



# Halitosis Update: A Review of Causes, Diagnoses, and Treatments

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**ABSTRACT** Up to 50 percent of the U.S. population reports that their own “bad breath” has concerned them during some point in the course of their lifetime. Half of this group is indeed likely to have an ongoing sporadic or a chronic breath malodor problem. This report looks at the phenomenon of malodorous breath, which oddly persists in a society rife with scientific and medical advancements. Also reviewed are the primary causes, diagnoses, treatments, and research frontiers.

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People have been concerned about “bad breath,” or halitosis, for a long time. More than 2,000 years ago, Hippocrates suggested a rinse using herbs and wine be used to sweeten the unpleasant odors of the breath.<sup>1</sup>

While up to half of the adult population is estimated to be affected by real or perceived halitosis at some time or another, one-quarter may have this problem chronically to the extent that others have “trouble enjoying their company.”<sup>2-4</sup> These estimates are difficult to validate, however, as many who readily admit breath malodor have none, while those who deny experiencing any significant breath problems are actually suffering from it.<sup>5</sup> We’ve all known the latter type, and putting oneself in the place of one who unknowingly inflicts others feeds our social paranoia. Thus, it is no surprise that over the decades, the public’s concerns over their own potential oral odors have not decreased, even while dental health has improved. These concerns continue to spawn ingenuity in the breath-freshening industry. For example,

in 2002, *Time* magazine hailed Listerine’s PocketPaks — the first breath strips that dissolved on the tongue — as one of their “Products of the Year,” along with breakthroughs such as the birth control patch.<sup>6</sup> Meanwhile, diagnostic devices, usually used in dental offices and research studies, are available to measure odor-producing chemical compounds in the breath.

In the United States, estimates are that the American public spends \$1 billion to \$3 billion a year for gum, mints, and breath fresheners, and there’s no sign of the popularity of these products dissipating any time soon.<sup>7,8</sup> The joke is on the consumer, however, when a product (e.g., Altoids, etc.) contains sugar, as this feeds bacteria, furthering odor production just as the mintiness dissipates. Also, alcohol-containing rinses can dry out the mouth, re-establishing an odor problem soon after their fragrance is gone. One report claims that even sugarless gum has been shown to slightly increase the production of methyl mercaptan (smells of feces).<sup>9</sup> So, when over-the-counter fresheners fail, it is not uncommon for some to consult with, or at least mention it to, a doctor of dental medicine or surgery.

Dentists get lots of education about treating teeth, but could probably learn more about malodor. In 2001, one dental conference established some best practices regarding oral malodor evaluation.<sup>3</sup> A few years later, the American Dental Association Council on Scientific Affairs released its “2003 ADA Seal Acceptance Program Guidelines for Products Used in the Management of Oral Malodors,” in which an example of a scale for odor assessment can be found.<sup>10</sup> These guidelines will protect the public by assuring that ADA Seal products that make malodor control claims have met strict criteria since mid-2005. Yet, some dentists still complain that the profession has yet to agree upon a standard assessment of halitosis.<sup>11</sup> Before the dust settles on assessment protocols or which products will end up bearing the ADA Seal, diagnostic and treatment products will continue to make their way into dental offices and the Home Shopping Channel. Halitosis is on the American consumer’s radar so fluorimetric sensor-based instruments — among other types of clinical gizmos — may be at a dental office near you, or in your own, for volatile sulfur compound diagnostic assistance.<sup>12</sup>

This review article summarizes some of the current literature on halitosis to provide an overview of etiology and treatment. Suggestions for management and prevention are provided, along with research frontiers in halitosis.

