Received: 5 January 2021 | Revised: 26 June 2021 | Accepted: 8 July 2021

DOI: 10.1111/odi.13958

ORAL DISEASES Leading in Oral, Maxillofacial, Head & Neck Medicine WILEY

ORIGINAL ARTICLE

Self-perceived and self-reported breath odour and the wearing of face masks during the COVID-19 pandemic

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Funding information
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior; Conselho Nacional de Desenvolvimento Científico e Tecnológico

Abstract

Objectives: To assess the self-perception of breath odour (SPBO) and oral hygiene habits (OHHs) while the wearing of face masks during the COVID-19 pandemic.

Subjects and Methods: This cross-sectional study included 4647 individuals who answered a structured questionnaire containing demographic, medical and dental variables and self-perceived breath odour. Variables associated with changes in self-perceived breath odour, self-perceived halitosis and changes in OHHs were assessed through multivariate logistic regression.

Results: Changes in self-perceived breath odour were reported by 1572 individuals and were associated with smoking, systemic conditions, dry mouth, tongue coating, the period of face mask use and its interaction with prior thinking of having bad breath. Likewise, 645 individuals started to consider having bad breath. This was associated with the interaction between prior family/friends saying they have bad breath and period of face mask use. Changes in OHHs were strongly associated with changes in SPBO and starting to consider having bad breath.

Conclusion: Changes in one's SPBO was associated with the wearing of face masks and was significant for changes in OHHs. Findings may be important to guide comprehensive preventive and therapeutic strategies in relation to oral health care.

KEYWORDS
breath odour, COVID-19, epidemiology, face mask, halitosis, self-report

1 | INTRODUCTION

Breath odour is the scent from the air exhaled through the mouth. The unpleasant odour from the oral cavity is named commonly as bad breath or halitosis (Kumbargere Nagraj et al., 2019; Madhushankari et al., 2015). Breath odour changes are multifactorial, both physiological or pathological, and may be associated with intra or extra-oral factors. In 80%–90% of the cases, the main causes of halitosis are related to intraoral factors such as poor oral hygiene, tongue coating, periodontal diseases and dental caries (Geest et al., 2016; Scully & Greenman, 2008). Extra-oral causes are related to diseases of the upper and lower respiratory tract, diabetes, liver problems, gastrointestinal tract conditions, use of medications, the intake of certain foods, alcohol consumption and smoking (Madhushankari et al., 2015; Zalewska et al., 2012).

Halitosis categories include genuine halitosis, pseudo-halitosis and halitophobia (Scully & Greenman, 2008; Wu et al., 2020). Halitosis has a worldwide occurrence and its prevalence has been estimated at around 25%–40% (Silva et al., 2018). However, this prevalence may be underestimated as many people do not notice their own breath or are aware of having halitosis (Mubayrik et al., 2017; Rosenberg et al., 1995).

Different physiological and psychological factors can affect the perception of breath odour; while many people develop misperceptions about having bad breath, others who do have breath odour changes are unaware of their condition (Eli et al., 2001; Faria et al., 2020). This inability is called the bad breath paradox (Rosenberg et al., 1995). Undoubtedly, the subjective perception of breath odour is a complex issue and little is known about the factors that affect this perception of breath odour in the general population (Eli et al., 2001).

The difficulty of scenting one's own bad breath has been previously attributed to adaptation and habituation, although this could be questionable (Rosenberg et al., 1995). Habituation, or decreased behavioural response, to odours is created by constant and repeated exposure and several psychophysical characteristics, whereas adaptation relates to the neural processes that constitute this decrease in a behavioural response. It refers to reduced perception, decreased perceiving intensity and increased detection thresholds (Pellegrino et al., 2017; Walliczek-Dworschak & Hummel, 2017). A wide variety of individual factors and the specific circumstances of exposure result in wide variability in the threshold for odour perception and identification by a given individual (Greenberg et al., 2013).

With the drastic worldwide increase in the number of cases of the Coronavirus Disease 2019 (COVID-19), a severe acute respiratory syndrome, countries have started to use different preventive measures and infection control strategies against this pandemic (Wang et al., 2020). Epidemiologic data suggested that droplets expelled throughout face-to-face exposure while talking, coughing or sneezing is the most common form of transmission (Wiersinga et al., 2020). Hence, the wearing of face masks on a daily-basis in all communities and populations across the world has been recommended to break the chain of transmission of the virus and control the disease spread (Cheng et al., 2020; Chou et al., 2020).

