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Nelly Alejandra Rodriguez Guajardo
Professor, Unidad Academica de Odontologia, Universidad Autonoma de Zacatecas, Zacatecas, Zip Code 98000, Mexico.

Gloria Martha Alvarez Morales
Professor, Unidad Academica de Odontologia, Universidad Autonoma de Zacatecas, Zacatecas, Zip Code 98000, Mexico.

Fatima Del Muro Casas
Professor Unidad Academica de Odontologia, Universidad Autonoma de Zacatecas, Zacatecas, Zip 98000, Mexico.

Maria Argelia Akemi Nakagoshi Cepeda
Professor, Facultad de Odontologia, Monterrey, Universidad Autonoma de Nuevo Leon, Zip 64460, Mexico

Leticia Tiburcio Morteo
Professor, Facultad de Odontología, Universidad Veracruzana, Veracruz, Mexico

Rosa Elena Ochoa Martínez
Professor, Facultad de Odontología, Universidad Veracruzana, Veracruz, Mexico

Melanie Loyola Quinter
Student, Dentistry, Facultad de Odontologia, Monterrey, Universidad Autonoma de Nuevo Leon, Zip 64460, Mexico.

Juan Manuel Solis Soto
Professor, Facultad de Odontologia, Monterrey, Universidad Autonoma de Nuevo Leon, Nuevo Leon, Zip 64460, Mexico

Corresponding Author:
Juan Manuel Solis Soto
Professor, Facultad de Odontologia, Monterrey, Universidad Autonoma de Nuevo Leon, Nuevo Leon, Zip 64460, Mexico

Halitosis: An updated scoping review

Nelly Alejandra Rodriguez Guajardo, Gloria Martha Alvarez Morales, Fatima Del Muro Casas, Maria Argelia Akemi Nakagoshi Cepeda, Leticia Tiburcio Morteo, Rosa Elena Ochoa Martínez, Melanie Loyola Quintero and Juan Manuel Solis Soto

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Abstract
Introduction: Halitosis is considered a condition that affects more than 50% of the population, it is of multifactorial origin, due to poor oral hygiene, prolonged fasting and imbalance in the intestinal microbiota**.**
Objective: To analyze the literature on relevant aspects of halitosis, particularly its etiology, epidemiology, diagnosis, treatment and manifestations.
Methodology: A literature review was carried out in PubMed, Scopus and Google Scholar databases using the keywords: etiology, epidemiology, diagnosis, treatment, oral manifestations, and Boolean parameters AND, OR and NOT.
Results: It is manifested due to both extraoral factors, associated with systemic diseases, and intraoral factors, such as tart tongue, periodontal diseases and poor oral hygiene practices, which represent between 80% and 90% of the cases. The main compounds responsible for bad breath are volatile sulfur compounds, especially hydrogen sulfide and acetaldehyde; it can be diagnosed by various tools such as organoleptic testing, assessment of small intestinal bacterial overgrowth, gas chromatography and biomarkers. Its treatment has advanced significantly, including approaches that seek to restore the balance of the oral microbiota, therapies based on traditional medicine, the use of biomarkers, and conventional treatments such as chlorhexidine, 5% glutamine, fractional exhaled nitric oxide and probiotics. Photodynamic therapies, especially aPDT, have shown particular promise.
Conclusion: Halitosis is mainly caused by volatile sulfur compounds and alterations of the oral microbiome, diagnosed with advanced tools and treated with innovative approaches such as photodynamic therapies, probiotics and traditional medicine. Its integrated management combines conventional methods and emerging therapies to restore oral balance, offering effective solutions in most cases.

Keywords: Halitosis, etiology, epidemiology, diagnosis, treatment.

1. Introduction
Halitosis is defined as the presence of an unpleasant odor in the breath, although its etiology is multifactorial, it is not yet fully understood [1]. The relationship between the oral microbiome, oral health and dysbiosis has been extensively studied, especially in European and American populations. However, despite the fact that halitosis affects millions of people worldwide, research on the oral microbiome in diverse and low-resource populations is limited. The posterior dorsum of the tongue has been identified as the main site of origin of volatile sulfur compounds (VSCs) responsible for bad breath [2, 3].
The association between halitosis and periodontitis is clinically relevant and points to possible interventions to improve oral health. This association is supported by the measurement of VSC and organoleptic assessments [4].
Halitosis not only negatively affects patients' social lives, but can also be a symptom of systemic diseases. Accurate identification of the source and cause of the unpleasant odor is essential for effective treatment [5]. It is a very common oral health problem in the adult population, about which there is still limited knowledge.

Although it is known that factors such as poor oral hygiene, adverse effects of treatments and systemic conditions contribute to the development of halitosis, further research is required to fully understand its etiology, epidemiology and manifestations, in order to provide accurate tools for diagnosis and treatment. In this paper we reviewed the literature on halitosis, particularly its etiology, epidemiology, diagnosis, treatment and manifestations.

