SYSTEMATIC REVIEW/META ANALYSIS

Effects of Exposure to Incense Smoke Associated with Impaired Lung Function and Respiratory Disease: A Systematic Review

I Made Dwi Mertha Adnyana[1], Budi Utomo[2*], Linda Dewanti[3], Shifa Fauziyah[4], Dwinka Syafira Eljatin[5], Muhamad Frendy Setyawan[6], Lesty Helda Marsel Sumah[7], Citra Al Karina[8]

[1-3,5-8]Universitas Airlangga, Surabaya, Indonesia
[4]Delima Husada Gresik Health Analyst Academy, Gresik District, Indonesia

DOI: 10.55489/njcm.140520232875

ABSTRACT

The community uses incense (*bakhour*) through ceremonies, traditional health practices, and aromatherapy. Nevertheless, evidence from experiments and studies of populations suggests that a habit of burning incense makes the lungs work less well. The study investigated the relationship between exposure to incense smoke and impaired lung function and respiratory diseases. Data tracing was carried out systematically following PRISMA guidelines from January to April 2022 and registered in the PROSPERO database. The articles selected in this review were cross-sectional, cohort, observational, and experimental studies based on the criteria: (1) animals or humans exposed to incense smoke; (2) exposure to incense smoke which was carried out indoors or outdoors; (3) the selected articles which were included in the original type of article; (4) the publication year between 2016-2021 and the selected articles entered into reputable journals (Scopus and Web of Science). JBI guidelines and synthesis guidelines without meta-analysis (SWiM) to determine the level of evidence and minimize bias and interpretation of results. This study describes respiratory symptoms or diseases, home use of incense, and lung function measurement. Six articles were included; 6 (100%) reported using incense indoors, and 5 (83%) reported using incense outside the home. Respiratory symptoms and diseases caused by exposure to incense sticks are 5 (83%) shortness of breath, 6 (100%) wheezing, asthma, and inflammation of the lungs, 2 (33%) chronic obstructive pulmonary disease, and 4 (67%) allergic rhinitis. Incense smoke particles decrease lung function based on FVC, FEV, PEFR, and FEF values of 25-75%. The results indicate that smoking incense adversely affects lung function and leads to respiratory diseases. The community and related parties can minimize and conduct education and prevention related to simultaneous incense exposure in the community to reduce the burden of diseases and disorders due to respiratory incense smoke in areas that use it daily.

Key-words: Air quality, Environmental Health, Incense smoke, Inhalation exposure, Respiratory disease

ARTICLE INFO

Financial Support: None declared
Conflict of Interest: None declared
Received: 21-02-2023, **Accepted**: 11-04-2023, **Published**: 01-05-2023
***Correspondence:** Budi Utomo (Email: budiutomo@fk.unair.ac.id)

How to cite this article:
I Made Dwi Mertha Adnyana, Budi Utomo, Linda Dewanti, Shifa Fauziyah, Dwinka Syafira Eljatin, Muhamad Frendy Setyawan, Lesty Helda Marsel Sumah, Citra Al Karina. Effects of Exposure to Incense Smoke Associated with Impaired Lung Function and Respiratory Disease: A Systematic Review. Natl J Community Med 2023;14(5):284-293. DOI: 10.55489/njcm.140520232875

www.njcmindia.com | pISSN09763325 | eISSN22296816 | Published by Medsci Publications

INTRODUCTION

Incense (*bakhour*) in the community is generally used for the ceremony. In addition, burning incense is used as a traditional health practice to utilize fragrant scents for medicinal purposes called *Usada* (Hindu-Balinese) and *Ayurveda* (Hindu-Indian).[1,2] Burning incense inside and outside homes, places of worship, and other public places has been used for generations, especially in the Asian region.[3] It is reported that the global consumption of incense exceeds 200 million tons per year. Therefore, it has considerable health and environmental implications.[4] Daily incense burning will continue to contribute to polluting particulates that can degrade the environment and lower the degree of health through decreased respiratory tract function.[5,6] According to several studies, exposure to incense smoke can impair lung organ function and create harmful health effects, considerably raising the risk of respiratory diseases caused by pollution.[7,8]