Face masks are traditionally used by some particular groups of the population for specific purposes, mainly healthcare and industrial workers in some activities as protective equipment. Some adverse effects of this use have been reported, such as tolerability issues, discomfort and headaches (Goh et al., 2020). Some relevant effects and consequences of the extended mask-wearing by the general population were also described and included changes in respiratory physiology, fatigue, temperature rise and moisture (Kisielinski et al., 2021). Moreover, many physiological and psychological effects of wearing face masks were also speculated (Vainshelboim, 2021). Nevertheless, to the best of our knowledge, no reports on self-perceived breath odour have been described in the literature.

This massive and simultaneous worldwide face mask use by the global population has no precedent. In this singular situation, we hypothesised that this continued practise by the worldwide citizenship during the COVID-19 pandemic could change the self-perception of breath odour (SPBO) among individuals. In this specific circumstance, breathing inside the mask may change odorant concentrations to keeping the odour intensity constant and therefore influencing the individual's perception.

The aim of the present study was to assess the SPBO, self-reported halitosis and oral hygiene habits (OHH) with the wearing of face masks during the COVID-19 pandemic and its associated variables.

2 | MATERIALS AND METHODS

2.1 | Sample and study design

The present cross-sectional study was carried out among members of the current faculty and staff of the Federal University of Minas Gerais, in the city of Belo Horizonte—Brazil, during August 2020. Sample comprised a multi-ethnic group of teaching staff, administrative personnel and ongoing students, male and female, who possessed any active e-mail in the institutional system. Through this email, individuals answered a questionnaire on face mask use, SPBO, medical and dental variables.

2.2 | Data collection and questionnaire items

A structured questionnaire including closed-ended questions was randomly sent via email to approximately 12,000 individuals, retrieving 4665 replies. After excluding 18 questionnaires containing incomplete or very discrepant information, final sample comprised of 4647 individuals. All data were collected and automatically connected to a spreadsheet through a web-based electronic tool.

Questionnaire items were selected and adapted from a previous study (Faria et al., 2020). The set of questions was assessed for comprehension, adequacy and linguistics, and rephrased until the understanding was clear and the questions were determined to be appropriate. The final structure of the questionnaire included a total of 18 items. Participants answered questions on demographic data, systemic conditions and ongoing medical treatment, oral health parameters and OHH, SPBO prior to wearing face masks (baseline), daily frequency of their use and changes in the SPBO and self-reported halitosis after its wearing constancy.

The questionnaire's self-reported items regarding breath odour were: (a) On a daily basis, previously to having to wear face masks—1. Would you say you have bad breath? 2. Have you ever been diagnosed of having bad breath by your dentist? 3. Has any member of your family or friend ever told you have bad breath? (b) In the current situation of COVID-19 pandemic—1. Has wearing a face mask changed your perception of your breath? 2. Considering this new situation, do you think you have bad breath?

2.3 | Ethical considerations

The Institutional Ethical Research Committee from the Federal University of Minas Gerais has approved the present study (protocol CAAE 00206118.2.0000.5149). It was fully conducted on the ethical

principles of the Helsinki Declaration, version 2002. All participants gave an informed consent prior to the entry in the study and had their rights preserved at all times.

2.4 | Statistical analysis

A descriptive analysis was performed to characterise the study sample regarding demographic, medical and dental variables of interest. Initially, sample was divided according to changes in SPBO after wearing face masks (presence/absence of changes) and groups were compared using the chi-squared or Student's *t* tests, when appropriate. Unadjusted odds ratio (OR) estimates were provided. Subsequently, multivariate logistic regression models were created to determine variables associated with: (a) changes in SPBO; (b) starting to consider having bad breath; (c) changes in OHH. All variables of interest were selected and entered the logistic regression models (full initial model). Next, variables were then manually removed step by step from this full initial model, or put back, and changes in coefficients were observed. Based on their biological plausibility, interaction terms were also tested in the logistic models: period of face mask wearing and prior bad breath knowledge (family/friends/dentist saying you have bad breath), presence of systemic conditions, medical treatment, medication use, smoking, self-reported dry mouth and self-reported tongue coating. Variables were retained in the final models if significant ($p < 0.05$). All variables included in the final models were determined to be independent assessing collinearity. Adjusted odds ratio (OR) estimates were provided. The 'presence of systemic conditions' variable was used in the analysis indicating the isolate or concomitant occurrence of the following conditions: psychological, gastric, respiratory, liver, thyroid, renal and lipid problems, recurring throat infections and blood disorders. The 'medical treatment' and 'medication use' variables indicate that participants were under any continuous medical treatment or medication. Changes in OHH were first considered as one single variable, indicating the isolate or concomitant occurrence of different habits changes. Then, they were grouped into 2 separated variables: increase in the frequency of prior OHH and starting new OHH.

