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LITERATURE REVIEW

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Halitosis: a conceptual, etiologic and therapeutic approach

Halitose: uma abordagem conceitual, etiológica e terapêutica

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ABSTRACT

Objective: Halitosis is the offensive odor emanated by the oral and nasal cavities and perceived by the individual and/or by other people. Halitosis is a symptom that directly impacts on the social aspects of an individual's life and may be a sign for a systemic disorder in some cases. **Material and Methods:** A search was conducted on the literature in order to gather the main aspects about halitosis and make a review about the main features necessary to the clinical practice when a professional deals with a patient with halitosis. **Results:** The information was summarized and discussed with a focus on what clinicians should be aware of when dealing with a patient with halitosis. **Conclusion:** Halitosis is a prevalent symptom that affects approximately 25% of the individuals. Its classification takes into consideration the origin of the compounds producing the malodor. The diagnosis must take into consideration the various etiological possibilities before defining the treatment. The treatment must be focused on the cause and since there is a wide range of possible causes, halitosis needs a multidisciplinary approach.

KEYWORDS

Dimethyl sulfide; Halitosis; Hydrogen sulfide; Odorants; Oral hygiene.

RESUMO

Objetivo: Halitose é um cheiro ofensivo expelido pela cavidade bucal e pela cavidade nasal e percebido pelo indivíduo e/ou pelas outras pessoas. A halitose é um sintoma que impacta diretamente aspectos sociais da vida de um indivíduo e pode ser um sinal de alguma desordem sistêmica em alguns casos. **Material e Métodos:** Uma busca foi feita na literatura para reunir os principais aspectos da halitose e conduzir uma revisão sobre as principais características necessárias à prática clínica quando um profissional lida com um paciente com a queixa de halitose. **Resultados:** A informação disponível foi sumarizada e discutida com foco naquilo que um clínico deve estar atento quando lida com um paciente com a queixa de halitose presente. **Conclusão:** A halitose é um sintoma prevalente que afeta aproximadamente 25% dos indivíduos. Sua classificação leva em consideração a origem dos compostos que produzem o mau hálito. O diagnóstico deve levar em conta as várias etiologias possíveis antes de definir um tratamento. O tratamento deve ser focado na causa e, como há uma ampla variedade de possíveis causas, a halitose é um sintoma que precisa de uma abordagem multidisciplinar.

PALAVRAS-CHAVE

Dimetil sulfeto; Halitose; Sulfeto de hidrogênio; Odorantes; Higiene bucal.

INTRODUCTION

Breath is the odor of the air exhaled through the mouth during exhalation. When this odor is unpleasant, it is denominated as bad breath or halitosis [1,2]. Halitosis is described as an unpleasant or offensive odor emanated by the oral and nasal cavities and perceived by the individual and/or by other people [3]. In most cases, its origin is related to oral cavity conditions [4-6]. However, though seldom, it can be associated with systemic pathological conditions [7].

Halitosis is frequently associated to important social, psychological and emotional aspects, and sometimes it is an obstacle to social interactions, creating discomfort and embarrassment [8,9]. Individuals affected by halitosis are more anxious and depressed than those who are not affected, and consequently, they have lower self-esteem and a decrease in their quality of life and social interactions [10]. A recent study showed that more than half of individuals with halitosis complaint feel uncomfortable when they are close to another person, hesitate to talk to other people and report that their social and professional life was negatively affected by bad breath [11].

Individuals affected by halitosis rarely look for a professional to solve the problem [12,13]. Despite the low rate of reports, studies show that halitosis is a prevalent condition, estimating that 10% to 30% of individuals have bad breath [14,15]. Therefore, halitosis prevalence on the population is underestimated [16,17] due to a lack of knowledge by patients about their own condition or embarrassment about reporting it.

As halitosis is a symptom, it reflects an intra or extraoral disorder and might be related to serious health conditions [1]. Health professionals, especially dentists, must know about the etiology, diagnosis and therapeutic approach for these individuals, in order to be able to identify the symptom and provide the necessary support, referring the patient to proper treatment of the causes.

This review makes a conceptual, etiologic and therapeutic approach of halitosis, aiming to understand its epidemiology and population impact, its main causes and diagnostic means, to guide the dentist to the adequate treatment options for each specific case.

METHODOLOGY

Different searches were conducted in PubMed to identify studies discussing different aspects of halitosis: the **classification and diagnosis**, the **etiology** and the **treatment**. For each aspect of interest, a search strategy was elaborated. To discuss classification and diagnosis of halitosis the following MeSH terms and free terms were combined: *halitosis AND (classification OR "delusional halitosis" OR halitophobia OR diagnosis OR organoleptic OR OralChroma OR "gas chromatography" OR Halimeter OR "sulfide monitors" OR "self-report" OR "volatile sulfur compounds" OR prevalence)*. In order to retrieve articles discussing the etiology of halitosis considering its different sources, the following keywords were combined: *halitosis AND (tongue coating OR periodontitis OR "periodontal diseases" OR xerostomia OR "dry mouth" OR oral hygiene OR "dental flossing" OR toothbrushing OR "respiratory disorders" OR "gastrointestinal disorders" OR "gastroesophageal reflux disease" OR GERD OR reflux OR "Helicobacter pylori" OR "H. pylori" OR "inflammatory bowel diseases" OR "Crohn's disease" OR "ulcerative colitis" OR "diabetes mellitus" OR hepatitis OR "renal failure" OR "kidney failure" OR infections OR smoking OR smoker OR tobacco OR alcohol OR alcoholism OR medication OR drugs OR medicine)*. Lastly, to discuss the treatment of halitosis, another search was performed using the terms *halitosis AND (treatment OR mouthwash OR toothpaste)*. A manual search within the reference list of the included studies were also performed to identify studies that the electronic search might have missed.