It has been reported that incense smoke contains nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), particulate matter (PM_1, $PM_{2,5}$, PM10), ozone (O_3), TSP (Total Suspended Particulate), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs).[9–13] Incense smoke inhaled by humans is considered more dangerous than people who smoke passively[14,15] and has produced various impacts, especially diseases of the upper and lower intestinal tracts. Previous research has revealed and proven that exposure to incense smoke causes breathing difficulties such as asthma, chronic obstructive pulmonary disease (COPD), wheezing or whistling, rhinitis, and pneumonia to mortality in the respiratory system.[7,16–18]

The constituents contained in incense smoke are considered detrimental to health and the environment.[19–21] This is caused by carcinogens capable of damaging the human respiratory organs for an extended period with the intensity of routine or frequent exposure.[21–25] Previous studies that have revealed the clinical effects of incense smoke exposure in experimental animals and humans have not been widely reported, especially those associated with changes in lung function and the mechanisms of the underlying changes. The study aimed to investigate the relationship between exposure to incense smoke and impaired lung function and respiratory diseases by focusing on respiratory disease symptoms, lung function examinations in incense users inside and outside the home, and testing the effects of incense smoke exposure on humans and experimental animals. This review hopes that long-term exposure to incense smoke on the environment and human and animal health and that the preventative actions that can be done to limit the hazards posed, especially for those who use it daily, will be revealed.

METHODOLOGY

Systematic review registration: This systematic review emoloyed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocol guidelines.[26] The study has been listed on the PROSPERO database with the registration number CRD420222988868.

Eligibility criteria: The articles selected in this review were cross-sectional, cohort, observational, and experimental studies. The feasibility of the article was determined by the researcher independently by reviewing eligible titles and abstracts based on the criteria: (1) animals or humans exposed to incense smoke or direct contact with exposure to incense smoke; (2) exposure to incense smoke which was carried out indoors or outdoors; (3) the selected articles which were included in the original type of article; (4) the publication year between 2016-2021 and the selected articles entered into reputable journals (Scopus and Web of Science). The year range was selected depending on the novelty of the research, and the journal's reputation determines the article's credibility. In this review, the article discussed exposure to incense smoke, impaired lung function due to incense smoke, damage mechanisms due to incense smoke, content in incense smoke, and other respiratory diseases affected by incense smoke and changes in lung tissue due to inhaling incense smoke. Articles that did not meet the criteria for eligibility, duplicates, discontinued, and irrelevant studies were excluded at this stage.

Sources of information, literature search strategies, and study selection: In this review, we used a trusted database and credible sources to find articles that fit the topic of discussion raised by: PubMed (MeSH term) ("*exposure incense*" AND "*Lungs*"); ScienceDirect ("*exposure incense*" AND "*Lungs*" AND "*respiratory disease*"); ProQuest ("*exposure incense*" AND "*Lungs*" AND "*respiratory disease*"); Cochrane Library ("*exposure incense*" AND "*respiratory disease*"); Emerald and Nature ("*exposure incense*" AND "*lung disease*" OR "*respiratory disease*"). All articles were included and filtered in two eligibility stages. The first screening stage was assessed by selecting titles and abstracts from articles relevant to a predetermined topic. Furthermore, abstracts that met the inclusion criteria were included in this review, while those that did not will be excluded. The second stage was filtered based on the results and discussions on the research topic, and conducted as a comprehensive and independent analysis as review material. The study exceptions were described in the PRISMA diagram (Figure 1).

Data extraction: Data extraction was carried out independently using each selected article's standard structure and form. The information collected and summarized in each article includes the first author's name and year of publication, study period (month or years), gender, respiratory symptoms/diseases

(Breathlessness, Wheezing, COPD, Asthma, Rhinitis, and Pneumonia), home use of incense (outside and inside), measurement of lung function (FEV1 (%), FVC (L/s), PEFR (L/s), FEF 25-75%), sample size, intervention, design study, and outcome. Three authors carried out the data extraction, and if there was disagreement in some interpretation, it was resolved by deliberation until consensus.

Quality assessment: The quality assessment of the articles in this study was conducted independently by three authors using the Joanna Briggs Institute (JBI) critical assessment checklist for cross-sectional, cohort, observational, and experimental studies (RCT).[26] Each article's evidence level was determined based on the 2013 JBI Levels of Evidence. In conducting this study, we used synthesis guidelines without meta-analysis (SWiM) in the systematic review to minimize bias resulting from this study.[27] If disagreements between authors arose, they were resolved through deliberation to reach a consensus.