All analyses were performed using statistical software (SPSS version 22.0—Statistical Package for the Social Sciences, IBM). The null hypotheses were rejected at the 5% level of significance or lower.

3 | RESULTS

Sample was composed by 4647 individuals, ranging from 18 to 79 years old (mean age of 31.80 years; standard deviation ±10.50; range 18–79), being 1519 men (32.7%) and 3128 women (67.3%). The wearing of face masks during daily activities through the COVID-19 pandemic was reported by all participants, with a daily frequency being less than 1 h for 1173 individuals (25.2%), from 1 to 2 h for 2240 individuals (48.2%), from 3 to 5 h for 710 individuals (15.3%) and more than 6 hours for 524 individuals (11.3%). The percentage of participants who have reported having changed their SPBO after wearing a face mask was of 33.8% ($n = 1572$). It is worth highlighting that 4123 individuals did not previously consider having bad breath (self-reported halitosis). After the wearing face mask during the pandemic, 645 individuals started to consider they had bad breath.

Demographic characteristics and prior self-reported measures for halitosis are shown in Table 1. Changes in SPBO was greater among smokers ($p = 0.004$), those who previously thought they had bad breath ($p < 0.001$), those whose family members or friends ($p < 0.001$) or that their dentist ($p < 0.001$) had already said that they had bad breath. Moreover, the period of face mask use, in a progressive manner, was associated with changes in SPBO, being that the odds of changing this perception was 2.36 times higher when the period of face mask use was more than 6 h ($p < 0.001$).

Table 2 shows medical and dental variables from the study sample. Individuals using any medication ($p = 0.016$) and presenting some systemic condition ($p = 0.002$) significantly reported changes in SPBO. It is interesting to underline that this change in this self-perception was significantly greater among individuals reporting psychological problems such as anxiety or depression ($p = 0.049$). Changes in the SPBO was also significantly greater among individuals with self-reported dry mouth ($p < 0.001$), self-reported tongue coating ($p = 0.001$) and those reporting daily use of dental floss ($p = 0.039$). It is important to note that 22% of the sample (1024 individuals) have changed some OHH, and this was significantly higher among those who reported changes in SPBO ($p < 0.001$).

The multivariate logistic model for the change in SPBO is shown in Table 3. Changes in self-perception were significantly associated with prior (at baseline) self-reported halitosis by a family member or friends (OR =1.49; $p < 0.001$), smoking (OR =1.38; $p = 0.011$), presence of systemic conditions (OR =1.17; $p = 0.031$), self-reported dry mouth (OR =1.21; $p = 0.005$), self-reported tongue coating (OR =1.21; $p = 0.004$), period of face mask use of 1–2 h daily (OR =1.24; $p = 0.008$), 3–5 h daily (OR =1.55; $p < 0.001$) and more than 6 h (OR =2.15; $p < 0.001$) and the interaction between prior thinking of having bad breath and period of face mask use of 1–2 h daily (OR =2.04; $p < 0.001$), 3–5 h daily (OR =2.26; $p = 0.001$) and more than 6 h (OR =2.13; $p = 0.003$).

The multivariate logistic model for starting to consider having bad breath is shown in Table 4. Variables retained in the model were smoking (OR =1.55; $p = 0.008$), presence of systemic conditions (OR =1.34; $p < 0.001$), self-reported dry mouth (OR =1.59; $p < 0.001$), self-reported tongue coating (OR =1.68; $p < 0.001$) and the interaction between family/friends thinking you have bad breath and period of face mask use of 1–2 h (OR = 3.32; $p < 0.001$), 3–5 h (OR = 3.07; $p < 0.001$) and more than 6 h (OR = 4.05; $p < 0.001$).

The multivariate logistic models for changes in OHH are shown in Table 5. These changes were associated with smoking (OR = 1.43; $p = 0.013$), presence of systemic conditions (OR = 1.19; $p = 0.049$), self-reported dry mouth (OR =1.22; $p = 0.011$), self-reported tongue coating (OR =1.21; $p = 0.018$), changes in self-perceived breath odour (OR =4.29, $p < 0.001$) and starting to consider having bad

TABLE 1 Demographic variables and baseline self-reported halitosis measures of the study sample