### Malodor Origin and Causation: Oral or Systemic?

Assessing causation is a dubious duty. Causes of bad breath can be multiple, and etiological culprits may shift over time. Ninety percent of the time, the dark, wet and warm oral cavity is the source of malodor (localized); systemic origin comprises roughly the remaining 10 percent of cases.<sup>3,13,14</sup>

**LOCALIZED SOURCES.** The oral cavity is an ideal breeding ground for microorganisms, and most sufferers have a localized cause for malodor in their mouths.<sup>15</sup> The properties of saliva, and the acts of chewing, drinking, throat clearing, and coughing all work in harmony to keep the mouth homeostatic, and thus healthy.

**THE TONGUE — WITH its malodorous colonized bacteria, shed cells, and decayed food — is the primary odor host of all sites in the human body.**

Insults such as smoking, conditions such as xerostomia, and the neglect of oral hygiene can tip the balance by contributing to the multiple factors that enable odiferous bacteria to grow with a virulence.

The benign act of eating can even be fraught with treachery. Common food impaction within crevicular spaces between teeth can produce unpleasant odors.

The surfaces of diseased gingiva, and the film-coated palate, teeth, tonsils/adenoids, throat, and sinuses, as well as ear infections, directly impart malodor to the exhaled air of otherwise unremarkable smelling expirations.

Under magnification, the tongue could be compared to the surface of the moon after a rain shower. Its craters and peaks are covered by a thin, sticky or tacky wetness colored clear to whitish yellow. The tongue — with its malodorous colonized bacteria, shed cells, and decayed food — is the primary odor host of all sites in the human body.<sup>16</sup> Research shows

that tongue cleaning reduces odor, but must be performed daily as the bacteria “bounce back” within a day, and even in as little as 15 minutes, depending on technique used and host response.<sup>17,18</sup>

Tests of mouthwash efficacy show that while they reduce overall mouth volatile sulfur compound scores, they don’t improve tongue-coating volatile sulfur compound scores.<sup>19</sup> The back of the tongue is akin to a sponge for postnasal drip, which itself isn’t offensive smelling until it commingles with and feeds the tongue’s resident bacteria.

When proper brushing, daily flossing, tongue cleaning, mouth rinsing, and gum chewing don’t work, the dentist’s office is typically the first stop for the afflicted. Dentists can run through a differential diagnosis and do a complete exam. Among the culprits, perhaps the patient’s prostheses are not being soaked in disinfectant nightly. If prescriptions are divulged in the health history, the dentist may determine if dry mouth is a drug side effect, which is itself a causal factor for halitosis.

**SYSTEMIC SOURCES.** Systemic causation (hepatic, pulmonary, renal, metabolic, etc.) of bad breath is infrequent. Yet, toxins in the blood that are produced by subsurface systemic illness do contribute to oral malodor as they are eliminated via the lungs.<sup>20</sup> When this air breezes through the nose and mouth, foul odorous gases fly away like invisible kites.<sup>20</sup> Furthermore, nerves, glandular disorders, and GI infections may be etiological and necessitate referral to physician specialists.

For example, coughing or sore throats, frequent throat clearing, sinusitis, tonsillitis, snoring, and intranasal obstructions could require an evaluation by an otolaryngologist.<sup>21</sup> Many adults suffer from disorders such as gastric acid reflux. All of these conditions can affect breath. If

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suspected by a dentist, the patient should be referred to his or her physician for diagnosis and treatment. Unusual malodor-incident occurrences have been recorded also, such as a chronically infected foreign body (for example, a metal ball bearing or plastic bead) lodged within the nose or sinuses unbeknownst to its host.

Occasionally, eating certain foods, such as raw onions, may be associated with oral malodor, but spicy foods like these are frequent odorant scapegoats. If oil of garlic or onion has adhered to the surfaces of the mouth, there may well be transient odor. But if it is in the stomach, it will not cause oral malodor outside the occasional belch in the short term because of the esophageal collapse and “trapdoor effect” that keeps its acidic soup from escaping.<sup>22</sup>

Thus, telling patients to restrict certain foods from their diet to cure chronic halitosis is not supported by research. Of course, metabolizing a lot of garlic can result in allyl methyl sulfide seeping out of the pores of the skin — not just the breath — but this calamity only lasts less than 24 hours.<sup>23</sup>

Finally, hormonal fluctuations or stress, such that can occur in some women’s menstrual cycles, has been implicated with higher volatile sulfur compound concentrations in one study.<sup>24</sup>

### Diagnostic Methods

Fifty percent of all dentists probably have half a dozen patients come through their practice each week who are self-admitted halitosis sufferers.<sup>25</sup> The question is, are they detecting them?