Data collection and analysis of data: The data collection protocol for this box was approved before starting the analysis and the work project. Bibliographic data results in features and follow-up results were extracted independently. The data was further reconciled to obtain data related to incense smoke exposure on impaired lung function and respiratory diseases in this review. In the selected article, we found a significant structural difference, especially in terms of the effect of lung function measurement results after exposure to incense smoke, which was very minimal (the estimated effect was not reported ultimately).

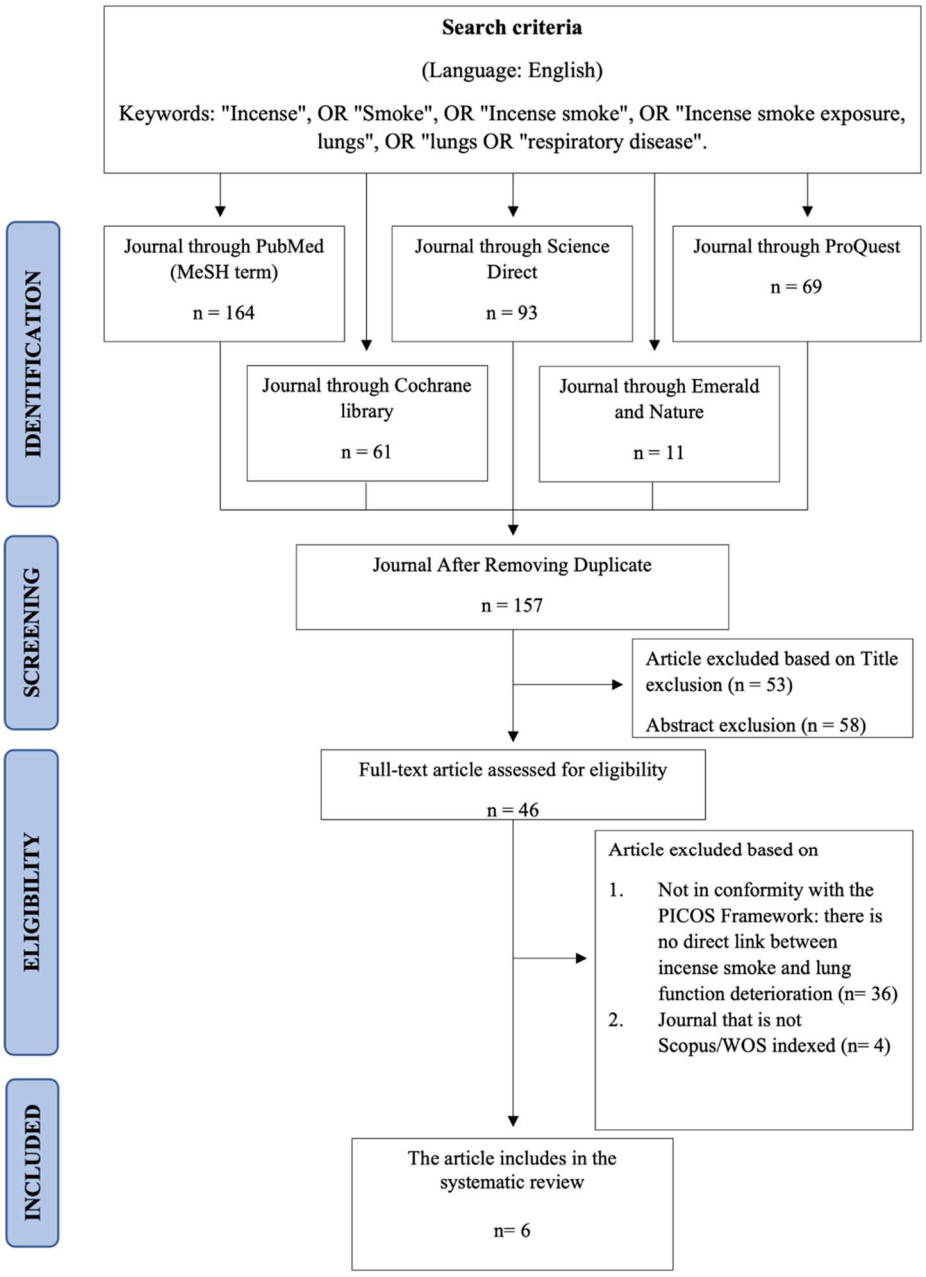

Figure 1: Process sorting, filtering, and determining articles based on PRISMA diagrams

Table 1: Summary of evidence and studies on the effects of exposure to incense smoke