2. Methodology

Information from articles published in PubMed, Scopus and Google Scholar was analyzed with emphasis on the last 5 years. The quality of the articles was evaluated based on the standard guidelines, i.e., identification, review, choice, and inclusion. The quality of the review was assessed using the measurement instrument for evaluating systemic reviews. The search was performed using Boolean logical operators AND, OR and NOT. It was realized with the word “halitosis”, along with the following terms: “etiology”, “epidemiology”, “diagnosis”, “treatment” and “manifestations”. Keywords were used individually and also as a whole.

3. Results

3.1 Etiology

The oral microbiome, a complex ecosystem composed of bacteria, fungi, archaea and viruses, is fundamental to oral health. However, various factors such as diet, smoking, alcohol consumption, lifestyle and medical conditions can alter this balance, leading to dysbiosis associated with problems such as halitosis [6]. Most cases of halitosis (80-90%) are intraoral in origin, mainly related to saburral tongue, periodontal diseases and poor oral hygiene [7]. A smaller percentage (10-20%) is attributed to extraoral factors associated with systemic diseases [8]. In addition, idiopathic halitosis is often linked to small intestinal bacterial overgrowth (SIBO) [9].

Mainly VSCs are responsible for bad breath, as well as hydrogen sulfide and acetaldehyde [10]. Certain genes associated with sulfur, indole, skatole and cadaverine metabolism (such as serA, metH, metK and dsrAB) are expressed to a higher extent in samples from patients with halitosis [11]. During fasting, an increase in dimethyl sulfide (DMS) concentrations is observed, which contributes to bad breath. In addition, there are changes in the composition of the oral microbiota, with a decrease in genera such as Neisseria, *Gemella* and *Porphyromonas* and an increase in *Megasphaera*, *Dialister*, *Prevotella*, *Veillonella*, *Bifidobacteria*, *Leptotrichia*, *Selenomonas*, *Alloprevotella* and *Atopobium* [12].

Understanding halitosis requires recognizing that it is not always a consequence of poor oral hygiene. VSCs, produced mainly by gram-negative anaerobic bacteria of the oral microbiota, play a key role. In addition, systemic conditions can influence the development of halitosis. Given its multifactorial origin, involving local, systemic and behavioral aspects, this condition has a significant impact on the quality of life of those who suffer from it, both socially and psychologically.

3.2 Epidemiology

Oral diseases represent a significant burden worldwide, exceeding in prevalence many other non-communicable diseases. Recent studies have shown that idiopathic halitosis, of extraoral origin, is associated with elevated DMS levels and increased inflammatory cytokines [13]. In addition, research in New Zealand has revealed higher levels of VSC in patients with oral lichen planus [14].

In ecuador, the impact of oral diseases, including halitosis, on the quality of life of the population has been evaluated. Studies in Karachi, Pakistan, have identified factors such as age, socioeconomic status, consumption of substances such as niswar and tea, and inadequate oral hygiene habits as risk factors for halitosis [15, 16]. While in Dhaka, Bangladesh, a high prevalence of self-perceived halitosis associated with alcohol consumption (71.43%), mouth breathing (64.60%), coffee/tea consumption (61.35%), overweight (61%) and obesity (60.77%) as well as sedentary habits has been observed [17]. Similarly, in Delhi, India, self-perceived halitosis has been related to the use of masks and less dental care during the COVID-19 pandemic [18].

Halitosis is a prevalent oral health problem worldwide, with a multifactorial etiology. Factors such as age, socioeconomic level, oral hygiene habits, substance consumption and the presence of systemic diseases influence its development. It can have a significant impact on people's quality of life, generating social problems, stress and anxiety. It is estimated to affect a considerable proportion of the adult population.

3.3 Diagnosis

There are several tools for the diagnosis of halitosis. One of them is the Halitosis Associated Quality of Life Test, which has shown good reliability and validity in Thai and Brazilian adult populations [19, 20]. Other investigations use organoleptic testing, while idiopathic halitosis is diagnosed by excluding known causes and assessing SIBO by hydrogen/methane lactulose breath test [6, 21].

To assess VSCs, a selective gas chromatography device such as the Oral Chroma can be used. In addition, it is possible to profile the salivary microbiota [12, 22] and to assess the lingual coating using the Winkel index. Clinical indices such as the papillary bleeding index and the Quigley-Hein index allow the determination of local inflammation and oral hygiene [23].

Another technique to detect intraoral halitosis is by analysis of biomarkers, such as paramethasone acetate, {1-[2-[2-(4-carbamimidoyl-benzoylamino)-propionyl]-piperidin-4-yloxy}-acetic acid, indole-3-acetic acid and valyl-arginine [24].

