







Exploring the Relationship Between Bakhour Use and Respiratory Health: A Cross-Sectional Study in the Jazan Region, Saudi Arabia

Mohammad A Jareebi ¹, Ahmad Y Alqassim ¹, Saja A Almraysi¹, Weaam A Alfaifi¹, Taif A Masri¹, Rana S Alaki¹, Wasan M Qawfashi¹, Khairiah Ibrahim Nehari¹, Sawsan B Hakami¹, Ibrahim M Gosadi ¹, Mohammed A Muaddi ¹, Abdullah A Alharbi ¹, Anwar M Makeen¹, Sarah MA Salih ¹, Ali Abdullah Masmali²

¹Department of Family and Community Medicine, Jazan University, Jazan, Saudi Arabia; ²Department of Jazan Health Affairs, King Fahd Central Hospital, Jazan, Saudi Arabia

Correspondence: Mohammad A Jareebi, Department of Family and Community Medicine, Jazan University, Jazan, Saudi Arabia, Email mjareebi@jazanu.edu.sa

Background: Despite deep cultural traditions, incense burning significantly impacts respiratory health. Effects of Arabian bakhour remain unknown in Saudi Arabia's Jazan region with prevalent use. This cross-sectional study addresses this gap by investigating bakhour exposure and respiratory diseases.

Methods: This was descriptive cross-sectional study conducted in Jazan area, Saudi Arabia, from October 2023 to March 2024. A total of 1612 participants age more than 18 years, both gender and resident of Jazan Area were included. Those aged less than 18 years were excluded. SPSS v 26 was used for data analysis.

Results: The sample (n=1612) had a mean age of 29±11 years and was 63% female. Bakhour use was nearly universal (98%), especially using coal (73%). Higher bakhour frequency significantly associated with increased cough (p<0.01) and dyspnea (p<0.01). Certain bakhour types linked to greater allergic rhinitis prevalence (p<0.01). Regression analysis revealed cough during bakhour use worsened respiratory health (increased respiratory score) by 3.89 times (95% CI 1.13–6.64; p=0.006) while dyspnea increased the score by 7.48 times (95% CI 4.70–10.25; p<0.001).

Conclusion: This study provides valuable insights into the association between Bakhour use and respiratory health in the Jazan region. The findings emphasize the need for further research and public health interventions to mitigate potential respiratory risks associated with Bakhour use.

Keywords: bakhour, respiratory health, cough, dyspnea, allergic rhinitis, household air pollution, environmental health

Introduction

Household air pollution (HAP) stemming from biomass fuel combustion poses a major global health concern, contributing to 4.3 million premature deaths annually.¹ Microscopic particulate matter and gases emitted from these solid fuels can profoundly impact respiratory health by inflaming airways and penetrating deep into the lungs.² The World Health Organization recognizes HAP as a leading worldwide risk factor, responsible for 3.2 million deaths annually.¹

Incense burning represents another major source of indoor air pollution with deep cultural and religious traditions, especially across Asia.^{3,4} Despite cultural significance, incense smoke contains high levels of fine particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds, polycyclic aromatic hydrocarbons, and metals that damage the respiratory tract and can exacerbate respiratory problems such as asthma, chronic obstructive pulmonary disease, and other breathing difficulties.^{3,5–7} Daily exposure to incense smoke in homes and temples is associated with poorer indoor air quality and inflammatory responses.^{3,8}

Furthermore, research has shown that bakhour exposure can cause significant damage to lung cells, highlighting the need to investigate its impact on asthma prevalence and symptoms children.^{3,9,10} Cross-sectional studies in Oman found exposure to bakhour smoke increased wheezing among asthmatic children.¹⁰ Additional research in Saudi Arabia showed bakhour smoke elicited acute throat and voice symptoms in adults along with associations between daily bakhour use and chronic obstructive pulmonary disease (COPD) risk in non-smoking women.^{8,11,12}

While evidence suggests incense burning adversely affects respiratory health, limited research exists on the relationship between bakhour smoke exposure and respiratory diseases in regions with prevalent cultural use. This cross-sectional study addresses this gap by examining associations between bakhour use characteristics and respiratory outcomes among adults in Saudi Arabia's Jazan region where heavy bakhour use is common but respiratory effects are understudied. We provide a comprehensive investigation of bakhour-related factors alongside measured respiratory health indicators. Findings will inform public health approaches regarding this widespread cultural practice affecting respiratory wellbeing.