Ref.	n	Sample (n)		Methods	Design study	Result	Conclusion	Levels of Evidence
		C	I					
Al Khathlan N et al [28]	125	80	45	Comparing the lung function of people exposed to incense smoke regularly (> 2 times/week) or daily with people who are not exposed to regular incense smoke (< 2 times/week)	Cross-sectional	The prevalence of wheezing or whistling was 35.5% in the exposed group and 6.4% in the non-exposed group. Prolonged exposure to incense smoke (> 2 times/week) is positively associated with the occurrence of respiratory distress symptoms: wheezing or whistling (AOR: 1.96; 95% CI: 1.06–3.64); shortness of breath (AOR: 1.23; 95% CI: 0.82–3.89); chest tightness (AOR: 1.54; 95% CI: 1.07–3.61); shortness of breath (AOR: 1.68; 95% CI: 1.13–3.17); and being awakened by a cough attack (AOR: 2.19; 95 % CI wheezing or whistling (AOR: 1.96; 95% CI: 1.06–3.64); shortness of breath (AOR: 1.23; 95% CI: 0.82–3.89); chest tightness (AOR: 1.54; 95% CI: 1.07–3.61); shortness of breath (AOR: 1.68; 95% CI: 1.13–3.17); and being awakened by a cough attack (AOR: 2.19; 95% CI 5.88±1.54 for PEF, 3.85±0.78 for FEV1, 4.72±0.95 for FVC, and 88.65±8.3 for FEV1/FVC ratio were the lung function test findings (%). There were substantial variations in FEV1 and FVC values between incense smoke-exposed and unexposed groups. Participants who worked in a bakhour store for more than two years showed a significantly higher prevalence of decreased pulmonary function (AOR: 1.72; 95% CI: 1.21-3.85). In the meantime, burning bakhour in the home impairs pulmonary function (AOR: 2.05, 95% CI: 1.08–3.29).	Exposure to incense more than twice a week resulted in a high risk of impaired lung function. A more significant proportion of incense shop employees have decreased lung function, and burning incense inside the home results in a decreased lung function index. Regular exposure to incense smoke can result in lung damage 1.72 times greater than no exposure. Burning incense in the house is 2.05 times more at risk, resulting in decreased lung function and causing respiratory diseases.	4.b.
Zhang Z et al[36]	4.041	N/A	3.811	Tested the link between burned incense and impaired lung function and respiratory disease in children in 27 primary schools from 2012 to 2014	Cohort	The average age of children used as a sample was 9.1 years. A total of 808 people reported the use of incense at home. The results of identification of respiratory diseases/symptoms obtained 147 (3.6%) asthma; 1656 (41.0%) allergic rhinitis; 115 (2.8%) Inflammation of the mucous membranes; 527 (13.0%) bronchitis; 123 (3.0%) bronchiolitis; 42 (1.0%) pneumonia; 399 (9.9%) wheezing; 1098 (27.2%) dry cough; and 501 (12.4%) cough phlegm. Males have higher FVC, FEV1, PEF, and MMEF scores than women, according to the findings of lung function tests. Blooming incense is related to a higher incidence of bronchitis [odds ratio (OR) = 1.39, 95 % confidence interval (CI): 1.11, 1.72] and bronchiolitis (OR = 1.72, 95% CI: 1.14, 2.56). A higher prevalence of pneumonia (OR = 2.79, 95% CI: 1.10, 6.87) and wheezing (OR = 1.49, 95% CI: 1.10, 2.05) is also associated with incense use in males, but not in females.	Exposure to incense smoke adversely affects lung function by reducing workability and increasing symptoms of respiratory diseases. Males are susceptible to developing bronchitis, bronchiolitis, pneumonia, and wheezing from incense smoke. Children who inhale incense smoke inside and outside the home have impaired lung function, lower lung function growth, and an increased risk of diseases and respiratory symptoms.	3.c.