The search was conducted without restriction of date and language. This review included primary studies, systematic reviews and other reviews bringing relevant insights to the field. Book chapters, letters, personal opinions, meeting abstracts and case reports were excluded.

Classification

Halitosis is normally classified in two main categories: genuine halitosis and delusional halitosis, according to the classification adopted by the *International Society for Breath Odor Research* (ISBOR), based on the origin of the compounds responsible for the malodor [18].

Genuine halitosis is the obvious malodor, exhaled by the mouth, in a level above the level considered as socially acceptable. Genuine halitosis can be physiological or pathological. Physiological halitosis is the morning bad breath, which occurs during the night due to reduction of salivary flow rate and increasing of the putrefaction processes by the microorganisms inside the oral cavity [19]. This is a transient malodor, that disappears when eating or brushing the teeth [20,21]. Physiological halitosis can also be caused by some specific food capable of modifying the smell of the exhaled air and for long starvation periods. As the morning bad breath, this type of halitosis is transient, therefore, physiological [22].

Pathological halitosis is the true bad breath, which occurs as a symptom associated to various disorders. Pathological halitosis is chronic and classified according to its origin in intraoral or extraoral halitosis [19]. In intraoral halitosis, the malodor originates from factors and processes that occur inside the mouth. In extraoral halitosis, the origin of the bad breath might be the respiratory tract, the gastrointestinal tract, the liver, kidneys or metabolic disorders [23]. Extraoral halitosis is divided into bloodborne halitosis or non-bloodborne halitosis, considering how the molecules of malodorous gases leave the site where they are produced and reach the oral cavity, from where they are exhaled to the exterior as bad breath [24,25].

There are two situations in which halitosis might have a psychological origin. One situation, classified as pseudo halitosis, happens when the individual reports a bad breath, but this cannot be clinically diagnosed. The other situation, defined as halitophobia, happens when the individual has an excessive fear of having bad breath, even after the treatment and a negative diagnosis made by a professional [26]. Both situations are defined on the literature as delusional halitosis [27,28]. The classification of the halitosis categories can be found on Figure 1.

Etiologic mechanisms

Halitosis is not a disease, but a sign that there is a disorder in the body, characterizing a symptom. The causes of bad breath are multifactorial. However, studies show that approximately 80% of bad breath is originated on the mouth [4,5,29,30].

Some intraoral sites favor the accumulation of bacteria and the putrefaction of organic compounds. The humidity and temperature inside the mouth facilitate the microbial degradation of amino acids containing sulfur, such as cystine, cysteine and methionine. The unpleasant odors usually originate from these sites [31].

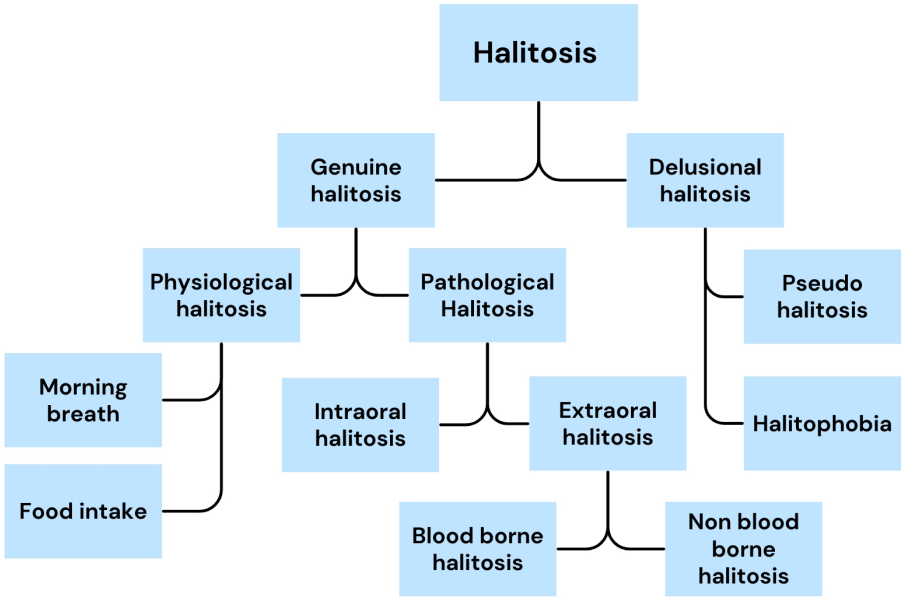

Figure 1 - Halitosis classification according to the origin of VSCs. Halitosis is divided in two main categories: genuine halitosis and delusional halitosis. Delusional halitosis can be defined as pseudohalitosis or halitophobia. Genuine halitosis can be physiological or pathological. Pathological halitosis can be of intra or extra oral origin, and extra oral halitosis can be divided into blood borne and non blood borne halitosis. Adapted from Izidoro et al. [18].