Materials and Methods

Study Design and Participants

This cross-sectional questionnaire-based study was conducted in the Jazan region of Saudi Arabia from October 2023 to March 2024. Adults aged 18 years and above residing in the Jazan region were eligible to participate. Individuals younger than 18 years were excluded. The target sample size was initially calculated as 384 using Raosoft's sample size calculator, based on a 95% confidence level and 5% margin of error. Accounting for an estimated 25% non-response rate, the total required sample was adjusted to 480. To further minimize sampling bias and improve representation, the sample was expanded to 1612 participants from diverse cities and regions across Saudi Arabia. Multistage random sampling was utilized to recruit participants from varied geographic areas. The final sample size of 1612 was confirmed using the following formula:

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{E^2}$$

where Z represents the Z statistic for the desired confidence level (1.96 for 95% confidence), p is the expected prevalence or response distribution (0.5 used for the most conservative estimate), and E is the margin of error.

Data Collection Tools

A structured questionnaire was developed specifically for this study to collect data on demographics, incense use, and respiratory health symptoms. The questionnaire content and structure were informed by a review of similar previous surveys on respiratory health and incense exposure. The questionnaire contained three sections - demographics, incense use, and respiratory symptoms. The demographics section collected information on age, gender, marital status, education, occupation, income, and smoking status. The incense use section asked about frequency and duration of use, type of incense, and location of use. The respiratory symptoms section included questions on chronic cough, phlegm, wheezing, breathlessness, chest tightness, nasal congestion, sneezing, and diagnosed respiratory conditions. The questionnaire was piloted among 25 participants from the target population to evaluate clarity, validity, flow, and completion time. Minor modifications were made based on pilot feedback before finalization. The final questionnaire consisted of 32 items and took approximately 10–15 minutes to complete. Data collection was conducted using an online survey platform. The questionnaire was self-administered by participants after providing online informed consent. Participation was voluntary and confidentiality was maintained by collecting no personal identifiers. Email invites with the survey link were distributed via social media platforms like WhatsApp, Telegram, and Twitter to recruit participants from the Jazan region.

Data Analysis

The completed questionnaires were exported from the online survey platform into Excel. The data was checked for errors, inconsistent values, and missing responses. Descriptive analysis was conducted to summarize sample characteristics and prevalence of respiratory symptoms. Respiratory health symptoms were assigned a score from 0–3 based on

frequency (0 - never, 1 - sometimes, 2 - weekly, 3 - daily) and summed to derive a total respiratory health score (range 0–24). Participants scoring above 15 were categorized as having “poor” respiratory health while those scoring 15 or below were grouped as “good” respiratory health. Chi-squared test was used to assess associations between categorical sociodemographic factors, Bakhour use variables and respiratory outcomes. Independent *t*-test was applied for comparisons of respiratory health score between groups. ANOVA was used to analyze differences in respiratory score by Bakhour frequency and type. Multiple linear regression was conducted with respiratory health score as the outcome and sociodemographic and Bakhour factors as predictors. A *p*-value <0.05 was considered statistically significant for all tests. Analysis was performed using R statistical software.

Ethical Approval

This study received ethical approval from the Standing Committee for Scientific Research at Jazan University (reference number REC-45/05/870, dated 4/12/2023). Electronic informed consent was obtained from all participants prior to beginning the online survey. Confidentiality and privacy of data were maintained by collecting no personal identifiers. All data was reported in aggregate form. Data access was limited to the research team. Participants could voluntarily withdraw from the study at any time. Additional ethical considerations included transparency in communicating study purposes, questionnaire pre-testing, voluntary participation with informed consent, avoiding questions that could produce emotional distress, and secure data storage. This study was conducted in accordance with the Declaration of Helsinki guidelines for human subjects research.

Results

Sociodemographic Characteristics of the Sample

Table 1 outlines the sociodemographic characteristics of the study sample, comprised of 1612 participants. The mean age of the participants is 29 years, with a standard deviation of 11 years. Family size, represented by the mean number of children per household, is reported as 6.1 with a standard deviation of 2.8. Gender distribution reveals that 37% of the participants are male, while 63% are female. The vast majority of the sample is Saudi (96%), with a small non-Saudi representation (4%). The city of Jazan constitutes 77% of the participants, while the remaining 23% reside in other cities. In terms of residence, 43% of the participants live in rural areas, and 57% in urban settings. Social status varies, with 57% being single, 39% married, and 3% divorced or widowed. The income distribution indicates that 57% of the participants earn “Less than 5000”, 18% earn “5000–9999”, 14% earn “10,000–14,999”, and 11% earn “≥15,000”.