Ref.	n	Sample (n)		Methods	Design study	Result	Conclusion	Levels of Evidence
		C	I					
Shaikh R et al[35]	60	N/A	N/A	The effects of exposure to incense smoke on impaired lung function in Pandits and Pujaris are examined using FVC, FEV, PEFR, and FEF values of 25-75%. To investigate the pulmonary function associated with burning incense, pundits and pujaris without a history of smoking, asthma, or allergic rhinitis participated in a mass screening study.	Observational	The results showed that of the 60 pandits and pujaris obtained, 15 people had a FeV1 value less than the normal range, 38 people had a FeV1 value in the normal range, and seven people had a FeV1 value more than the average distance. FVC examination, 51 people have FVC values below the normal range; 6 ordinary FVC people and 3 FVC people exceeded normal limits. Fifteen people below standard obtained FEV1/FVC ratio check; 6 people were in the normal range, and 39 had FEV1/FVC ratios exceeding the standard limit. Meanwhile, 53 people were less than average; 5 ordinary people and two people exceeded the standard limit. Continuous exposure to incense smoke increases the risk of discomfort in the throat and nose among temple employees. Daily burning of incense contributes to the emission of high levels of pollutants that cause increased oxidative stress, induce an irritating response, alter lung structure, and decrease lung function.	There was a decrease in lung function in Pandits and Pujaris in the temple, with a decrease in FVC, FEV, PEFR, and FEF values of 25-75%. Gas/incense smoke accumulation symptoms include dry throat, cough, fatigue, dizziness, and respiratory tract infections.	3.e.
Guo SE et al[37]	18	N/A	N/A	Measuring lung function of COPD patients exposed to incense smoke daily and testing $_{PM2.5}$ and $_{PM10}$ from incense smoke associated with COPD incidence	Cohort	Out of 18 COPD patients, majority (83.3 %) of them lived in rural areas and opened their windows and doors during the day (77.8%). The measurement of concentrations of pollutants revealed PM10 and PM2.5. 30 minutes after incense burning, PM10 and PM2.5 concentrations were the highest, followed by PM2.5 levels. Five levels were equivalent to concentration levels one hour after burning incense. PM2.5 concentrations increased considerably 10 minutes (P<0.01), 20 minutes (P<0.05), and 30 minutes (P<0.01) after burning incense, but concentrations returned to baseline 1 hour, 3 hours, and 5 hours afterward. PM10 levels were comparable to PM2.5 levels, with concentrations increasing considerably at 10 minutes (<0.01), 20 minutes (P<0.05), and 30 minutes (P<0.01) after burning incense and returning to the initial level 1 hour, three h, and five h later.	Burning incense for a short time does not result in or does not affect lung function. However, the exposure that takes place every day can result in the severity of symptoms and respiratory diseases in people with COPD, as seen $_{in\ PM2.5}$ and $_{PM10}$ values.	3.c.
Chen YC et al[30]	5.010	N/A	N/A	Investigate associations between lung function in adolescents aged 14-16 years who are exposed to incense smoke indoors and outdoors in adolescents participating in mass asthma screening programs	Cohort	The findings of personal attribute exams and environmental exposure in the samples revealed that boys had higher average FVC and FEV scores than girls (3.70±0.58 L vs. 2.77±0.40 L) and that 71% of students were exposed to incense-burning smoke at home for religious worship. Lung function assessments associated with incense burning and household exposure resulted in an average FVC score of 0.07 L lower for males and 0.05 L lower for females. Using incense daily (both p<0.05). Z-scores for FVC and FEV1 were substantially lower in students with daily exposure to incense burning, compared to those who stayed at home without burning incense (β=−.107 (SE=.033) during z-scores of FVC −.144 (SE=.041) for z-scores of FEV1, p<.05).	Daily exposure to outdoor and indoor incense smoke is a risk factor associated with impaired lung function. More than 70% of study participants experienced a decrease in FVC and FEV1, indicators of decreased lung function and capacity that will cause respiratory diseases.	3.c.

Ref.	n	Sample (n)		Methods	Design study	Result	Conclusion	Levels of Evidence
		C	I					
Yamamoto N et al[7]	35	5	30	Six-week-old female mice were exposed to incense smoke to explore the association between incense smoke exposure and impaired lung function and asthma. There are three treatment groups, namely (1) rats not exposed to incense smoke (IS); (2) rats exposed to high doses of IS; and (3) Mice exposed to low doses of IS. High doses of incense burned 3.2 g, and low doses of 1.6 g burned for 60 minutes. Exposure is carried out in stages by giving smoke exposure to is-filled exposure rooms and fresh air at 4 L / minute.	Experimental	The effect of a single exposure to IS on airway function obtained exposure to IS increases AHR, which is reflected by the value of PC200 and depends on the dose of acetylcholine. The number of macrophages, lymphocytes, and BALF increased significantly in MICE exposed to IS compared to unexposed mice. Flow cytometric analysis of lung-derived cells revealed that exposure enhanced low Ly-6G/Ly-6C populations of highly inflammatory macrophages, whereas non-exposed cells were below the detection threshold. The mRNA levels of claudin-1, -2, -10b, and -12 were significantly reduced by exposure to IS 6 hours after exposure; claudin-3, -7, -18, E-cadherin, and ZO-1 at 9 hours post-exposure; and claudin-15 and occludin at 24 hours post-exposure, as determined by qRT-PCR analysis of exposed mouse lung tissue.	The incense smoke I inhaled led to impaired lung function and asthma. Exposure to incense smoke causes hyperresponsiveness (AHR), impaired bronchial epithelial barrier function in the lungs, increased recruitment of inflammatory macrophages, protein abnormalities associated with tight apical junctions (TJs) in the lungs, and epithelial barrier degradation.	1.c.