Proteolytic Gram-negative bacteria are capable of degrading these organic compounds and metabolizing such amino acids, releasing gaseous molecules containing sulfur, called volatile sulfur compounds (VSCs) [6,32]. Almost 90% of the composition of the malodor exhaled by the oral cavity is composed by hydrogen sulfide (HS), dimethyl sulfide (DMS) and methyl mercaptan (MM), released on this process [18]. Other VSCs molecules can be found, but in very lower concentrations [25].

Extraoral pathological halitosis is also mostly caused by the presence of VSCs in the exhaled air. In bloodborne extraoral halitosis, VSCs produced in distant sites are adsorbed into the blood and circulate to the lungs. In the lungs they are released during gaseous exchanges and volatilized with the exhaled air. The main VSCs responsible for the malodor in these cases is DMS. MM and SH immediately reacts with the blood and undergo irreversible oxidization, preventing them from reaching lungs. DMS is a neutral molecule, stable on the blood and can be transported to the alveolus in an intact form [25]. Hepatic, renal, intestinal and metabolic pathologies can give rise to bloodborne halitosis. Non-bloodborne extraoral halitosis is originated mainly on the superior and inferior respiratory tract, and a small part has gastric origin. Its occurrence is explained by the anatomical proximity between the site where the VSCs are produced and the oral cavity, allowing VSCs to reach the mouth and to be exhaled within the air [24,25]. A scheme for bloodborne halitosis can be found on Figure 2.

Despite the importance of VSCs on the halitosis etiology, its absence does not imply on the absence of halitosis. Approximately 15% of halitosis cases can be caused by other volatile organic compounds (VOCs), without sulfur on their composition. It is the case of extraoral bloodborne halitosis caused by renal disorders and Diabetes Mellitus, where the VOCs with a structure different from that of VSCs are adsorbed into the blood and released by the lungs, being exhaled through the mouth [25].

Epidemiological aspects

Halitosis is a prevalent condition in the population. However, literature brings inconsistent data about its prevalence, possibly as a result from different diagnostic methods and different criteria to define and measure bad breath on the individuals in different studies [33]. Different studies suggest that the variation on the prevalence of halitosis is from approximately 2.4% to 78% [16,17,33-36], and according to a systematic review this prevalence would be of 31.8% [36]. Despite the fact that