Habitual and Health-Related Characteristics

Table 2 comprehensively outlines the habitual and health-related characteristics of the study cohort, consisting of 1612 participants. The mean weight is reported as 64 kg, with a standard deviation of 17 kg, while the mean height is 162 cm, with a standard deviation of 9.6 cm. The Body Mass Index (BMI) is presented with a mean of 24 kg/m² and a standard deviation of 5.6. Regarding smoking habits, 18% of participants report being smokers, with the majority (82%) being non-smokers. Among smokers (*n*=294), the distribution of smoking types reveals 44% using cigarettes, 36% using shisha, and 20% using vape. Health-related characteristics indicate that 5% of participants have hypertension (HTN), while the majority (95%) do not. The prevalence of diabetes mellitus (DM) is 4%, with 96% not reporting the condition. Sick cell anemia (SCA) is noted in 3% of participants, whereas 97% do not have this condition. Additionally, thalassemia is present in 1% of participants, with 99% not exhibiting this health condition.

Table 3 delineates Bakhour-related variables among the 1612 participants included in the study. Nearly the entire cohort (98%) reported engaging in Bakhour use. Among Bakhour users, the predominant utilization method involves coal (73%), followed by both coal and electronic methods (24%), and a negligible proportion using only electronic means (1%). The types of Bakhour utilized were diverse, with Oud being the most prevalent (42%), followed by Mastic (27%), Maamoul (23%), and other types (5%). A small fraction of participants (2%) identified as non-Bakhour users. The mean Bakhour use frequency was reported as 4.5 times per week, with a standard deviation of 2.9.

Table 1 Sociodemographic Characteristics of the Sample (n = 1612)

Characteristics	Mean \pm SD
Age	29 \pm 11 years
Family member	6.1 \pm 2.8 kids/household
Characteristics	Frequency (%)
Gender	
Male	594 (37%)
Female	1018 (63%)
Nationality	
Saudi	1551 (96%)
Non-Saudi	61 (4%)
City	
Jazan	1246 (77%)
Other cities	366 (23%)
Residence	
Rural	691 (43%)
Urban	921 (57%)
Social status	
Single	926 (57%)
Married	632 (39%)
Divorced/widowed	54 (3%)
Income	
Less than 5000	912 (57%)
5000–9999	288 (18%)
10,000–14,999	228 (14%)
\geq 15,000	184 (11%)

Respiratory Health (Self-Reported)

The prevalence of cough is reported with 28% of participants, while 72% report no cough. The frequency distribution of cough reveals 5% experiencing it daily, 8% weekly, and 15% monthly. Cough during Bakhour use is reported by 24% of participants, with 76% indicating its absence during this activity. Shortness of Breath (SoB) is noted in 27% of participants, with 5% experiencing it daily, 10% weekly, 12% monthly, and 73% reporting no SoB. Additionally, 6% experience SoB in the morning, 21% at night, and 73% report no SoB at these times. SoB during Bakhour use is reported by 24% of participants. Wheezing is present in 13% of participants, while conditions such as asthma, COPD, and allergic rhinitis are each reported by 13% of participants. The majority (87%) report the absence of these respiratory conditions (Table 4).

Table 2 Habitual and Health Related Characteristics (n = 1612)

Characteristics	Mean ± SD
Weight	64 ± 17 kg
Height	162 ± 9.6 cm
BMI	24 ± 5.6 kg/m ²
Characteristics	Frequency (%)
Smoking status	
Yes	294 (18%)
No	1318 (82%)
Smoking types (n=294)	
Cigarettes	128 (44%)
Shisha	106 (36%)
Vape	60 (20%)
Hypertension (HTN)	
Yes	88 (5%)
No	1524 (95%)
Diabetes Mellitus (DM)	
Yes	71 (4%)
No	1541 (96%)
Sickle cell anemia (SCA)	
Yes	45 (3%)
No	1567 (97%)
Thalassemia	
Yes	14 (1%)
No	1598 (99%)

Respiratory Health Score

The respiratory health scores, as assessed by the Respiratory Symptom Experience Scale, demonstrated a broad range among participants, varying from a minimum of 0 to a maximum of 48. A lower score indicates better respiratory health, while higher scores suggest poorer respiratory health. The summary statistics reveal a central tendency with a median of 14.00 and a mean of 15.76, highlighting a relatively symmetric distribution. Given the close alignment of the median and mean, indicative of a normal distribution, we implemented a categorization strategy based on the mean value (15.76). Participants were divided into two groups: those with good respiratory health and those with poor respiratory health. This resulted in 54.09% of participants categorized as having good respiratory health (n = 872) and 45.91% as having poor respiratory health (n = 740) (Figure 1).