Diagnosing oral odor is an ubiquitous affair. There are different compounds that can be measured and devices to do the measuring, and none are free of pitfalls. In fact, low self-esteem may contribute to the false and debilitating

TABLE 1

### Organoleptic Intensity Scale (Based on Rosenberg<sup>34</sup>).<sup>10</sup>

Rating	Odor Intensity
Odor cannot be detected	0
Questionable malodor, barely detectable	1
Slight malodor, exceeds the threshold of malodor recognition	2
Malodor is definitely detected	3
Strong malodor	4
Very strong malodor	5

paranoia that one’s breath is horribly offensive; this is known as “delusional halitosis.”<sup>26</sup> This “halitophobia” is not uncommon and is associated with mental illness and depression.<sup>27</sup>

At the initial consultation, a screening questionnaire can assess the psychological status of a patient complaining of halitosis, for these patients will never feel their problem is cured/controlled no matter what “evidence” to the contrary that the dentist produces.<sup>28</sup>

Calibration and correlation issues arise when the quality (hedonic) and strength rankings of a patient’s breath can vary appreciably from examiner to examiner. A five-point (0-5) organoleptic intensity scale (TABLE 1) based on Rosenberg and others has a different ranking for “barely detectable” than for “slight malodor.”<sup>10,29-33</sup> Would two dentists in the same practice both differentiate these rankings similarly? Probably not without hedonic training. Thus, using standard odorants, calibration and standardization between two or more evaluators is needed.

A nine-point hedonic scale was used in 2004 research by Li and colleagues that had a midpoint (“5”) for neutral odor.<sup>34</sup> A four-point scale has also been suggested in the literature.

In 2001, the ADA Conference on the Diagnosis and Management of Oral Malodor by consensus adopted some of Rosenberg and colleagues’ protocols as “methods of choice.”<sup>3</sup> For example:

- From the mouth, breath should

be evaluated at 10 centimeters away by the nose of a blinded judge;

- From a spoon, it should be evaluated five seconds after the spoon has scraped the dorsal tongue, and at a distance of 5 cm from the judge’s nose;

- From used floss, it should be evaluated 3 cm from the judge’s nose.

Besides determining a problem exists, there are various traits to record (e.g., “Is the malodor occasional or chronic?”) to characterize the problem during the exam. Various types of questionnaires are available to record malodor health history taking, and to assist in diagnoses.<sup>35</sup>

**SELF-DIAGNOSIS.** The age-old method of breathing into the cupped palms to discern one’s own breath may or may not detect anything. Regardless, if a foulness is detected by this antiquated method, rating its severity and improvement/degradation over time is not possible in this way. The value in self-diagnosing may be in establishing a suspicion of a problem. By licking the wrist with the length of the tongue (including as far back as possible) and waiting 15 seconds before sniff-testing, one is allegedly able to discern negligible or problematic tongue odors.<sup>36,37</sup> By doing the same with floss, one can detect negligible or problematic periodontal odors. By having another person evaluate mouth breath (while nose pinched closed) versus nose expirations (while holding mouth closed) can help detect odors of sinus origin.

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Products for self-diagnosing by patients include some that the consumer has rejected because of perceived high price. OK-to-Kiss (Emjoi) was a palate and treatment solution kit that is no longer offered by the company. It had a novel color change that correlated to an enzyme that related to one's malodor status.<sup>38</sup> Before dentists recommend products described in the literature to their patients, they should research whether they are still available and an idea of cost involved.