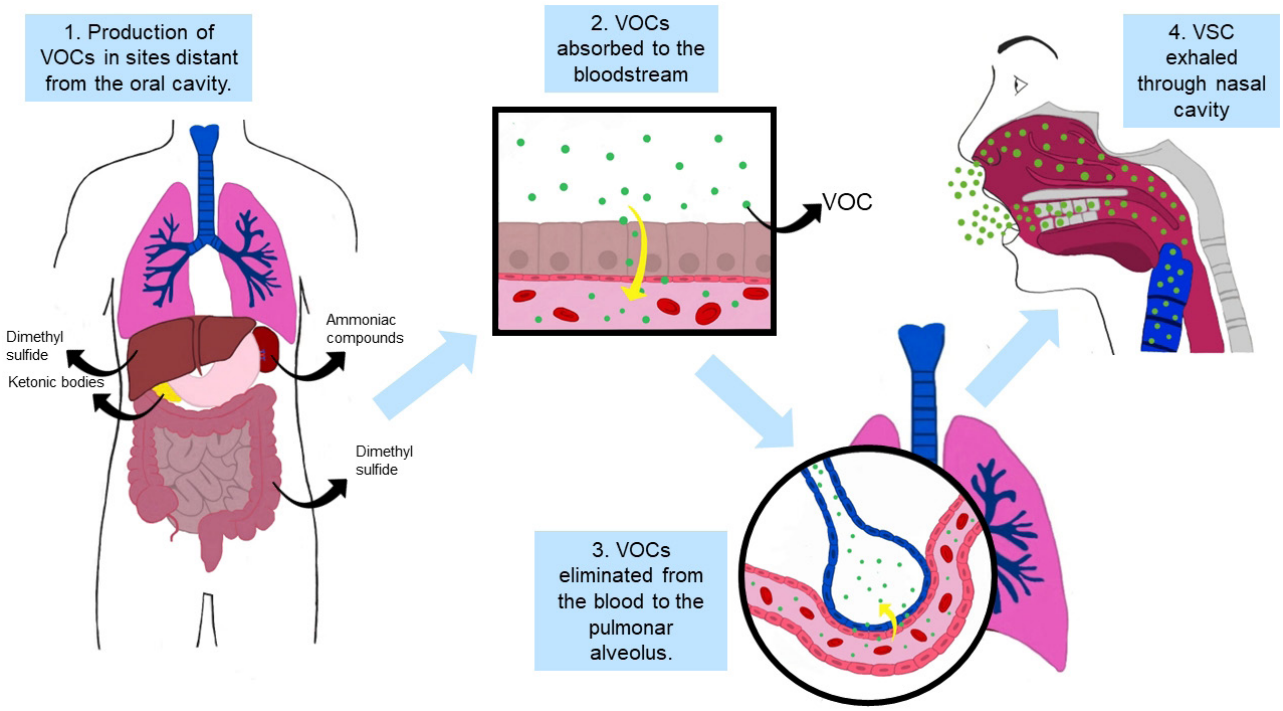

Figure 2 - Bloodborne halitosis. VSCs are produced in sites far from the mouth, such as liver, kidneys, intestines or pancreas, and transported through the blood to the lungs. Then, they are exhaled withing the air as bad breath. Figure inspired by the BioRender.com element designs.

there is no consensus on the literature regarding the prevalence rate of halitosis or which gender is more affected [33,37], if we consider prevalence rates available on the literature, we could estimate that at least one out of every four people has halitosis [38,39] and that it is more common and intense in elderly people [40]. Halitosis prevalence increases with age increasing. For elderly people, halitosis is more severe and common. It has been reported that above the age of 65, the prevalence is twice the prevalence that of individuals in their twenties [12].

Furthermore, the perception of bad breath varies among different cultures [41,42]. For example, the self-reported prevalence of halitosis on individuals above 16 years-old in the Netherlands was 43.7% [43], while in individuals above 15 years-old in France was 22% [44]. In an infant population, with an average of 12 years-old, the reported prevalence was 37.6% [37]. In Brazil, the self-reported halitosis represented a prevalence of 16.6% in adults [45].

The substantial variation in halitosis prevalence is a consequence of methodological variations in research, including the lack of well-defined diagnostic criteria and the use of different methods and instruments [46]. Some studies use the self-report as a diagnostic measurement [17,35], while others use the organoleptic method [5,16] or automatic method as the sulfide monitors or gas chromatography [37]. In a cross-sectional study from New-Zealand, different prevalence rates were found for the same population with different diagnostic methods: 31.2% for sulfide monitors, 14.3% and 25.6% self-report [47]. These differences demonstrate that the prevalence of halitosis can vary depending on the classification adopted and the diagnostic method applied [46].

Diagnosis

Considering that halitosis has a multifactorial feature [34], in addition to the intraoral clinical examination, the analysis of the individual's medical and dental history should be included as a protocol for every person complaining of bad breath. In some situations, considering that systemic diseases might be associated to halitosis, a medical evaluation might be necessary.

At the first moment, evaluating the presence or absence of genuine halitosis is essential, as the majority of patients are not good judges of their own breath [48]. This diagnosis can be made through tests capable of detecting malodor or the involved gases. The main available methods include the organoleptic method, the sulfide quantification, the gas chromatography [27] and patient self-report [45].

The organoleptic method is a simple exam and considered as the gold standard for the diagnosis of halitosis on the clinical practice [5], once it reflects the presence of an unpleasant odor detected by an observer [49]. The organoleptic measurement is a sensorial test based on the perception of bad breath by an examiner properly trained and calibrated. As this method does not need sophisticated equipment or technique, this methodology is more accessible and practical for clinical use. The technique consists in classifying the odor exhaled through the nose and the mouth using a scoring system that measures the intensity of malodor [50].

Once it depends on the olfactory accuracy from the examiner, the organoleptic method is considered subjective and a good qualitative method, but without quantitative accuracy [51], and might be uncomfortable for the examiner and the examined individual [49]. It is recommended that the patients avoid consuming strongly scented foods before the appointment test, for at least 24h. The patient and the examiner should refrain from drinking coffee, tea, juice, smoke and using cosmetics and perfume [27]. The examiner instructs the patient to inhale through the nose and exhale slowly through the mouth, while the examiner stands at a distance of approximately 20 cm from the patient and classifies the exhaled odor [50,51]. This classification is made in a scale from 0 to 5: 0) undetectable odor; 1) questionable odor, barely detectable; 2) discrete odor, exceeds the threshold for recognizing malodor; 3) malodor detected; 4) strong malodor; 5) very strong malodor. Patient classified on score 2 and above has clinical halitosis (clinically perceived). On scores 4 and 5, the patient is classified as severe halitosis [49].

Sulfide monitors (Halimeter®) are electrochemical devices that measure the level of VSCs in expired air [52]. It is a non-selective volumetric method that only measures the total volume of VSCs in the sample [23], and it is not able to distinguish the gases HS, MM and DMS [20]. This is a good diagnostic method for the presence or absence of halitosis caused by VSCs. But for extraoral halitosis caused by VOCs other than the three above mentioned, this method is not

recommended [22,53,54]. Halimeter is more sensible to HS and have a lower response for MM and DMS. When Halimeter is used, the DMS concentrations are underestimated in almost 70% [55].