Table 3 Bakhour Related Variables (n = 1612)

Characteristics	Frequency (%)
Bakhour use	
Yes	1575 (98%)
No	37 (2%)
Bakhour utilization method	
Coal	1173 (73%)
Electronic	12 (1%)
Both	390 (24%)
Not Bakhour user	37 (2%)
Bakhour type	
Oud	676 (42%)
Maamoul	376 (23%)
Mastic	440 (27%)
Other	83 (5%)
Not Bakhour user	37 (2%)
Characteristics	Mean \pm SD
Bakhour use frequency (per week)	4.5 \pm 2.9 times/week

Table 4 Respiratory Health (n = 1612)

Characteristics	Frequency (%)
Cough	
Yes	456 (28%)
No	1156 (72%)
Cough frequency	
Daily	85 (5%)
Weekly	136 (8%)
Monthly	235 (15%)
No cough	1156 (72%)
Cough during Bakhour Use	
Yes	392 (24%)
No	1220 (76%)
Shortness of Breath (SoB)	
Yes	437 (27%)
No	1175 (73%)

(Continued)

Table 4 (Continued).

Characteristics	Frequency (%)
SoB frequency	
Daily	86 (5%)
Weekly	158 (10%)
Monthly	193 (12%)
No SoB	1175 (73%)
SoB timing	
Morning	100 (6%)
Night	337 (21%)
No SoB	1175 (73%)
SoB during Bakhour Use	
Yes	388 (24%)
No	1224 (76%)
Wheezing	
Yes	213 (13%)
No	1399 (87%)
Asthma	
Yes	213 (13%)
No	1399 (87%)
COPD	
Yes	213 (13%)
No	1399 (87%)
Allergic rhinitis	
Yes	213 (13%)
No	1399 (87%)

Association Between Bakhour Variables and Respiratory Health

The presented findings in [Table 5](#) provide insights into the relationships between various variables associated with Bakhour use and health outcomes, specifically cough, cough frequency, shortness of breath (SoB), SoB frequency, wheezing, and allergic rhinitis. In terms of cough, neither the use of Bakhour nor the specific processes involved (coal and electronic methods) nor the type of Bakhour used show statistically significant associations. However, the frequency of Bakhour used demonstrates a significant association with cough ($p < 0.01$). Regarding cough frequency, no significant associations are observed with Bakhour use, process, or type. Yet, a notable finding emerges as the frequency of Bakhour use itself exhibits a significant correlation with cough frequency ($p < 0.01$). Moving to shortness of breath, while there is no significant association with the use and type of Bakhour, a significant finding arises in the association between the process of using Bakhour and shortness of breath ($p < 0.01$). However, the frequency of Bakhour use does not show a significant association with shortness of breath. Concerning the frequency of shortness of breath, no significant

