

Halitosis and Associated Risk Factors in Children: A Cross-sectional Study

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ABSTRACT

Aim: To investigate risk factors associated with halitosis in children using OralChroma™.

Materials and methods: Sixty-seven children between the ages of 3 and 8 who attended a pre-general anesthesia assessment at the Dental University Hospital at King Saud University, Riyadh, Saudi Arabia, were enrolled in this study after satisfying the inclusion criteria. Demographic data, medical history, and oral hygiene practices were obtained by a standardized questionnaire completed by the parents of each child. Clinical dental examination was conducted to record the following: caries index (dmft/DMFT), simplified debris index (DI-S), modified gingival index (MGI), and Winkel tongue coating index (WTCl). Clinical halitosis was assessed using the OralChroma™ device that measures the concentration of volatile sulfur compounds (VSCs) including hydrogen sulfide (H₂S), methyl mercaptan (CH₃SH), and dimethyl sulfide (CH₃SCH₃). Statistics were completed using Spearman's correlation coefficient and Mann-Whitney *U*-test to assess the association with the VSC scores with continuous and binary variables, respectively. Then, multivariate linear regression analysis was performed to detect the degree of association.

Results: High VSC measures were detected in 58 children (87%). The dmft/DMFT was significantly associated with H₂S level ($\beta = 26.84, p = 0.034$) and CH₃SH level ($\beta = 19.96, p = 0.016$) after controlling possible confounders. There was no significant association of DI-S, MGI, and WTCl with the VSC measures.

Conclusion: The result suggested that dmft/DMFT score (children's caries experience) is associated significantly with high levels of H₂S and CH₃SH in the sample studied.

Clinical significance: Caries experience in children is a significant risk factor for halitosis and should be considered during the management of halitosis.

Keywords: Children, Dental caries, Halitosis, OralChroma, Volatile sulfur compounds.

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INTRODUCTION

"Halitosis" is one of the terms used to describe oral bad breath that may relate to extra- or intra-oral factors, with the latter accounting for 90% of all cases.¹ It has been reported as a common problem worldwide among adult and elderly populations.¹ Halitosis also affects children with a prevalence ranged between 8 and 45%.²⁻⁶ An association was reported between halitosis and multiple risk factors in studies conducted on the pediatric population including caries, food impaction, poor oral hygiene, proximal restoration, gingival health, tongue coating, mouth breathing, and presence of orthodontic appliances.^{2,5-13} However, the results of these studies are inconsistent and contradictory due to the different clinical indices used and the different methods used to assess halitosis.

The most common methods used by researchers to assess halitosis in children are organoleptic assessment,^{3,6} sulfide monitors,^{11,14} or combining both methods.^{2,5,7,9-12} Organoleptic measurement was considered gold standard to measure halitosis because its simple method of conduction and cheapness. It requires no special equipment, and human judgment could be the most logical measurement method for perceived olfactory stimulus.^{15,16} However, this method raises several problems; mainly, the reliability of the examiner, the effect of the environment on the olfactory capacity of the examiner, the need for examiner training, and the potential risk for disease transmission via expelled air.^{11,15-17} A sulfide monitor is a portable device that measures total sulfur compounds in breaths and is mainly used to monitor the prognosis of oral halitosis rather than detect it because it cannot differentiate

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between different sulfur compounds.¹⁸ The other limitation of this method is the incorrect positive halitosis detection due to the presence of additional volatile vapors that do not cause halitosis like acetone, ethanol, or methanol.¹⁶ Currently, OralChroma™ is a commercially available type of gas chromatography, combining both the compact gas chromatography system and the semiconductor gas sensor that allow a quick measurement of volatile sulfur compounds (VSCs).¹⁹ It provides separate values for hydrogen sulfide (H₂S), methyl mercaptan (CH₃SH), and dimethyl sulfide (CH₃SCH₃) which represent 90% of VSCs and are considered the major compounds associated with halitosis.²⁰ This device's reliability for assessing and diagnosing halitosis has been reported

in many studies¹⁷ and is considered to be the gold standard when evaluating the VSC concentrations.²¹ One recent study showed a significant correlation between OralChroma™ with other evaluation methods of halitosis in children.¹³

In the literature, risk factors for oral origin associated with halitosis in children have been investigated with the use of either organoleptic and/or sulfide monitors. However, no study has investigated the oral risk factors associated with an increase in VSCs in children using OralChroma™. Therefore, this study was conducted to investigate the possible risk factors associated with halitosis in children using OralChroma™.