Gas chromatography has the ability to quantify and distinguish the different VSC present on the breath, allowing the differentiation between intraoral and extraoral halitosis [53]. The most known device of gas chromatography is the compact OralChroma®, which is able to provide a quick evaluation of the VSC, capable of measuring and distinguishing the key compounds of bad breath (DMS, MM e SH) and distinguish halitosis subtypes based on their origin [56]. Despite having a high sensitivity and accuracy being able to measure extremely low concentrations of VSC, the gas chromatography is an expensive device which requires trained professionals to perform the exam. This makes it less appropriate to the routine diagnosis [23]. Furthermore, the accuracy and precision of this device depends on constant update of its software and on its calibration [56].

Diagnostic tests should be applied to evaluate the exhaled air through the mouth and the nose separately, aiming to distinguish intraoral from extraoral halitosis. Patients with intraoral halitosis will have the malodor exhaled only through the mouth, while patients with extraoral halitosis will have the bad breath exhaled through mouth and nose [54]. If a malodor cannot be identified during the exams, these should be repeated after two or three distinct days and if their absence is persistent, a pseudohalitosis diagnosis should be considered.

At a later stage, the professional's role is to associate the information obtained during anamnesis with the results of the sensitive and objective tests conducted. Halitosis has a predominantly clinical diagnosis which is based on the patient's medical and dental history. A well-defined diagnosis is determinant for future treatments. When the professional suspects a systemic cause, it is important to assemble a multidisciplinary team to conduct this investigation, which may require additional tests [45].

Self-reporting has been used in various health specialties to understand the prevalence and risk factors of some systemic conditions [45]. Halitosis self-report has a good accuracy with the clinical measures for severe halitosis (75%), but a lower accuracy for clinical halitosis (50%) [46]. Nevertheless, it shows a good general correspondence with the organoleptic method [57]. The self-report is a good sorting method [46]. At the population level, it has the ability to detect potential problems in groups of affected individuals, reducing the costs with tests and the time employed on research. In a research scenario it would be impossible for the researcher to individually test each participant [45]. At the individual level, it has the ability to detect individuals with halitosis complaints and to guide them to the correct treatment.

Causes

Oral cavity is responsible for 85% to 90% of halitosis cases. The oral environment is humid and has an ideal temperature for growth of many microorganisms capable of metabolizing aminoacids and producing VSCs [18]. *In vitro,* many oral bacteria produce VSCs, especially MM and HS [49]. The main intraoral factors capable of causing halitosis are the tongue coating, periodontitis, bad oral hygiene and the presence of infections, caries and mucosal wounds [31]. Especially in a post-pandemic reality, where people spent several months without proper dental assistance due to fear of contraction of COVID-19, intraoral factors should be carefully evaluated [58].

Tongue coating

Tongue is the main site of malodor production and bad breath is associated with the presence of bacteria on the dorsum of the tongue, mostly Gram negative [49,59]. The superficial anatomy of the tongue dorsum with papilae and fissures is a retentive structure for the microorganisms [60,61], and an anatomic niche, where the environment relatively inaccessible to saliva and oxygen favors the growth of an anaerobic microbiota [60].

This microbiota adheres to the coating on the dorsum of the tongue that comprises desquamated epithelial cells, blood cells, nutrients and bacteria, and this composition can change from one individual to another [60]. Data on the literature shows that there is not a specific specie responsible for the malodor, in fact what happens is an abnormal growth of many bacteria, especially the proteolytic ones [49,62]. Microorganisms, especially Gram negative, are able to produce VSCs using food debris and desquamated epithelial cells from tongue coating [18]. The dorsum of the tongue is responsible for almost 60% of the VSCs production [63], and the area posterior to the circumvallate papilla is the region with the

greatest capacity to harbor Gram negative bacteria and produce VSCs with greater intensity [18].

Periodontitis

There is a positive correlation between VSCs concentration and periodontitis severity, once periodontal pathogens (mainly *Porphyromonas gingivalis)* are capable of producing these compounds [3]. Subgingival biofilm is primarily composed by Gram-negative anaerobic microorganisms, with a proteolytic nature and ability to produce VSCs [18].

It was demonstrated that approximately 82% of the patients diagnosed with periodontitis presented halitosis, and that periodontitis patients had a greater risk of having halitosis when compared to patients without periodontitis [3]. A positive correlation between halitosis and periodontal clinical parameters, especially probing pocket depth higher than 4 mm, was demonstrated. As PPD increases, the VSCs concentration on breath also increases [6,27,63-65]. Furthermore, on periodontitis patients there is a trend to an increased volume of tongue coating, contributing to the increase of malodor [63].

Bad oral hygiene

Tooth brushing is an important factor on the reduction of severe halitosis risk, because it reduces the substrate and the bacterial load on the mouth [17]. A lower oral hygiene index and less adherence to the use of dental floss are associated to a higher severity of halitosis [46]. It is also possible to observe that lower education level and higher age are associated to worse oral hygiene index [66,67], directly contributing to halitosis occurrence.

Infections and intraoral wounds

All factors creating food or plaque retention, and allowing the bacterial aminoacids putrefaction, could cause halitosis [18]. Tongue coating, periodontitis and bad oral hygiene are the main intraoral factors associated to halitosis, but less frequent causes of halitosis include caries, ulcers, food impaction, nocturnal use of prothesis or bad prothesis hygiene, neoplastic wounds and a low salivary rate [23].