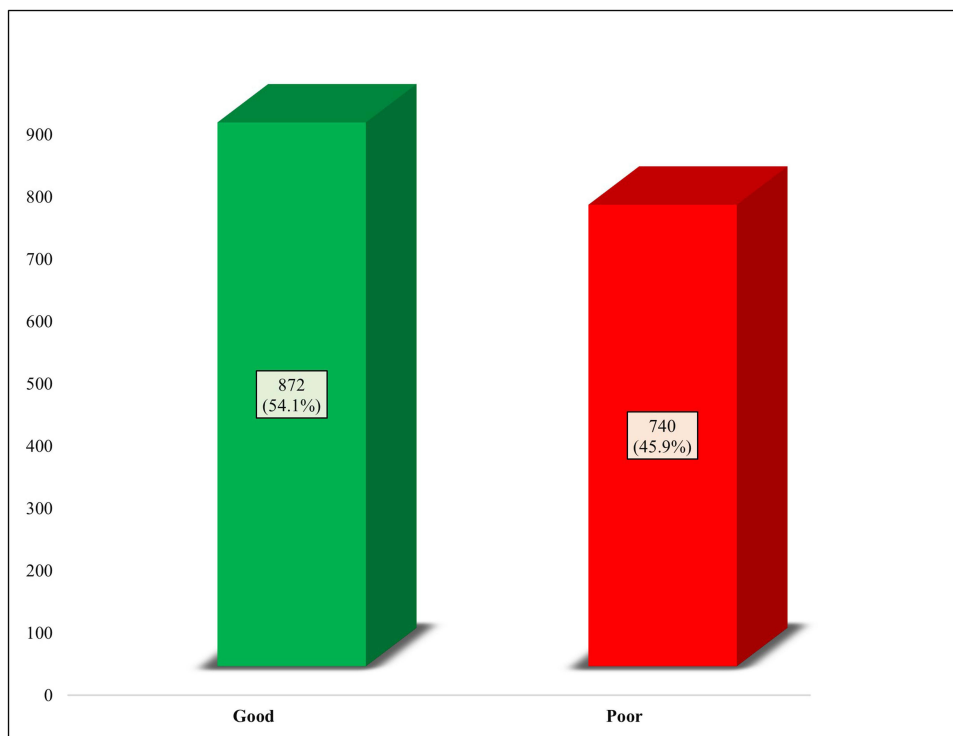


Figure 1 Respiratory Health Among Participants.

associations are found with Bakhour use, process, or type, except for a significant correlation with the frequency of Bakhour use ($p < 0.01$). In the case of wheezing, neither the use nor the type of Bakhour shows significant associations, but a significant correlation exists between the process of using Bakhour and wheezing ($p < 0.01$). Finally, about allergic rhinitis, neither the use nor the process of using Bakhour shows a significant association. Notably, a significant association is found between the type of Bakhour used and allergic rhinitis ($p < 0.01$). The details of these associations are shown in the [Appendix Tables 1–6](#).

Table 5 Association of Cough, Shortness of Breath, Wheezing, and Allergic Rhinitis with Bakhour Use*

	Cough	Cough Frequency	SoB	SoB Frequency	Wheezing	Allergic Rhinitis
Bakhour use	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	P < 0.05
No						
Yes						
Process	$p > 0.05$	P < 0.05	P < 0.01	P < 0.05	P < 0.01	$p > 0.05$
Both						
Coal						
Electronic						
Not Bakhour user						

(Continued)

Table 5 (Continued).

	Cough	Cough Frequency	SoB	SoB Frequency	Wheezing	Allergic Rhinitis
Bakhour type	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	P<0.01
Maamoul						
Mastic						
Oud						
Other						
Not Bakhour user						
Bakhour Frequency	P<0.01	P<0.01	p>0.05	P<0.05	p>0.05	p>0.05

Notes: *The test used for the analysis was the chi-square test. Bold values indicate a p-value < 0.05, which signifies a significant association between bakhour variables and respiratory symptoms.

Association Between Bakhour Variables and Respiratory Health Score

The multiple linear regression analysis aimed to explore the relationship between Bakhour variables, sociodemographic factors, and the respiratory health score. The respiratory health score, where higher values indicate lower respiratory health, serves as the dependent variable. Among the Bakhour variables, Bakhour use, specific processes (Coal and Electronic), and different types of Bakhour (Mastic, Oud, Other) did not show statistically significant associations with the respiratory health score. Likewise, the frequency of Bakhour use exhibited a non-significant impact on the respiratory health score. Notably, the presence of cough upon Bakhour use demonstrated a significant positive association, indicating an increase in the respiratory health score (indicating poorer respiratory health) when cough is present during Bakhour use ($p = 0.006$). Similarly, shortness of breath (SoB) triggered by Bakhour showed a significant positive association, suggesting a higher respiratory health score in the presence of SoB during Bakhour use ($p < 0.001$). Age exhibited a non-significant association with the respiratory health score, while gender did not show a significant effect. The overall model explained approximately 47% of the variance in the respiratory health score ($R^2 = 0.47$). The rest of the associations are shown in [Table 6](#).

Table 6 Multiple Linear Regression of Bakhour Variables and Respiratory Health Score

Predictors	Respiratory Health Score		
	Beta	CI	p
Bakhour use (reference: no)			
[Yes]	-1.40	-7.52-4.73	0.654
Process (reference: no Bakhour use)			
[Coal]	-1.21	-3.82-1.41	0.364
[Electronic]	-0.43	-9.35-8.49	0.924
Bakhour type (reference: no Bakhour use)			
[Mastic]	2.19	-0.93-5.31	0.168
[Oud]	0.13	-2.61-2.87	0.924

(Continued)

Table 6 (Continued).