The diagnosis of halitosis begins with the primary symptom, bad breath, and requires a thorough evaluation of the oral cavity. This evaluation includes breath testing, analysis of compounds such as VSC and DMS, evaluation of the salivary microbiota, and the use of biomarkers. In addition, it is important to consider the presence of systemic diseases and the use of medications that may contribute to bad breath.

3.4 Treatment

In some African populations, traditional medicine is used to treat various oral conditions, including halitosis [25]; for example, *Phyllanthus emblica* fruit extract has been shown to reduce the inflammatory response to bacteria associated with bad breath [26]. Likewise, lavender essential oil has been shown to be effective in damaging the cell membrane of Fusobacterium and decreasing VSCs [27].

Other treatments include the use of 5% glutamine and chlorhexidine, which have been shown to significantly reduce halitosis, as well as pneumonia and oral bacterial load [28]. In addition, combinations of compounds such as ε-PL, FP and domiphen, along with newly formulated mouthrinses, have shown anti-plaque and anti-halitosis properties [29].

The use of antimicrobial or probiotic drugs can help regulate oral or intestinal flora, thus improving halitosis and overall

oral health. Probiotic preparations have been shown to be effective in the treatment of idiopathic halitosis, probably due to their impact on SIBO [9]. On the other hand, fractional exhaled nitric oxide (FeNO200) treatment is recommended for the diagnosis of idiopathic halitosis of extraoral origin, as it has been shown to be highly effective [13].

Photodynamic therapies offer promising options for the treatment of halitosis. One of these involves exposing tissues to blue light (400-500 nm) at a sublethal intensity, which enhances the ability of plants such as lavender and echinacea to reduce VSC production, thereby improving the efficacy of anti-bad odor agents [30]. Antimicrobial photodynamic therapy (aPDT) has also been shown to be effective in reducing the concentration of hydrogen sulfide, a gas associated with bad breath [31]. The combination of annatto, blue LED and photodynamic therapy has been shown to be a viable option for treating halitosis in mouth-breathing children [32].

Halitosis may be a symptom of an underlying medical condition. Although any effective treatment must be based on improved oral hygiene, there are a variety of therapeutic options. In some populations, traditional medicine, including the use of essential oils, remains popular. Other alternatives include the use of antiseptics such as chlorhexidine, supplements such as glutamine and probiotics, as well as more advanced treatments such as fractional exhaled nitric oxide (FeNO200) and photodynamic therapies. The latter, especially those of the antimicrobial type, have been shown to be particularly effective in the treatment of halitosis. However, their access may be limited due to cost.

3.5 Manifestations

Although halitosis is not a fatal disease, it has a significant impact on people's quality of life and can have psychological, social, professional and affective consequences [33]. This problem can lead to social isolation [34]. In addition, it has been associated with poor diet and nutritional deficiencies, mainly for vitamins and bio elements [35].

Halitosis and oral ulcers are more frequent during the late luteal phase of the menstrual cycle, coinciding with estrogen and progesterone hormonal changes [36]. Chronic alcohol consumption can alter the oral microbiome, favoring the growth of oral pathogens [37]. Likewise, functional constipation has been associated with halitosis due to DMS production [21].

Patients who have been treated for squamous cell carcinoma of the head and neck often have elevated levels of hydrogen sulfide, resulting in halitosis [38]. Similarly, people with chronic kidney disease and patients with rheumatoid arthritis show a higher prevalence of halitosis, in addition to other oral complications such as caries, periodontitis, oral candidiasis and xerostomia [39, 40].

In the case of patients with COVID-19, the presence of the ACE2 receptor in the oral mucosa facilitates SARS-CoV-2 infection and can manifest with halitosis, petechiae, hemorrhagic blisters, pustular enanthema and mucositis [41, 42].

The most evident and characteristic symptom of halitosis is bad breath, the intensity of which can vary. It is usually more noticeable during fasting, with an inadequate diet, after alcohol or tobacco consumption, during the menstrual cycle and in people with certain medical conditions such as rheumatoid arthritis, COVID-19 or those who have been treated for squamous cell carcinoma of the head and neck.

4. Conclusions

Halitosis, a multifactorial condition affecting more than 50% of the adult population, is associated with poor oral health, fasting, inadequate diet, systemic diseases, and side effects of certain medications. It is diagnosed mainly by bad breath and is characterized by alterations in SIBO and an increased concentration of VSC and DMS. There are numerous advances in the treatment of halitosis, including approaches that seek to restore the balance of the oral microbiota, therapies based on traditional medicine, the use of biomarkers, chlorhexidine, 5% glutamine, fractional exhaled nitric oxide, probiotics and photodynamic therapies, most notably aPDT.

Conflict of Interest
Not available

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