Variables	Changes in self-perceived breath odour		
	No ($n = 3075$)	Yes ($n = 1572$)	p
Gender			
Female	2071 (67.3%)	1057 (67.2%)	0.939
Male	1004 (32.7%)	515 (32.8%)	
Age (mean/years)	31.83 ± 10.58	31.76 ± 10.36	0.205
Age range (years)			
18–30	1627 (52.9%)	831 (52.9%)	0.221
31–50	1222 (39.7%)	631 (40.1%)	
51–80	226 (7.3%)	110 (7.0%)	
Smoking			
No	2902 (94.4%)	1449 (92.2%)	**0.004** (OR =1.42 95%CI 1.12–1.81)
Yes	173 (5.6%)	123 (7.8%)	
Alcohol consumption			
No	1469 (47.8%)	713 (45.4%)	0.118
Yes	1606 (52.2%)	859 (54.6%)	
Would you say you have bad breath?			
No	2831 (92.1%)	1292 (82.2%)	**<0.001** (OR =2.51 95%CI 2.09–3.02)
Yes	244 (7.9%)	280 (17.8%)	
Has any family member/friend ever told you have bad breath?			
No	2416 (78.6%)	1063 (67.6%)	**<0.001** (OR =1.76 95%CI 1.53–2.01)
Yes	659 (21.4%)	509 (32.4%)	
Have you ever been diagnosed by your dentist of having bad breath?			
No	3005 (97.7%)	1506 (95.8%)	**<0.001** (OR =1.88 95%CI 1.34–2.65)
Yes	70 (2.3%)	66 (4.2%)	
Period of face mask use			
Less than 1 h (reference)	857 (27.9%)	316 (20.1%)	(reference)
1–2 h/daily	1500 (48.8%)	740 (47.1%)	<0.001 (OR =1.34 95%CI 1.14–1.56)
3–5 h/daily	438 (14.2%)	272 (17.3%)	**<0.001** (OR =1.68 95%CI 1.38–2.10)
More than 6 h	280 (11.3%)	244 (15.5%)	**<0.001** (OR =2.36 95%CI 1.91–2.93)

Abbreviation: OR, odds ratio.

Significant p-values are shown in bold.

breath (OR = 1.83, $p < 0.001$). It is important to note that individuals who changed their SPBO presented 4.76 times higher chance of increasing the frequency of prior OHH and 3.84 times higher chance of starting new OHH. In addition, individuals who started considering to have bad breath presented 1.76 times higher chance of increasing the frequency of prior OHH and 2.13 times higher chance of starting new OHH.

4 | DISCUSSION

The present study showed that 33.8% of the study sample changed their SPBO after wearing a face mask during the COVID-19 pandemic and that 645 individuals started to consider having halitosis. These perceptions were associated with changes in OHH.

Many factors affect the way people perceive odours and also on the way they relate to their own breath odour. As a result, this self-perception is described as multifactorial, closely related to body image and both physiological and psychological factors (Eli et al., 2001). Qualitative odour judgments depend on a large extent of personal experiences and personality traits. In general, many people seem to be unable to assess their own breath (Eli et al., 2001; Rosenberg et al., 1995). This singular and new situation of having to wear face masks for daily activities during the COVID-19 pandemic, especially for longer periods, can lead individuals to pay more attention to their breath, particularly because face masks physically contain and return breath.

Self-assessment or SPBO and halitosis are highly relevant outcomes, since it involves the individual itself in the process. It can be considered a true patient-centred outcome, which is remarkably relevant regarding