Predictors	Respiratory Health Score		
	Beta	CI	p
[Other]	0.93	-5.53-7.40	0.776
Bakhour Frequency	-0.21	-0.57-0.15	0.255
Cough upon Bakhour (reference: no)			
[Yes]	3.89	1.13-6.64	0.006
SoB upon Bakhour (reference: no)			
[Yes]	7.48	4.70-10.25	<0.001
COPD (reference: no)			
[Yes]	5.11	3.31-6.92	<0.001
Asthma (reference: no)			
[Yes]	3.28	1.80-4.76	<0.001
Age	0.08	-0.07-0.22	0.304
Gender (reference: female)			
[Male]	-0.12	-2.79-2.55	0.929
Smoking (reference: no)			
[Yes]	0.92	-0.18-2.01	0.101
Observations	1612		
R2	0.470		

Discussion

While prior research shows that incense smoke adversely impacts respiratory health, limited evidence exists on its effects in populations with high cultural use. This cross-sectional study is the first to investigate associations between respiratory diseases and incense (bakhour) among adults in Saudi Arabia's Jazan region, where bakhour use is prevalent yet respiratory health impacts are unknown. We addressed this knowledge gap by analyzing self-reported respiratory outcomes in relation to various bakhour exposure characteristics among a large sample of adults from this understudied population. The study condenses the background details, avoiding repetition from the Introduction. It highlights the lack of prior research focused on the respiratory health impacts of cultural incense use specifically in the high-exposure Jazan region. This opening clearly emphasizes the knowledge gap addressed by examining associations between bakhour use patterns and respiratory diseases in this population.

In this large sample, nearly all participants reported bakhour use. We identified significant associations between bakhour exposure characteristics and respiratory outcomes. Higher bakhour use frequency correlated with increased cough and shortness of breath. Specific types of bakhour associated with greater allergic rhinitis prevalence. These findings align with previous studies showing incense smoke irritates airways and provokes symptoms like cough and dyspnea.^{4,5,13} Our Results similarly demonstrate correlations between incense exposure patterns and respiratory issues, particularly increased cough and shortness of breath with frequent bakhour use among adults in Jazan. The association of certain bakhour types with rhinitis also accords with research indicating incense smoke can trigger allergic responses.¹⁴⁻¹⁶

Several other studies from Asian populations, where different types of incense are burnt for religious purposes, reported significant associations between exposure to incense smoke and respiratory symptoms.^{17–19} Our findings showing associations between bakhour use and respiratory issues align with prior studies demonstrating links between incense exposure and cough, dyspnea, wheezing, and conditions like COPD.^{20,21} Though specific respiratory effects and strength of associations varied across studies, past research overall indicates consistent connections between incense smoke and adverse respiratory health impacts. As it is responsible for regulating IgE and stimulating mucosal immunity, and increased activation may lead to exacerbation of allergic respiratory diseases.²²

Incense smoke contains fine particulate matter and gases like PM_{2.5}, carbon monoxide, and volatile organic compounds that can be inhaled deep into the lungs.^{3,23} Our study found increased risk of respiratory symptoms like cough and shortness of breath with frequent bakhour use. The particulate matter likely causes airway inflammation and irritation. Specific components may also provoke allergic responses, as we found associations between certain bakhour types and increased allergic rhinitis. This aligns with previous research finding links between incense smoke chemicals and elevated IgE levels or eosinophilic inflammation related to allergies and asthma exacerbation.^{3,14,24} The exact mechanisms and specific causal components still need further investigation, but the evidence indicates that chemicals in bakhour smoke negatively impact respiratory health.

Culturally appropriate education campaigns, avoidance advice for at-risk groups, smoke-free public spaces, improved ventilation standards, enhanced clinical screening, further etiological research, and increased preventive respiratory health services are warranted to curb hazardous bakhour exposures in Jazan region. Implementing multifaceted interventions informed by local cultural practices and epidemiological evidence can help mitigate bakhour smoke risks revealed by this study. Priorities include increasing public awareness, reducing exposure in public areas and homes, improving surveillance and healthcare access for affected populations, establishing exposure limits, and expanding the research basis to support regulatory policies to ultimately preserve respiratory health.