MATERIALS AND METHODS

Sample Selection and Ethical Approval

This cross-sectional study was carried out during the period from January to September 2019. Sixty-seven children between the ages 3 and 8 years were recruited from patients who attended morning GA (general anesthesia) screening clinics at Dental University Hospital, King Saud University (KSU), Riyadh, Saudi Arabia. The inclusion criteria were healthy (ASA I and II), cooperative child during breath sample collection and initial clinical examination, with no history of upper respiratory tract infection, tonsillar infection, allergic rhinitis, *Candida* infection, gastrointestinal diseases, and no history of antibiotic usage during the last month before the appointment. The aim and the protocol of the study were explained to the parents one day before the screening appointment over the phone to obtain initial approval and to instruct parents regarding the breath sample test. All parents were told that their child should not eat or drink and refrain from brushing their teeth and using mouthwashes for a couple of hours before the breath sample collection. Patients were scheduled early in the morning and a written consent with all the details of the study was obtained from the parents of all participants. The study was approved by the ethical committee in KSU.

Clinical Oral Examinations

A self-administrated questionnaire was carried out first to obtain the demographic data and oral hygiene practices. Then, patients were examined on the dental chair by the primary investigator (nursing assistant) to collect the following data: dental caries score using dmft/DMFT (decayed, missing, and filled teeth) index by WHO (2013),²² oral hygiene level using simplified debris index (DI-S) by Greene and Vermillion (1964),²³ gingival health condition using modified gingival index (MGI) by Lobene et al. (1986),²⁴ tongue coating using Winkel tongue coating index (WTCI) by Winkel et al. (2003),²⁵ and the number of abscessed teeth. Intraexaminer reliability was assessed before conducting the study on 10 children similar to the sample but not included in the study at 2-week intervals for the clinical variables (dmft/DMFT, DI-S, MGI, and WTCI) using correlation coefficient and all scores were above 0.7.

Measuring the Level of VSCs Using OralChroma™

The breath sample procedures were explained to the parents and their child in the halitosis clinic using an instructional video. Children were instructed to close their mouths and breathe through the nose for 1 minute. Then, using a disposable plastic syringe, a breath sample of 1 mL was attained and injected immediately into the OralChroma™ device (Nissha FIS, Inc., Abimedical Corporation, Osaka, Japan). The concentration of gases H₂S, CH₃SH, and CH₃SCH₃ was measured. Clinically, the present halitosis was considered when

any of the VSCs is equal or higher than the following cognitive threshold according to the manufacturer's instructions: for H₂S ≥112, CH₃SH ≥26, and CH₃SCH₃ ≥8, all in parts per billion.

Sample Size and Statistical Analysis

At the power of 90% and 0.8 effect size, the sample size was calculated with a 0.05 level of significance.^{10,26} A total of 67 children were included in the study. Data were analyzed with SPSS software (IBM Inc., Chicago, USA). Descriptive statistics were used, such as the mean and standard deviation or frequencies and percentages, to describe quantitative and categorical variables. Gingival health (0 = no inflammation, 1 = inflamed) and dental abscess (0 = no abscess, 1 = abscess present) were dichotomized for the purposes of analysis. The normalization of the data was tested using Kolmogorov–Smirnov and Shapiro test. The association of VSC levels with clinical variables was examined using Spearman's correlation coefficient for continuous variables and Mann–Whitney *U*-test for binary variables. Multivariable linear regression was used to detect the degree of association after controlling the possible confounding factors. The level of statistical significance was set at *p* <0.05.

RESULTS

Sixty-seven Saudi children including 44 females and 23 males with a mean age of 5.3 ± 1.7 years participated in this study. Fifty-eight (86.6%) children were reported to have clinical halitosis using OralChroma™. The mean ± standard deviation and frequency of clinical variables are presented in Table 1. Mean ± SD of dmft/DMFT and WTCI are 11.3 ± 3.3 and 3.6 ± 1.3, respectively. Most of the samples had poor oral hygiene (*n* = 47, 70.1%), about half of the participants had gingival inflammation in varying degrees (*n* = 31, 46.3%),

Table 1: Descriptive presentation of the clinical data for the children, (*n* = 67)