TABLE 2 Medical and dental variables of the study sample

Variables	Changes in self-perceived breath odour		*p*
	No (*n* = 3075)	Yes (*n* = 1572)	
Medical treatment			0.17
No	2685 (87.3%)	1350 (85.9%)	
Yes	390 (12.7%)	222 (14.1%)	
Medication use			**0.016**
No	2010 (65.4%)	971 (61.8%)	(OR =1.17 95%CI 1.03–1.33)
Yes	1065 (34.6%)	601 (38.2%)	
Presence of systemic conditions[a]			**0.002**
No	915 (29.8%)	401 (25.5%)	(OR=1.24 95%CI 1.08–1.42)
Yes	2160 (70.2%)	1171 (74.5%)	
Psychological problems, such as depression or anxiety			
No	2796 (90.9%)	1401 (89.1%)	**0.049** (OR=1.22 95%CI 1.00–1.50)
Yes	279 (9.1%)	171 (10.9%)	
Gastric problems, reflux			0.796
No	3029 (98.5%)	1550 (98.6%)	
Yes	46 (1.5%)	22 (1.4%)	
Respiratory problems, asthma			0.319
No	2700 (87.8%)	1396 (88.8%)	
Yes	375 (12.2%)	176 (11.2%)	
Recurring throat infections			
Tonsilitis			0.209
No	1932 (62.8%)	958 (60.9%)	
Yes	1143 (37.2%)	614 (39.1%)	
Diabetes			0.099
No	3030 (98.5%)	1558 (99.1%)	
Yes	45 (1.5%)	14 (0.9%)	
Blood disorders, anaemia			0.318
No	2808 (91.3%)	1449 (92.2%)	
Yes	267 (8.7%)	123 (7.8%)	
Liver problems, hepatitis			0.733
No	3026 (98.4%)	1549 (98.5%)	
Yes	49 (1.6%)	23 (1.5%)	
Thyroid problems			0.438
No	2910 (94.6%)	1479 (94.1%)	
Yes	165 (5.4%)	93 (5.9%)	
Renal problems			0.058
No	3030 (98.5%)	1537 (97.8%)	
Yes	45 (1.5%)	35 (2.2%)	
Cholesterol and lipid problems			0.521
No	3065 (99.7%)	1565 (99.6%)	
Yes	10 (0.3%)	7 (0.4%)	
Self-reported dry mouth			
No	1933 (62.9%)	867 (55.2%)	<0.001 (OR=1.38
Yes	1142 (37.1%)	705 (44.8%)	95%CI 1.22–1.56)

(Continues)

TABLE 2 (Continued)

Variables	Changes in self-perceived breath odour		*p*
	No (*n* = 3075)	Yes (*n* = 1572)	
Self-reported tongue coating			**<0.001**
No	1996 (64.9%)	878 (55.9%)	(OR=1.46 95% CI 1.29–1.66)
Yes	1079 (35.1%)	694 (44.1%)	
Daily tongue brushing			0.919
No	2604 (84.7%)	1333 (84.8%)	
Yes	471 (15.3%)	239 (15.2%)	
Daily dental flossing			**0.039**
No	1532 (49.8%)	733 (46.6%)	(OR =1.14 95%CI 1.01–1.28)
Yes	1543 (50.2%)	839 (53.4%)	
Changes in oral hygiene habits[b]			**<0.001**
No	2723 (88.6%)	900 (57.3%)	(OR =5.78 95%CI 4.98–6.71)
Yes	352 (11.4%)	672 (42.7%)	
Increasing the frequency of toothbrushing			**<0.001**
No	2939 (95.6%)	1194 (76.0%)	(OR=6.84 95%CI 5.56–8.42)
Yes	136 (4.4%)	378 (24.0%)	
Starting to make use of dental floss			**<0.001**
No	3042 (98.9%)	1504 (95.7%)	(OR=4.17 95%CI 2.74–6.35)
Yes	33 (1.1%)	68 (4.3%	
Increasing the frequency of dental flossing			**<0.001**
No	2981 (96.9%)	1411 (89.8%)	(OR=3.62
Yes	94 (3.1%)	161 (10.2%)	95%CI 2.78–4.70)
Starting to make use of mouthwashes			**<0.001**
No	3028 (98.5%)	1452 (92.4%)	(OR=5.32
Yes	47 (1.5%)	120 (7.6%)	95%CI 3.78–7.50)
Increasing the frequency of mouthwashes use			**<0.001**
No	3027 (98.4%)	1481 (94.2%)	(OR=3.88
Yes	48 (1.6%)	91 (5.8%)	95%CI 2.72–5.23)
Started using chewing gums/mint tablets			**<0.001**
No	3062 (99.6%)	1521 (96.8%)	(OR =7.90 95%CI 4.28–14.57)
Yes	13 (0.4%)	51 (3.2%)	
Increased the frequency of using chewing gums/mint tablets			**<0.001**
No	3064 (99.6%)	1521 (96.8%)	(OR =9.34 95% (4.85–14.57)
Yes	11 (0.4%)	51 (3.2)	
Seeking for a healthcare professional			**0.004**
No	3074 (100%)	1566 (99.6%)	(OR =11.78 95%CI 1.42–97.91)
Yes	1 (0.0%)	6 (0.4%)	

Abbreviation: OR, odds ratio.

Significant *p*-values are shown in bold.

[a]Systemic conditions could occur simultaneously.

[b]Oral hygiene habits can change simultaneously.

contemporary research in the health field (Lopes et al., 2016). Although self-perceived health expresses subjective assessments, indicators based on this concept can be used to assess health status and health care, as well as be used as a monitoring tool, at populational and individual levels. In the present study, changes in SPBO were strongly associated with the period of face mask use, in a progressive manner.