This study has strengths in its large sample size drawn from the understudied Jazan population with high cultural bakhour use. Our findings significantly contribute to the limited evidence on bakhour exposure risks, demonstrating consistent associations between use patterns and adverse respiratory health effects in this population. These results highlight the need to address this modifiable factor to promote respiratory wellbeing in Jazan region. The implications underscore the importance of implementing culturally-appropriate public health strategies to increase awareness and reduce hazardous exposures. Overall, this study generates crucial evidence to inform prevention policies and interventions to preserve respiratory health in bakhour-using populations.

Limitations

This study has certain Limitations. The cross-sectional design provides associations at one time point but cannot determine causality or long-term impacts requiring longitudinal assessments. Self-reported data may involve recall bias, emphasizing the need for objective clinical measurements in future studies. Respiratory health was evaluated based on symptoms and previous diagnoses rather than direct functional assessments. However, the study mitigates limitations through the large, diverse sample representing the target population. It includes comprehensive bakhour exposure and respiratory health indicators beyond previous studies focused only on specific outcomes like asthma. The research significantly contributes much-needed initial evidence on this topic in an understudied population. Going forward, findings would be enriched by longitudinal evaluations over extended bakhour exposure periods, measurements of lung function, and identification of specific hazardous components. This study provides a crucial foundation highlighting key associations to inform future investigations into the respiratory health impacts of cultural bakhour use.

Conclusions

The findings demonstrate consistent links between Bakhour exposure patterns and respiratory outcomes including increased cough, dyspnea, and allergic rhinitis. The results hold important public health implications for this population with prevalent Bakhour use, emphasizing the need for longitudinal investigations, explorations of mechanisms, and cultural interventions to mitigate hazardous exposures and associated respiratory risks. This research makes a significant

contribution by generating key insights to inform policies and practices aimed at preserving respiratory health in the context of deeply rooted cultural traditions. Overall, the study underscores the value of evidence-based, multifaceted public health strategies to promote awareness and reduce harmful smoke exposures, supporting improved respiratory wellbeing at both individual and population levels.

Institutional Review Board Statement

This study received ethical approval from the Standing Committee for Scientific Research at Jazan University (reference number REC-45/05/870, dated 4/12/2023). Electronic informed consent was obtained from all participants prior to beginning the online survey. Confidentiality and privacy of data were maintained by collecting no personal identifiers. All data was reported in aggregate form. Data access was limited to the research team. Participants could voluntarily withdraw from the study at any time. Additional ethical considerations included transparency in communicating study purposes, questionnaire pre-testing, voluntary participation with informed consent, avoiding questions that could produce emotional distress, and secure data storage. This study was conducted in accordance with the Declaration of Helsinki guidelines for human subjects research.

Data Sharing Statement

Data available in the manuscript.

Informed Consent Statement

Written consent was taken.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Raju S, Siddharthan T, McCormack MC. Indoor air pollution and respiratory health. *Clinics Chest Med.* 2020;41(4):825–843. doi:10.1016/j.ccm.2020.08.014
2. Gordon SB, Bruce NG, Grigg J, et al. Respiratory risks from household air pollution in low and middle income countries. *Lancet Respir Med.* 2014;2(10):823–860. doi:10.1016/S2213-2600(14)70168-7
3. Lin T-C, Krishnaswamy G, Chi DS. Incense smoke: clinical, structural and molecular effects on airway disease. *Clin Mol Allergy.* 2008;6(1):3. doi:10.1186/1476-7961-6-3
4. Lee CW, Ttt V, Wee Y, et al. The adverse impact of incense smoke on human health: from mechanisms to implications. *J Inflamm Res.* 2021;14:5451–5472. doi:10.2147/jir.S332771
5. Jetter JJ, Guo Z, McBrien JA, Flynn MR. Characterization of emissions from burning incense. *Sci Total Environ.* 2002;295(1):51–67. doi:10.1016/S0048-9697(02)00043-8
6. Lee S-C, Wang B. Characteristics of emissions of air pollutants from burning of incense in a large environmental chamber. *Atmos Environ.* 2004;38(7):941–951. doi:10.1016/j.atmosenv.2003.11.002
7. Al-Kassimi FA. The dangers of incense burning: COPD in Saudi Arabia. *Int J Chron Obstruct Pulmon Dis.* 2013;8:251–253. doi:10.2147/copd.S42057
8. Guo S-E, Chi M-C, Lin C-M, Yang T-M. Contributions of burning incense on indoor air pollution levels and on the health status of patients with chronic obstructive pulmonary disease. *PeerJ.* 2020;8:e9768. doi:10.7717/peerj.9768
9. Chen KF, Tsai YP, Lai CH, Xiang YK, Chuang KY, Zhu ZH. Human health-risk assessment based on chronic exposure to the carbonyl compounds and metals emitted by burning incense at temples. *Environ Sci Pollut Res Int.* 2021;28(30):40640–40652. doi:10.1007/s11356-020-10313-1
10. Al-Rawas OA, Al-Maniri AA, Al-Riyami BM. Home exposure to Arabian incense (bakhour) and asthma symptoms in children: a community survey in two regions in Oman. *BMC Pulm Med.* 2009;9(1):23. doi:10.1186/1471-2466-9-23
11. Alaitan AM, Memon JI, Rehmani RS, Qureshi AA, Salam A. Chronic obstructive pulmonary disease: hospital and intensive care unit outcomes in the Kingdom of Saudi Arabia. *Int J Chron Obstruct Pulmon Dis.* 2012;7:819–823. doi:10.2147/copd.S37611