Respiratory disorders

Due to the proximity between the oral cavity and the airways, there is a significant increase in VSCs in exhaled breath during episodes of pathologic airways disorders [23].

Approximately 3% of extraoral halitosis cases are originated on the tonsils, which accumulate a white material, called caseum, on their crypts [46,65,68]. The crypts system is an ideal environment to the anaerobic bacterial activity [68]. Caseums have a morphology similar to the dental biofilm, with desquamated epithelial cells, keratin and food debris [69] colonized by anaerobic bacteria that produces VSCs, very similar to the tongue coating microbiota [68]. Caseum presence means a 10-fold increased risk of changes in the VSCs exhaled pattern, and consequently, on halitosis. The caseum chronic formation is frequently related to halitosis and 77% of people who have caseum also have halitosis. The main cause of bad breath in these individuals is the decomposition of organic debris forming caseum by proteolytic bacteria [69].

Bacterial sinusitis is the main cause of malodor exhaled though nasal cavity. It presents a characteristic malodor, especially when a purulent mucus is present. Bacteria involved in mucus production are capable of directly producing VSCs. This purulent material, due to the anatomical proximity, drips from the nasopharynx to the oropharynx and may reach the base of the tongue. This phenomenon is called postnasal dripping and promotes an increase in the number of bacteria that form the existing tongue coating, as well as an increase in the nutrients utilized by these bacteria in their metabolism. This mechanism increases the production of VSCs [18].

Other respiratory tract conditions are less frequently associated to halitosis, as pulmonary abscess, necrotizing pneumonia, emphysema, pulmonary carcinoma, bronchiectasis and tuberculosis [18].

Gastrointestinal disorders

Despite the recurrent halitosis complaint among patients with gastrointestinal disorders, these represent the origin of only 0.5% of halitosis cases [18]. Biological plausibility of the involvement of gastrointestinal disorders with halitosis can be explained through two distinct mechanisms: a) the release of VSC produced in the stomach through the esophagus; b) the adsorption of VSC from gastrointestinal tract (GTI) to the bloodstream and subsequently diffusion on the lungs and release with the exhaled air [23].

Helicobacter pylori is a bacterium that demonstrated ability to produce MM and HS *in vitro*, what suggests its direct involvement on halitosis development. These VSC are absorbed, carried by the blood to the lungs where they are diffused and exhaled within the air [70]. It was demonstrated that the *H. pylori* eradication results in halitosis resolution [71-74].

Gastroesophageal reflux disease is characterized by the retrograde flux of gastric contents from stomach to esophagus, bringing unpleasant symptoms, halitosis among them [75]. Gastroesophageal reflux may cause halitosis through 3 distinct mechanisms: 1) postnasal dripping of the stomach contents, that reach the nasopharynx through the esophagus, irritates the nasopharynx mucosa and leads to the mucus dripping on the tongue basis, increasing the tongue coating volume; 2) altered function of the esophagus sphincter that could allow the gastric contents to return to the mouth; 3) direct damage of the peptic acid on the supraesophageal mucosa [76].

Inflammatory bowel diseases (IBD) are chronic conditions that affects the colon and the small intestine. Crohn's disease and the ulcerative colitis are part of this group of diseases [77]. Studies show a significant prevalence of halitosis among the patients carrying IBD [78] and this prevalence increases with the severity of the IBD clinical condition [79].

Diabetes mellitus

Individuals with type II diabetes mellitus (T2DM) may present a characteristic breath malodor, described as a "sweet and fruity smell" [18]. On diabetic ketoacidosis, the decarboxylation of acetyl coenzyme A in starvation situations produces an excess of ketonic bodies which circulate through the bloodstream until reaching the lungs where they are volatilized within the exhaled air, producing a breath with the characteristic diabetes ketoacidosis sweet smell [23].

Hepatic disorders

Bad breath caused by hepatic conditions is denominated *foetor hepaticus* and is related to DMS volatilized within the pulmonary air. DMS is originated on the intestines, however, the altered hepatic function results in higher concentration of this compound in the bloodstream, once the liver is unable to eliminate it. Consequently, DMS concentration is elevated within the exhaled air through the mouth and through the nose [25].

Renal disorders

Renal disorders are associated with an ammoniac breath, called *uremic fetor*. Patients with renal failure have elevated levels of ammonia, urea, isoprene and other compounds, once the kidneys are not able to eliminate them [23]. The malodor is typically uremic and associated to hyposalivation, common in patients with renal disorders [18].

Smoking

Cigarette smoke contains VSCs that can be detected by a sulfide monitor [18]. However, this concentration depends directly on the period of time that has passed since the individual's last cigarette [66]. Furthermore, when oral hygiene and halitosis levels between smokers and non-smokers was compared, it was observed a worse oral hygiene and a higher occurrence of severe halitosis among smokers [66].

The decrease of salivary flow rate in smokers favors the deposits accumulation, especially on the tongue, increasing the tongue coating which is one of the main factors causing intraoral halitosis [18,66].