TABLE 3 Final multivariate logistic model for changes in self-perceived breath odour

Variables	Coefficient	OR (95%CI)	*p*
Constant	−1.398	—	<0.001
Family/friends think you have bad breath	0.397	1.49 (1.29–1.72)	<0.001
Smoking	0.321	1.38 (1.08–1.76)	0.011
Presence of systemic conditions	0.155	1.17 (1.01–1.35)	0.031
Self-reported dry mouth	0.187	1.21 (1.06–1.37)	0.005
Self-reported tongue coating	0.194	1.21 (1.06–1.39)	0.004
Period of face mask use			
Less than 1 h		(reference)	<0.001
1–2 h/daily	0.218	1.24 (1.06–1.46)	0.008
3–5 h/daily	0.436	1.55 (1.25–1.91)	<0.001
More than 6 h	0.767	2.15 (1.71–2.71)	<0.001
Interaction between prior thinking of having bad breath and period of face mask use and			
Less than 1 h		(reference)	<0.001
1–2 h	0.712	2.04 (1.54–2.70)	<0.001
3–5 h	0.816	2.26 (1.40–3.65)	0.001
More than 6 h	0.756	2.13 (1.28–3.54)	0.003

Abbreviation: OR, odds ratio.

TABLE 4 Final multivariate logistic model for starting to consider having bad breath.

Variables	Coefficient	OR (95% CI)	*p*
Constant	−2.601	—	<0.001
Smoking	0.435	1.55 (1.12–2.13)	0.008
Presence of systemic conditions	0.291	1.34 (1.09–1.64)	<0.001
Self-reported dry mouth	0.46	1.59 (1.33–1.89)	<0.001
Self-reported tongue coating	0.521	1.68 (1.41–2.01)	<0.001
Interaction between family/friends think you have bad breath and period of face mask use			
Less than 1 h		(reference)	<0.001
1–2 h	1.169	3.32 (2.55–4.05)	<0.001
3–5 h	1.121	3.07 (2.06–4.58)	<0.001
More than 6 h	1.4	4.05 (2.65–6.20)	<0.001

Abbreviation: OR, odds ratio.

Individuals wearing a face mask for more than 6 h daily presented 2.15 times higher chance of changing their SPBO. Prior self-reported halitosis (at baseline) pointed out by others (friends or family members [adjusted OR = 1.76]) were also strongly associated with changes in SPBO.

It has been suggested that one's breath self-perception has psychological elements, being related to the concept of body image. Subjects who had more positive feelings about their bodies generally tended to score themselves as having less oral malodour. In this context, each one has a 'breath odour image' that is highly personalised and socially influenced by previous objective and subjective experiences (Eli et al., 2001), and that affects their self-perception. Breath odour's self-perception and self-estimation are closely related to preconceived assumptions and evaluations, being similarly subjective (Rosenberg et al., 1995). It is also importantly notable that previous thoughts of having bad breath and the period of face mask use increased the chances of changing the SPBO.

Breath odour may also be a consequence of a lifestyle, as a result of the ingestion of certain food and drinks, or from habits such as smoking tobacco or drinking alcohol (Scully & Greenman, 2008, 2012). Smoking habits are an extrinsic origin of halitosis (Kayombo & Mumghamba, 2017; Lu et al., 2014; Settineri et al., 2010). Tobacco smoke contains volatile sulphur compounds, which are at least partly responsible for the oral malodour of smokers. In this present study, smokers presented a 1.38 higher chance of changing their SPBO and 1.55 higher chance of considering to have bad breath. Smoking was also associated with changes in OHH (adjusted OR = 1.43). It is interesting to note that poor oral hygiene and halitosis were previously reported among smokers when compared to non-smokers (Jiun et al., 2015). Hence, orientation on smoking health hazards and OHH is crucial. But far beyond that, every health professional plays an important role in counselling and guiding their patients towards smoking cessation.

TABLE 5 Final multivariate logistic model for changes in oral hygiene habits.