12. Mesallam TA, Farahat M, Shoeib R, et al. Acute effects of inhaling Oud incense on voice of Saudi adults. *Ann Saudi Med.* 2015;35(2):111–119. doi:10.5144/0256-4947.2015.111
13. Maskey S, Khadgi J, Shrestha N, Acharya A, Park K, Pokhrel A. Characteristics of fine particles from incense burning at temple premises of Kathmandu Valley, Nepal. *Environ Monit Assess.* 2023;195(11):1382. doi:10.1007/s10661-023-11918-y
14. Nemmar A, Hoet PHM, Vanquickenborne B, et al. Passage of inhaled particles into the blood circulation in humans. *Circulation.* 2002;105(4):411–414. doi:10.1161/hc0402.104118
15. Nolte H, Backer V, Porsbjerg C. Environmental factors as a cause for the increase in allergic disease. *Ann Allergy Asthma Immunol.* 2001;87(6 Suppl 3):7–11. doi:10.1016/s1081-1206(10)62333-2
16. Almqvist C. High allergen exposure as a risk factor for asthma and allergic disease. *Clin Rev Allergy Immunol.* 2005;28(1):25–41. doi:10.1385/craia:28:1:025
17. Yang CY, Chiu JF, Cheng MF, Lin MC. Effects of indoor environmental factors on respiratory health of children in a subtropical climate. *Environ Res.* 1997;75(1):49–55. doi:10.1006/enrs.1997.3774
18. Ho C-K, Tseng W-R, Yang C-Y. Adverse respiratory and irritant health effects in temple workers in Taiwan. *J Toxicol Environ Health Part A.* 2005;68(17–18):1465–1470. doi:10.1080/15287390590967405
19. Cuijpers CE, Swaen GM, Wesseling G, Sturmans F, Wouters EF. Adverse effects of the indoor environment on respiratory health in primary school children. *Environ Res.* 1995;68(1):11–23. doi:10.1006/enrs.1995.1003
20. Custovic A, Simpson A, Woodcock A. Importance of indoor allergens in the induction of allergy and elicitation of allergic disease. *Allergy.* 1998;53(48 Suppl):115–120. doi:10.1111/j.1398-9995.1998.tb05011.x
21. Lebowitz MD. Health effects of indoor pollutants. *Annu Rev Public Health.* 1983;4(1):203–221. doi:10.1146/annurev.pu.04.050183.001223
22. Abhishek Kumar P, Krishna PA, Krishna PA. Survey of body mass index (BMI) on median motor nerve conduction velocity (NCV) in normal population of Malwa region. *Indian J Clin Anatomy Physiol.* 2023;10(2):104–107. doi:10.18231/j.ijcap.2023.022
23. Yadav VK, Malik P, Tirth V, et al. Health and environmental risks of incense smoke: mechanistic insights and cumulative evidence. *J Inflamm Res.* 2022;15:2665–2693. doi:10.2147/jir.S347489
24. Alarifi SA, Mubarak MM, Alokail MS. Ultrastructural changes of pneumocytes of rat exposed to Arabian incense (Bakhour). *Saudi Med J.* 2004;25(11):1689–1693.

International Journal of General Medicine

Dovepress

Publish your work in this journal

The International Journal of General Medicine is an international, peer-reviewed open-access journal that focuses on general and internal medicine, pathogenesis, epidemiology, diagnosis, monitoring and treatment protocols. The journal is characterized by the rapid reporting of reviews, original research and clinical studies across all disease areas. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/international-journal-of-general-medicine-journal>