Clinical parameters	Mean ± SD	Frequency (%)
Age	5.3 ± 1.7	
Caries index—total dmft/DMFT	11.3 ± 3.3	
Winkel tongue coating index	3.6 ± 1.3	
Debris index		
• Fair		20 (29.9)
• Poor		47 (70.1)
Modified gingival index		
• Absence of inflammation		36 (53.7)
• Mild localized inflammation		23 (43.1)
• Mild generalized inflammation		5 (7.5)
• Moderate inflammation		1 (1.5)
• Severe inflammation		2 (3.0)
Gingival health		
• No inflammation		36 (53.7)
• Inflammation		31 (46.3)
Presence of dental abscesses		
• No		32 (47.8)
• Yes		35 (52.2)
Daily toothbrushing practice*		
• No		24 (35.8)
• Yes		43 (64.2)

*Obtained from questionnaire

Table 2: Level of VSCs in correlation with clinical parameters, (*n* = 67)

Clinical parameters	H ₂ S	<i>p</i> value	CH ₃ SH	<i>p</i> value	CH ₃ SCH ₃	<i>p</i> value
Caries index (dmft + DMFT) [§]	0.275	0.025	0.248	0.043	0.190	0.124
Winkel tongue coating index – WTCI [§]	0.131	0.292	0.104	0.401	0.167	0.178
Debris index*						
• Fair	143 (526.7)	0.603	26 (129.5)	0.238	3 (10.5)	0.076
• Poor	225 (260)		63 (97)		10 (39)	
Gingival health*						
• No inflammation	143 (229.25)	0.054	36 (81.75)	0.031	10 (27.5)	0.929
• Inflammation	235 (657)		86 (132)		9 (39)	
Presence of dental abscesses*						
• No	137.5 (303)	0.572	46.5 (95.5)	0.669	8 (22.3)	0.402
• Yes	225 (396)		62 (123)		10 (39)	
Daily toothbrushing practice*						
• No	130 (198)	0.059	59 (99.2)	0.619	11.5 (41)	0.181
• Yes	227 (476)		51 (126)		7 (19)	

[§]Spearman's correlation; *Median (IQR) and Mann–Whitney *U*-test

Table 3: Multiple linear regression summary of H₂S levels and clinical parameters

Variables	H ₂ S		
	<i>B</i>	<i>Std. error</i>	<i>p</i> value
Caries index (dmft + DMFT)	26.842	12.413	0.034
Gingival health	135.446	80.378	0.097
Daily toothbrushing practice	166.382	77.332	0.035

Table 4: Multiple linear regression summary of CH₃SH levels and clinical parameters

Variables	CH ₃ SH		
	<i>B</i>	<i>Std. error</i>	<i>p</i> value
Caries index (dmft + DMFT)	19.961	8.032	0.016
Gingival health	77.158	52.104	0.144

and more than half of the samples had dental abscesses (*n* = 35, 52.2%). Forty-three children (64.2%) brushed their teeth daily according to their parents.

Association of VSCs and Clinical Parameters

The age and gender were assessed in association with VSC values, and no statistically significant association was found in the bivariate analysis. The association between VSC values and the clinical parameters presented in Table 2. Both H₂S and CH₃SH mean concentrations were significantly associated with the dmft/DMFT index and gingival health in the bivariate analysis. To confirm the degree of association of H₂S and CH₃SH concentrations with potential risk factors, a multiple linear regression test was performed (Table 3 and 4). The dmft/DMFT index was associated significantly with a mean level of H₂S and CH₃SH (*p* = 0.03, 0.02), respectively. In addition, daily toothbrushing practice was associated with the level of H₂S (*p* = 0.04).

DISCUSSION

It is widely believed nowadays that halitosis is caused by the increase of VSC concentrations in the oral cavity due to the action of anaerobic microorganisms by breaking down the components of the epithelial cells, salivary proteins, and food debris.¹⁶ The H₂S and CH₃SH are believed to be the main VSCs that contribute to intraoral halitosis, while CH₃SCH₃ is mainly linked with extraoral halitosis.²⁷ In this study, the CH₃SH and H₂S levels were higher than that of CH₃SCH₃, which is consistent with earlier studies that support the high concentration of both gases in halitosis of oral origin.^{13,20}

The present study showed a high prevalence of halitosis in comparison to other studies.^{3,5,6,9,10,13} This finding is not surprising as the halitosis was measured objectively using the OralChroma™ device that can detect a low concentration of VSC molecules²⁸ unlike other studies that evaluated halitosis subjectively using the organoleptic technique,^{3,6} which also carries the risk of transmission of infectious disease or used sulfide monitors that cannot detect all halitosis-causing VSCs.^{11,14} Also, the sample selected in this study was from children with a high caries index who are on the waiting list for GA due to their uncooperative behavior to provide treatment on the dental chair or due to extensive dental needs. Additionally, the time of breath sampling collection may have influenced the results as previous studies showed an increase in halitosis scores when the breath was evaluated in the morning.^{15,29}