**DIAGNOSTIC TOOLS, DEVICES OR INSTRUMENTS.**

To have a tool for measuring bad breath that works, it has to have something to measure. Strongly odiferous oral substances known as volatile sulfur compounds are produced by a combination of ingredients such as anaerobic bacteria that are gram-negative, and sloughed epithelial cells breaking down (rotting), among a host of other organochemical orchestrations. This degradation process involves the release of the gases dimethyl sulfide, hydrogen sulfide, dimethyl disulfide, and methyl mercaptan. Measuring volatile sulfur compound concentration in expired mouth air produces data that aids in diagnosing halitosis.<sup>39,40</sup> In *Scientific American*, Rosenberg's 2002 bad breath article included a "Most Unwanted List" of bacteria and associated smell (TABLE 2).<sup>4</sup>

Interestingly, the severity of periodontal disease and the concentration of volatile sulfur compounds (how bad the odor) has been linked.<sup>41</sup>

In the literature, there is consensus that the human nose is the primary "organoleptic device" for detecting foulness. But for quantification and research, there are two categories of electronic devices that have been marketed over the years that range from under \$100 to thousands of dollars. Each measures odor—one for differentiating out the various volatile sulfur compounds via gas chromatography and then

TABLE 2

**Most Unwanted List\***

Cadaverine	Corpse
Hydrogen sulfide	Rotten eggs
Isovaleric acid	Sweaty feet
Methyl mercaptan	Feces
Putrescine	Decaying meat
Trimethylamine	Decomposing fish

\*Adapted from, and used with permission, "The Science of Bad Breath," Rosenberg M, *Scientific American*, 286(4):72-9, April 2002.<sup>4</sup>

detecting the volatile sulfur compounds (for example, a portable GC known as OralChroma (ABILIT, Osaka City, Japan) does a halitosis analysis for three gases that are in volatile sulfur compounds); another involves a semiconductor gas sensor.<sup>39,42</sup> The latter includes the Halimeter (InterScan, Chatsworth, Calif.), a gas analysis sensor that measures the volatile sulfur compounds, and has been thought of as the "gold standard" instrument by some.<sup>43</sup> Although it has some disadvantages, it is resourceful in that it is used to record the volatile sulfur compound status, and degree of change, as well as source.<sup>3</sup> There are other detectors measuring volatile sulfur compounds and tying them into gingival health or tongue odor.<sup>44,45</sup> More recently, the sensor-based FF-1 Odor Discrimination Analyzer (Shimadzu, Japan) dubbed the "electronic nose" was tested with promising initial findings.<sup>46</sup>

Some chairside tests for proteolytic activity of bacteria, microbiology smears for bacteria type, and an assay for enzymes are also available.<sup>3</sup> Commercially available sulfide monitors such as the benzoyl-DL-arginine-naphthylamide test are marketed. Modestly priced devices are available such as the BreathAlert Breath Checker, Tanita, Arlington Heights, Ill.), and other portable sulfide monitors.<sup>47</sup> Research findings, however, caution of fluctuations in sulfur concentrations in the breath, which could complicate assessment.<sup>48</sup> Another study warns of

the useful but occasionally inaccurate estimation of some sulfide detectors.<sup>49</sup>

**EXAMINER PERCEPTION.** Dentists can perform the organoleptic sniff testing exam on a patient at two or more visits. A tube and a privacy screen dividing him or her from the patient is suggested.<sup>50</sup> This clinical assessment barrier reduces embarrassment for patients, who probably have never exhaled directly at a person's nose before. The dental team should learn helpful assessment questions and become well-versed in proper dialogue with patients in the data-gathering process.<sup>51</sup>