Halitosis in smokers is also closely related to periodontal issues since smoking is one of the main risk factors for the progression of periodontitis and destruction of the supporting structures [66]. Cigarette smoke can change the subgengival ecosystem, increasing the absolute number of proteolytic Gram-negative bacteria, periodontal pathogens, directly producers of VSCs [18]. It also changes important cellular and endothelial functions promoting the progression of periodontitis and tissue destruction [80].

Alcoholism

Alcohol consumption is a risk factor for halitosis because the alcohol oxidation in the mouth and the liver produces acetaldehyde and other volatile products with a strong odor. Furthermore, alcohol intake is associated to a lower salivary flow rate and xerostomia, both risk factors for halitosis [18].

Xerostomia

Saliva is responsible for promoting the cleanliness of mouth tissues, removing debris

and microorganisms. This is the reason why hyposalivation may promote anaerobic bacterial growth and the putrefaction of debris that remains on the oral cavity after food intake. This process increases the production of VSCs in the mouth [18].

Medicines

The use of medicines is a common cause of hyposalivation [18], and this is the most common adverse effect of medicines affecting the oral cavity [81]. In individuals with a complaint of xerostomia, the main cause was the use of medicines [82,83].

In a recent systematic review, the main medicines capable of causing halitosis were evaluated. Cysteamine, used to the nephropathic cystinosis treatment or Huntington's disease, was the halitosis most associated medicine. Other medicines associated were anticholinergic oxybutynin and glycopyrrolate. Less frequently, the antidepressant imipramine, antihistamine and steroids. Medicines for neoplasia treatment was also associated to halitosis, as the PX-12 chemotherapy and with a lower intensity silibinin. A study demonstrated that cysteamine and PX-12 caused halitosis in 100% of the individuals [81].

Dietary intake

There are some foods with a high amount of sulfur. These foods, when suffer degradation on the intestines trigger a process similar to what happens when DMS is excessively produced on the intestine [25]. Onion and garlic are foods associated with this phenomenon. Garlic releases allyl methyl sulfide and onion releases methyl propyl sulfide [82]. The intake of these can increase the DMS concentration within the exhaled air [25].

Treatment

The first step on halitosis management is a detailed examination of the patient to identify the cause and drive the treatment to the identified causes [70]. An accurate diagnosis is essential to solve the issue.

To intraoral halitosis, the course of the treatment must be determined after a detailed intraoral examination, including teeth and soft tissues [18]. When the identified cause is the tongue coating, periodontitis or caries, the primary way to reduce intraoral halitosis is to eliminate the bacteria synthetizing the chemical compounds responsible for malodor [46,84] through a mechanical reduction of the microorganisms [18]. Patients must receive guidance about brushing their teeth, mechanical cleanliness of the tongue [84] and flossing or interdental cleaning devices such as interdental brushes [15,85-87]. Even though oral hygiene practices are a daily issue, some people have a lack of proper knowledge about the correct execution and frequency of such practices [88]. These hygiene habits must be incorporated on the individual's oral hygiene routine [89] and should be individualized, considering that some individuals may have some risk factor for plaque retention, such as orthodontic devices [90].

When the origin of halitosis is identified as periodontitis, the patient must receive the proper periodontal treatment and follow up, referred to a specialist able to conduct this therapy. Oral hygiene guidance previously mentioned are fundamental for patients with periodontitis, once the treatment's success depends on the cooperation of the patient and their adherence to a daily routine of oral hygiene. When necrosis and pericoronitis are identified, treatment must be performed aiming to solve these problems and re-establish the health status in the mouth [89].

As a complement to the treatment of intraoral causes, we can use some oral hygiene products which can reduce microorganisms or have the ability to mask the malodor. There are mouthwashes and toothpastes with antiseptic activity [87] and there are also products with oxidizing potential available [46], which will perform a chemical reduction of the microorganisms and VSC neutralization respectively [18]. Besides these, there are products acting only by masking the malodor [62].

Antiseptic products available for use are chlorhexidine, essential oils and cetylpyridinium [18,62]. They have a demonstrated effect on the reduction of the production of VSCs through the reduction of the microbial load on the mouth cavity, performed by the antibacterial effect [62,91].

Chlorhexidine is nowadays considered as the gold standard of the antiseptics and an excellent supporting product on halitosis treatment [18]. Chlorhexidine containing mouthwashes show success on the reduction of the supragingival plaque antimicrobial activity, as well as on the tongue coating microbial load [92]. However, chlorhexidine is associated