Variables	Coefficient	OR (95%CI)	*p*
Model 1: Changes in oral hygiene habits			
Constant	−2.407	–	<0.001
Smoking	0.358	1.43 (1.08–1.90)	0.013
Presence of systemic conditions	0.174	1.19 (1.00–1.42)	0.049
Self-reported dry mouth	0.201	1.22 (1.05–1.43)	0.011
Self-reported tongue coating	0.190	1.21 (1.03–1.41)	0.018
Changes in self-perceived breath odour	1.455	4.29 (3.62–5.07)	<0.001
Starting to consider having bad breath	0.603	1.83 (1.53–2.19)	<0.001
Model 2: Increase in the frequency of prior oral hygiene habits			
Constant	−2761	–	<0.001
Smoking	0.309	1.36 (1.00–1.85)	0.049
Presence of systemic conditions	0.197	1.22 (1.00–1.45)	0.047
Been diagnosed by the dentist of having bad breath	0.447	1.56 (1.04–2.36)	0.034
Changes in self-perceived breath odour	1.559	4.76 (3.92–5.77)	<0.001
Starting to consider having bad breath	0.567	1.76 (1.45–2.14)	<0.001
Model 3: Starting new oral hygiene habits			
Constant	−3.765	–	<0.001
Interaction between self-reported dry mouth and presence of systemic conditions	0.271	1.31 (1.02–1.69)	0.035
Changes in self-perceived breath odour	1.346	3.84 (2.85–5.19)	<0.001
Starting to consider having bad breath	0.754	2.13 (1.61–2.81)	<0.001

Abbreviation: OR, odds ratio.

Smoking also predisposes to xerostomia (dry mouth) that is a further cause of oral malodour (Scully & Greenman, 2008), and it was also associated with self-perceived halitosis (AlSadhan, 2016). In the present study, self-reported dry mouth was significantly associated with changes in SPBO, starting to consider having bad breath and changes in OHH. Dry mouth (xerostomia) can also be related to some systemic conditions, such as stress, depression and the use of medication (Bollen & Beikler, 2012; Koshimune et al., 2003). In this study, the presence of systemic conditions was associated with changes in SPBO (adjusted OR = 1.17) and starting to consider having bad breath (adjusted OR = 1.34). Interestingly, the interaction of systemic conditions and self-reported dry mouth was associated with starting new OHH (adjusted OR = 1.31). Particularly regarding systemic conditions, psychological problems such as anxiety and depression were associated with changes in self-perceived breath odour (unadjusted OR = 1.22). Different systemic conditions are determined to be associated with breath odour alterations (Bollen & Beikler, 2012; Scully & Greenman, 2008). It should be highlighted that mood swings, anxiety and stress were strongly reported in different populations during the COVID-19 pandemic (De Miranda et al., 2020; Gorenko et al., 2020).

Medications, drug reactions or side-effects can cause xerostomia and be an indirect cause of oral malodour (Torsten et al., 2017). Although not retained in the final adjusted models, medication use was more prevalent among individuals reporting changes in self-perceived breath odour. Certain medication are potential sources of blood-borne halitosis, in which malodourous compounds in the blood stream are carried to the lungs and enter the breath. The pharmacological compounds identified as causes of halitosis are administered to treat a broad spectrum of diseases, or used in different therapeutic regimes, not necessarily correlated to any specific one (Torsten et al., 2017). These compounds associated with medication-induced halitosis were pointed in the literature to be among dimethyl sulfoxide, cysteamine, nitrates and nitrites (isosorbide dinitrate), disulfiram, penicillamine, chloral hydrate, phenothiazine, suplatast tosilate and paraldehyde (Scully & Greenman, 2008; Torsten et al., 2017).

Tongue coating is considered as the main etiological factor for intraoral halitosis (Bollen & Beikler, 2012; Lu et al., 2014; Quirynen et al., 2009; Wu et al., 2020). Malodour from oral origin arises mainly from the resident microorganisms on the dorsum of the tongue, and there may be a relationship between the quantity of tongue coating and the degree of odour (Lu et al., 2014; Scully & Greenman, 2012). Self-reported tongue coating was significantly associated with changes in SPBO (adjusted OR = 1.21), starting to consider having bad breath (adjusted OR = 1.68), and changes in OHH (adjusted OR = 1.21). These findings here corroborate others that demonstrated that self-perception of tongue coating was strongly associated with SPBO itself (Faria et al., 2020; Settineri et al., 2010; Youngnak-Piboonratanakit & Vachirarojpisan, 2010). Tongue coating

index was also associated with subjective halitosis (Patel et al., 2017). It is interesting to see that self-assessment of tongue coating and the perception of a bad taste in the mouth can lead to an exaggerated self-perception of bad breath (Rosenberg et al., 1995).

Changes in OHH were a relevant finding. Results showed that individuals who changed their SPBO or started considering to have bad breath significantly changed their OHH ($p < 0.001$). Moreover, individuals previously diagnosed by the dentist of having bad breath presented 1.56 times higher chance of increasing the frequency of prior OHH; those with dry mouth and systemic conditions presented 1.31 times higher chance of starting new OHH. Interestingly, seeking for health care professionals was extremely low among study participants. Within this context, it is of great importance for dental professionals to provide individuals with proper guidance regarding behavioural changes and oral hygiene instructions.