To remove confounding odors from the subject on test day, patients should not use perfumes or scented deodorants, lotions, shampoo/conditioner, or lip balm. Thus, it is advisable to bathe with unscented soap. Alcohol and tobacco product use should be ceased for a day or two before the exam, as well as spicy foods. No coffee for several hours before the exam, and no water or eating for a few hours before the exam. Antibiotic use should be ceased three weeks before the assessment.<sup>16</sup>

While some dentists who diagnose halitosis in their clinics instruct their patients not to brush, floss, or gargle the day of the exam, this is unreasonable to others, some who believe it would lead to overdiagnosing halitosis. The 2003 ADA Seal guidelines previously mentioned earlier suggests that appropriate clinical protocol is that those who have "intrinsic" oral malodor will exhibit this odor two hours after oral activity ceases (eating, drinking, or toothbrushing).<sup>10</sup>

**Treatment and Prevention**

Reducing oral malodor may involve dental and oral care, oral hygiene management, and pharmaceuticals. Surgery has reduced oral malodors, but this is a secondary outcome to that for other indi-

cations. Initial treatments for bad breath are, in fact, often the same as those for management and preventive strategies.

**ORAL AND THROAT HEALTH.** A dentist must provide oral care and repair so that all restorations and prostheses are intact. Care, including treatment of any soft tissue pathology, must be current. Just as homeowners with pets who clean their carpets once a year have homes that tend to have less odor than those who do so only every five to 10 years, patients who delay their six-month prophylaxes to “every few years” are inviting problems. Plaque may be gathering between teeth and below the gumline in preparation for periodontal disease. At this stage, there is no measurable sign (i.e., pocket depth, attachment loss) of the disease except pungent odor. Recent research has indicated that a concentration of sulfide gas is the first “periodontal parameter” associated with initiation and progression of early plaque-induced periodontitis.<sup>44</sup> Fortunately, a standard prophylaxis can wipe out the gathering pathogens, reversing breath degradation. Patients who have a six-month dental cleaning often find this simple commitment will keep breath problems (not to mention gum disease) away.

Frequent sore throats and other observations should be duly noted, as causation and impact will need to be understood. Tiny openings like tunnels on the surface of tonsils can get plugged with sloughed cells, food, and bacteria, creating recurring infections in some patients. This can be a source of odor in these individuals. Even small, calcified, bacterial debris called tonsilloliths may be expelled. Outside of the mouth, tonsilloliths smell putrid but, interestingly, those who expel them don't necessarily have bad breath.<sup>36</sup> Dentures need to be checked for acrylic breakdown, and the ridges checked for apthous ulcers and the mouth for fungal infection.

Some dentists take a PH reading (alkaline pH is associated with increased odor), and all should do a gingival and a periodontal exam. *Porphyromonas gingivalis* is one of many species that seem to be associated with periodontal disease and strongly correlated with putrefactive odors.<sup>4,52</sup>

**ORAL HYGIENE MANAGEMENT STRATEGIES.** Besides showing the patient proper brushing and floss techniques, tongue cleaning should be explained and demonstrated because research shows this regimen acts to ameliorate malodor.<sup>53</sup> But the act of “scraping” can be too damaging to the sensitive tissue. Thus, instead of a tongue scraper, one or two gentle dorsal sweeps with an extra-soft toothbrush head devoid of paste and at an angle of least resistance can work safely, as can a folded square of gauze.

Patients who undergo an oral hygiene program designed to educate them as to proper home care techniques were found in one study to have reduced volatile sulfur compound levels compared with a control group.<sup>54</sup>

Oral rinses should be suggested to following the tongue cleaning regimen. Chlorine-containing preparations (including a stabilized form of chlorine dioxide or a peroxide rinse), have long been advocated for destroying putrefied mouth oils.<sup>22,55</sup> Other rinses include essential oils, for example, Listerine (Pfizer, New York, N.Y.) and Tooth & Gum Tonic (Dental Herb, Northampton, Mass.).<sup>56</sup> Others contain the stain-producing chlorhexidine, hydrogen peroxide, zinc acetate, sodium bicarbonate, and chloride.<sup>57-59</sup> The use of triclosan, zinc chloride, or oil-water-cetylpyridium chloride-containing mouthrinses seem to reduce oral bacteria and thus odor as well.<sup>3,59-64</sup> Less frequently, but increasingly, we learn of natural remedies such as tea extract and herbal plant compounds for freshening breath via antimicrobial activity.<sup>65,66</sup>