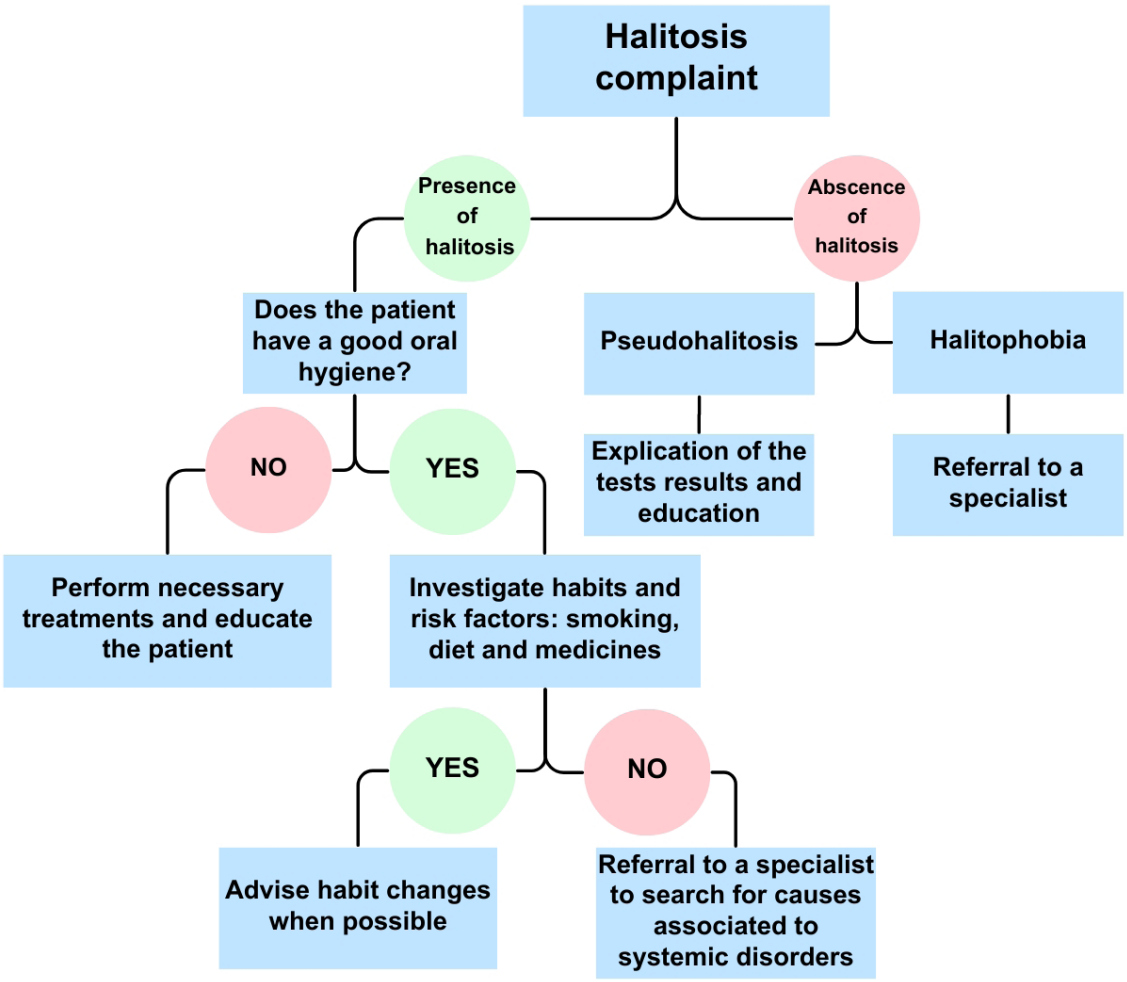

Figure 3 - Tree of decisions suggesting the steps a professional must follow to identify the correct cause of halitosis before deciding the treatment. Information adapted from the paper from Campisi et al. [89] and Seeman et al. [95].

to teeth and tongue staining as well as taste changing, which limits its use for extended periods of time [12]. Cetylpyridinium is a quaternary compound that has bacteriostatic effect on the VSC producing bacteria [93], reducing the intensity of the malodor. However, cetylpyridinium is unstable in solution and has a small effect on dental biofilm reduction, especially when compared to chlorhexidine, which performs a greater effect on biofilm [94]. Mouthwashes based on essential oils are used for their reported ability of rupturing the bacterial cell membranes. However, literature is scarce when we search for their ability on reducing VSCs. Essential oils may act masking the malodor due to its naturally strong smell [62].

Zinc containing toothpaste are a good auxiliary method on halitosis treatment, due to their demonstrated ability to reduce VSC [70]. Zinc is a metal ion and interacts with sulfur on VSC precursors, neutralizing these molecules and reducing the bad breath intensity [91].

When the individual presents some associated cause as cigarette, alcohol and dietary habits that may contribute to the bad breath occurrence, we must guide the patient and when possible, try to institute a habit modification [89]. When halitosis is associated to the use of medicines or a systemic condition, the patient must be referred to the doctor to the proper treatment or replacing the medicine when possible.

Patients with delusional halitosis should be properly guided. Oral hygiene instruction and the explanation about halitosis causes and risk factors are valid for every patient. Sometimes halitophobic patients are difficult to manage and should be addressed with discretion, normally with a carefully referral to a physician [49]. A tree of decision regarding the clinical assessment of the patient is represented on figure 3, in order to guide the steps for correct diagnosis.

CONCLUSION

Halitosis is a prevalent health issue and may affect the social life of people carrying this symptom. Halitosis is mostly caused by oral health issues, mainly tongue coating accumulation and periodontitis. But halitosis might also be a symptom of a wide range of systemic conditions, including respiratory, renal, hepatic and endocrine disorders. A correct diagnosis and a multiprofessional approach are fundamental for the clinical management and the treatment of this condition, aiming a better prognostic for the individual.

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Author's Contributions

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