In the current study, the correlation between the children's caries experience (dmft/DMFT) with H₂S and CH₃SH levels was statistically significant, but not with CH₃SCH₃. This finding is in agreement with the literature that shows that the main contributors to intraoral halitosis are believed to be H₂S and CH₃SH, while CH₃SCH₃ is mainly associated with extraoral halitosis.²⁷

This result is consistent with Gholami et al. who reported relation of dental caries with halitosis, while other studies did not find the same association.^{3,5–8,10,15} The difference between this finding and the previous studies is related to differences in sample size, age, evaluation methods, and DMFT scores. For example, Amir et al. and Nalçacı et al. found no association using a smaller sample with a wider age range (5–14 and 7–15 years, respectively) and lower DMFT scores compared to this study.^{7,10} Also, no association was reported by Kanehira et al. who evaluated

children less than 5 years with lower decay scores.⁵ Similarly, Ueno et al. and Patil et al. found no association in their samples, which consisted of school-age children with a higher proportion of caries-free children.^{3,6}

The present study did not find an association between VSCs and tongue coating, which agrees with Lin et al.'s study.⁹ However, a relationship between halitosis and tongue coating was found in many studies conducted on children.^{3,6,7,10} It is worth mentioning that two of these studies reported the impact of tongue cleaning on halitosis and showed contradictory results.^{9,29} Lin et al. evaluated two tongue cleaning methods on VSCs using a Halimeter and noticed an increase in VSC levels postcleaning in both groups and attributed that to a gag reflex induced by cleaning the tongue, which resulted in a pharyngeal breath that increased VSC scores.⁹ On the contrary, Kara et al. noted a positive effect of tongue hygiene on halitosis which was part of an intervention including scaling and oral hygiene; however, tongue coating score pre- and post-intervention were not mentioned.²⁹

The relationship between halitosis and oral hygiene (debris index) and gingival health in this study was not significant, as more than half of the children had no inflammation which is in agreement with the previous studies^{5,6,9} in contrast to others.^{2,3,7,10} Studies supporting an association of plaque, gingival, and periodontal health were conducted on patients who originally complained of halitosis^{7,10} or who were caries free and evaluated to figure out the risk factors² or children from an older age-group.³

The association of oral hygiene practice showed a significant association with H₂S levels. This result was surprising, as it showed children who brush their teeth daily have higher levels; the plausible explanation for this result may be the lack of manual dexterity in this age-group or social desirability bias. Similar to other factors, studies showed contradictory results that either reported an association between the frequency of toothbrushing and halitosis^{3,7} or no association.^{5,6,9,10}

Half of the children in the present study have dental abscesses; however, abscesses were not associated with VSCs. The only explanation for this is that certain odors do not contribute to VSC levels or cannot be measured by gas chromatography.³⁰

In summary, the results of studies on the associated factors with halitosis in children are not consistent and inconclusive. It should be taken into account that the objectives, sampling, evaluation methods of halitosis, indices used for clinical parameters, and statistical methods differ between studies. However, it can still be explained that studies conducted on caries-free, low caries prevalence children or children complaining of halitosis show that usually oral hygiene, gingival and periodontal status, and tongue coating play significant roles in halitosis. On the contrary, children with a high caries index associate significantly with higher concentrations of VSCs. On the contrary, children with a high caries index associate significantly with higher concentrations of VSCs.

The limitations in this study are as follows: the sample was not randomly selected and not representative of the population and did not include children with a low caries index. The positive points of this study are the use of the most objective method in measuring halitosis (OralChroma™) to assess the effect of clinical parameters on VSC measurements and to limit the study to a small and young age-group (from 3 to 8 years). Further research should be conducted on different age-groups to assess the risk factors, compare caries-free/low caries and high caries children, and investigate the impact of full dental rehabilitation on the VSC measurements.

CONCLUSION

In this study, the dmft/DMFT index (children's caries experience) was associated significantly with intraoral halitosis caused by high H₂S and CH₃SH levels. Other clinical parameters, such as DI-S, MGI, WTCl, and dental abscesses were not associated with higher VSCs measurements in children.

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