Individuals with halitophobia (halitophobics) often display other psychological phenomena, such as compulsive toothbrushing (Eli et al., 2001). Brushing teeth many times and adopting countermeasures against oral malodour were strongly reported by individuals with high social anxiety scale scores and halitosis (Zaitsu et al., 2011). Masking agents are frequently used to cover halitosis, because of their instant relieving effect and commercial accessibility (De Geest et al., 2016). Individuals who are conscious of their bad breath may attempt to mask it through compulsive brushing or with a range of over-the-counter methods such as chewing gum, mints, scented liquid drops and the use of mouthwashes (Borden et al., 2002; Kumbargere Nagraj et al., 2019). Most of these merely provide a competing and temporary scent that is capable of masking the unfavourable malodour. Some mouthwashes contain certain components that can neutralise the malodour or the bacteria which produce it (Kumbargere Nagraj et al., 2019). Good short-term outcomes have been reported with mouthwashes containing chlorhexidine gluconate, ceptylpyridinium chloride and essential oils and may have beneficial effects in the management of halitosis (De Geest et al., 2016; Scully & Greenman, 2008). It was stated that chewing gums containing active ingredients proved to reduce organoleptic scores of halitosis, albeit data were determined to be heterogeneous among studies and practical implications might be impaired (Muniz et al., 2017).

Individuals with breath odour alterations, that being genuine halitosis, pseudo-halitosis or halitophobia, need special attention since this can significantly have negative impacts on their quality of life, social interactions and well-being, leading directly to low self-esteem, mood disorders, depression and anxiety and behavioural changes (He et al., 2020; Patel et al., 2017; Wu et al., 2020). Therefore, since wearing a face mask has become usual and ubiquitous in the community, changes in breath odour perception while doing so can be an alert sign. Individuals should be oriented to seek for proper and comprehensive health care. Halitosis can also be caused by oral disorders, including periodontal conditions and even the first manifestation of many systemic diseases (Scully & Greenman, 2008; Wu et al., 2020). The wearing of face masks could also be a motivating factor for individuals to seek for oral and periodontal health care, especially having tongue coating and periodontitis as important causes of halitosis. Management of halitosis requires not only regular oral malodour treatment but also proper attention to psychological factors (Patel et al., 2017; Settineri et al., 2010; Wu et al., 2020; Zaitsu et al., 2011; Zalewska et al., 2012). It is important for health care professionals, including dental professionals and general physicians, to understand halitosis aetiology to appropriately identify and manage all the associated factors, including proper explanations and patient counselling in a multidisciplinary approach.

Some limitations of the present study should be addressed. It was a questionnaire-survey study and some response bias may have occurred. Although the study benefits from its large sample, extrapolation of the results should be exercised with caution due to specific sample characteristics such as being limited to the university staff and students, and comprising mostly of female individuals. Educational and socioeconomic characteristics should also be considered. Nevertheless, findings provided relevant information and could be considered as a starting point for future studies. Individuals' self-perception of oral health is an important patient-centred outcome and should guide health professionals during health care provision.

5 | CONCLUSION

Changes in self-perceived and self-reported breath odour was significantly associated with the wearing of face masks, in a progressive manner regarding its period of use. Changes in OHHs was associated with those changes in self-perceived breath odour, including increasing the frequency of prior habits or starting new ones. Findings may be important to guide comprehensive preventive and therapeutic strategies in relation to oral health care in a multidisciplinary approach.

ACKNOWLEDGEMENTS

Authors declare having no conflict of interest. The present study was supported by grants from the Coordination for the Improvement of Higher Education Personnel (CAPES – Brazil) and the National Council for Scientific and Technological Development (CNPq – Brazil) (Productivity research grant #302251/2019-7.

AUTHOR CONTRIBUTIONS

Sandro Felipe Santos Faria: Data curation; Investigation; Methodology; Resources; Writing-original draft. Fernando Oliveira Costa: Conceptualization; Methodology; Supervision; Writing-original draft; Writing-review & editing. Alexandre Pereira: Data curation; Investigation; Writing-original draft. Luis Otavio Cota: Conceptualization; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Supervision; Writing-original draft; Writing-review & editing.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/odi.13958.

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How to cite this article: Faria, S. F. S., Costa, F. O., Pereira, A. G., & Cota, L. O. M. (2021). Self-perceived and self-reported breath odour and the wearing of face masks during the COVID-19 pandemic. *Oral Diseases*, 00, 1–11. https://doi.org/10.1111/odi.13958