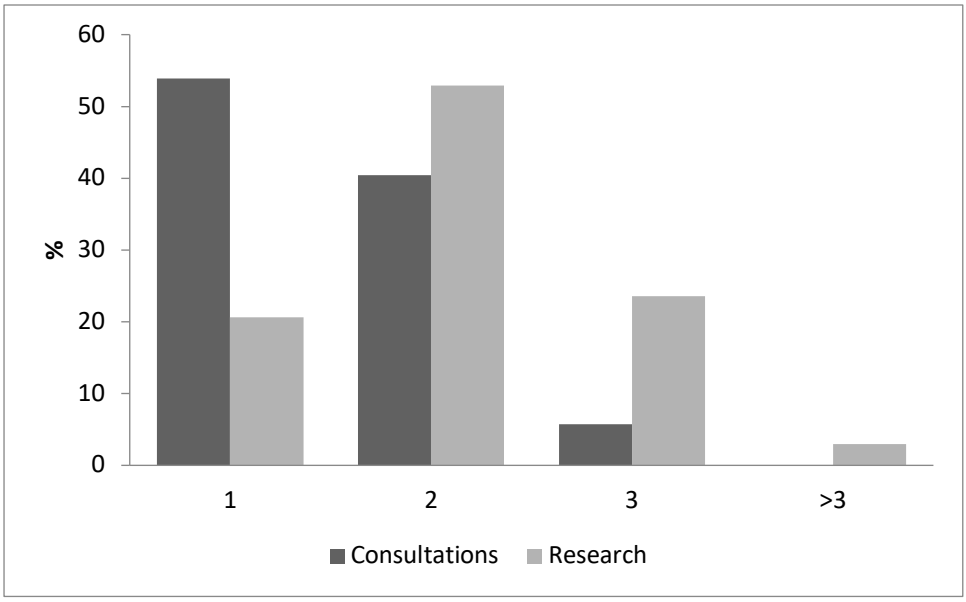


Figure 6: Number of odor judges

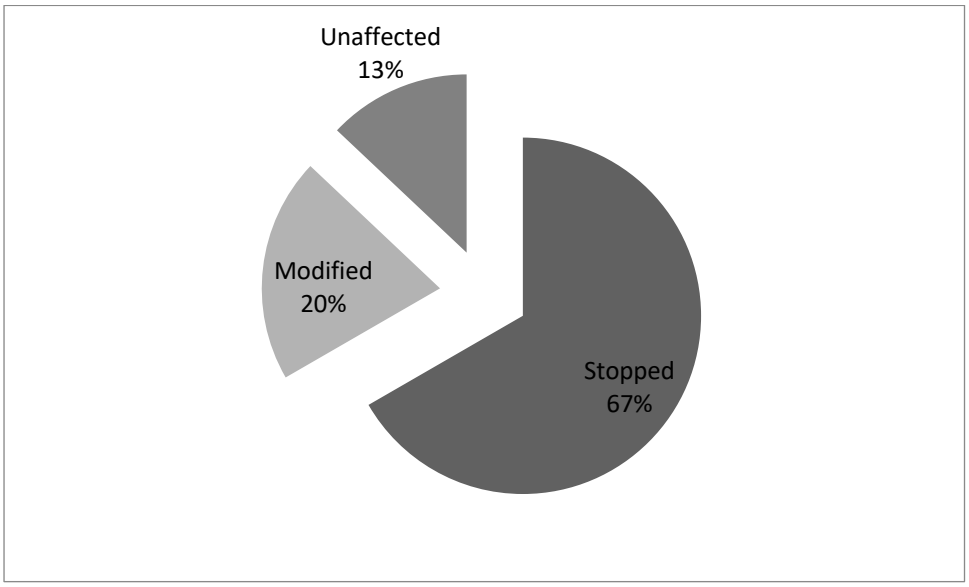


Figure 7: Effect of COVID-19 on the organoleptic examen

Online appendices

Online appendix 1: the questionnaire in English

1. I am currently active in: … (open question)
2. To which gender identity do you most identify: (1 response possible)
   - Man
   - Woman
   - Non-confirming
3. What is your profession? (1 response possible)
   - GP
   - ENT-doctor
   - Dentist/ dental specialist
   - Oral hygienist
   - Scientist in biological/ (bio)medical sciences
   - Other: …
4. When did you graduate (year)?
5. From when (until when) are/were you active in the field of halitosis
6. What do/did you specifically do in the field of halitosis (multiple answers possible):
   - I participate in a specialized halitosis consultation
   - I participate in research in the field of halitosis
7. In general, who is the best person to diagnose halitosis according to you? (1 answer possible)
   - GP
   - ENT-doctor
   - Dentist/ dental specialist
   - Oral hygienist
   - Psychologist
   - Other: …
8. In your opinion, which exams are necessary for a correct diagnosis of halitosis (multiple answers possible)?
   - Medical history
   - Dental history
   - Halitosis history
   - Diet history
   - Organoleptic examination of the breath
   - Instrumental examination of the breath
   - Exam of teeth and the gum
   - Exam of the tongue
   - ENT Exam
   - Other: …
9. Which devices do/did you have in your consultation/research lab to evaluate the breath (multiple answers possible):
   - Halimeter®
   - Halimeter® PLUS

- Halimeter® BLU
- OralChroma™ CHM-1
- OralChroma™ CHM-2
- Gas chromatograph
- Other: …

10. Which devices would you like for your consultation/research if there were no financial/logistical limitations (multiple answers possible)?
    - Halimeter®
    - Halimeter® PLUS
    - Halimeter® BLU
    - OralChroma™ CHM-1
    - OralChroma™ CHM-2
    - Gas chromatograph
    - Other: …
11. Do/did you do an organoleptic measurement(s) (1 answers possible)?
    - Yes:
    - No:
12. Was your organoleptic scoring method affected because of COVID-19 (1 answers possible)?
    - No
    - Yes, I stopped doing this because of COVID-19
    - Yes, I modified my organoleptic exam
      Explain:…
13. How were you trained (multiple answers possible)?
    - By an experienced judge
    - By using volatile odorous compounds
    - Other:…
14. If you do/did organoleptic measurement(s) in a clinical environment with how many organoleptic judges are/were you in general (1 answer possible)?
    - 1
    - 2
    - 3
    - Not applicable
    - More: …
15. If you do/did organoleptic measurement(s) for research purpose with how many organoleptic judges are/were you in general (1 answer possible)?
    - 1
    - 2
    - 3
    - Not applicable
    - More: …
16. Which odours do you score during your organoleptic exam (multiple answers possible)?
    - Nose odour

- Mouth odour (after closing the mouth for 1-3 minutes)
- Mouth odour when exhaling
- Mouth odour when counting
- Odour of the tongue coating

17. If you perform an organoleptic examination, which scale do/did you use (multiple answers possible)?
    - An odor-strength 6-point organoleptic scale, scored from 0 to 5 (typically known as the Rosenberg scale)
    - Another odor-strengh scale, namely:…
    - Distance malodour scale (Bornstein e.a., 2009)
    - A hedonic method, namely
    - Other: …
18. Do you use special methods, such as (multiple answers possible):
    - A privacy screen
    - The negative pressure method
    - A privacy screen and the negative pressure method
    - No
    - Other:
19. How did COVID-19 change your halitosis practice/research? (open question)