Xerostomia that can result from drugs and snoring/sleep apnea requires management strategies such as chewing gum, sipping water, and trying gels and saliva substitutes.

**PHARMACEUTICAL/OVER-THE-COUNTER ARMAMENTARIUM.** Dentists and hygienists should be able to explain the properties of various dentist-dispensed and over-

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the-counter rinses and their ingredients. If oral lesions or diseases are present, prescriptions for antibiotics may be needed. For those with known sinus and allergy problems, discussions of over-the-counter medications for drying sinuses may be suggested to probe the perioral role of postnasal drainage as a cause. But even if such over-the-counter medication balances the patient's sinus issues, the resulting dryness from the medication can counterbalance the oral malodor dilemma. Thus, these patients' malodor progress should be monitored to better understand the complex balance of treatments needed.

**SURGICAL SITUATIONS.** Some patients report improved breath postsurgically when treated for infected adenoids or tonsils. Yet, oral malodor alone is not a sufficient indicator for surgery, and is in no way guaranteed to improve oral malodor.

## Research Horizons

Future aspects of malodor investigations are largely absent in the dental literature. Speculation in the literature tends to center on novel therapies and diagnostics under investigation. One breath spray promises to reduce breath odorants, while producing an unpleasant taste in the mouth should its user try to smoke.<sup>67</sup> The reports have ranged from measuring volatile sulfur compound in perio pockets to predict periodontal disease progression, to the availability of an online breath assessment.<sup>68</sup> Someday, genetic markers may even predispose us of our halitosis potentiality. Currently, rRNA microarrays are identifying the hundreds of oral species and phylotypes on the tongue.<sup>69,70</sup>

## Discussion

Like the process of identifying food allergies via elimination, tagging the cause(s) of halitosis may at times be an ongoing collaborative project between the patient and dentist.

This area is overdue for substantive research attention, as few university-based clinical studies that are not manufacturer-funded have been done. The data on oral malodor itself need to be assessed for reliability. Therefore, we must weigh the findings of large-scale, well-designed, industry-sponsored research with the understanding that they serve to pedal a product that benefits from favorable research results being published.

Furthermore, it is hoped that dentists will pursue continuing education on assessment, diagnosis, and treatment protocols, for an aging America is sure to result in greater numbers of patients with breath malodor complaints. Besides reading halitosis articles in dental journals and taking continuing education courses at dental meetings, a nonprofit group, the International Society for Breath Odor Research,

meets biannually so that dentists can keep abreast of new findings and learn strategies from colleagues interested in this field.

## Conclusion

At least half the world's population suffers from oral malodor, and most of it originates in the mouth. The nose is the primary diagnostic tool, with optional devices that measure volatile sulfur compounds as quantitative tools to augment and quantify the process.

Organized dentistry and government agencies can more strongly educate the public that proper oral care, including tongue cleaning, are the real "bad breath busters."

As of this writing, although no consumer orodental products have yet earned or been assured retention of the ADA Seal for complying with the new 2003 Acceptance Program Guidelines, it is reassuring to know they will be required to do so if they want to bear the ADA Seal and continue to make oral malodor therapeutic claims.<sup>10</sup>

Could organized dentistry and government go further? Perhaps a public information campaign could be developed that would ask something along the lines of: "Would you wear cologne instead of taking a shower? Then why are you using breath mints instead of seeing your dentist? Research shows nine in 10 people with bad breath can be cured by a dentist." ■■■■

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