Table 2: Lung capacity measurements are associated with respiratory disease caused by incense smoke inhalation

Ref.	Study period (month)	Gender (n)		Respiratory symptoms/diseases						Home use of incense		Measurement of Lung Function			
		Male	Female	BTH	WZ	CPD	ASM	RH	PNU	outdoor	indoor	FEV1 (%)	FVC (L/s)	PEFR (L/s)	FEF 25-75%
Al Khathlan N et al[28]	3	65	60	+	+	+	+	+	+	Yes	Yes	3.85	4.72	5.88	N/A
Zhang Z et al[36]	24	2.063	1.978	+	+	N/A	+	+	+	Yes	Yes	10.2	7.7	39.9	28.6
Shaikh R et al[35]	4	38	22	+	+	N/A	+	N/A	+	Yes	Yes	2.53	3.15	8.23	3.61
Guo SE et al[37]	6	16	2	-	+	+	+	-	+	Yes	Yes	N/A	N/A	N/A	N/A
Chen YC et al[30]	12	2.485	2.525	+	+	-	+	+	+	Yes	Yes	3.05	3.26	N/A	N/A
Yamamoto N et al[7]	6	0	35	+	+	-	+	+	+	No	Yes	N/A	N/A	N/A	N/A

Abbreviation: N/A = Not applicable; + = positive; - = negative; BTH = Breathlessness; WZ = Wheezing; CPD = Chronic Obstructive Pulmonary Disease; ASM = Asthma; RH = Rhinitis; PNU = Pneumonia.

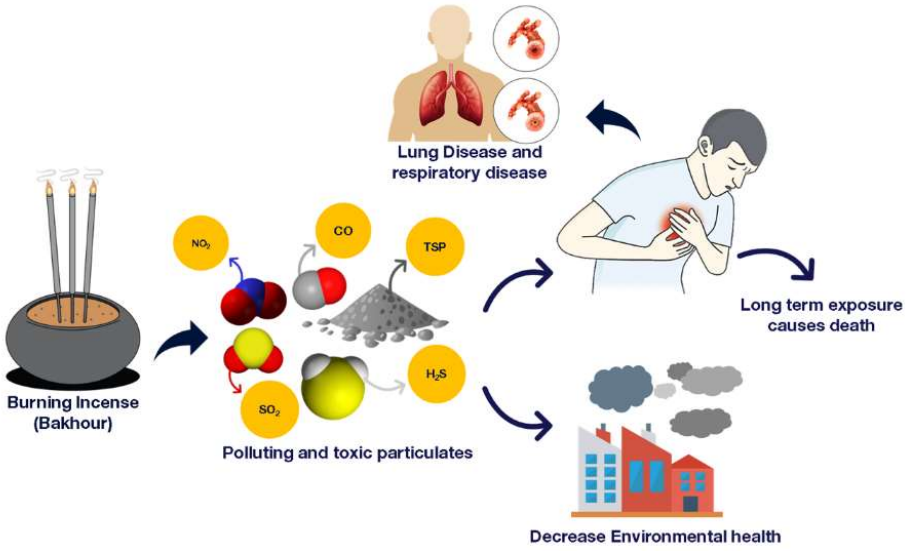

Figure 2: A brief mechanism of exposure to incense smoke decreases lung function

The reported results of all articles that met the established criteria did not measure the results of the study statistically but rather in the form of descriptive studies, which resulted in this study being able to only summarize, collect, and rearrange the reported empirical evidence following the purpose of the study and not proceed to meta-analysis. We presented the results of evidence-based synthesis in a comprehensive and articulated manner in the narrative and summary of the table.

RESULTS

Search results: The literature search in this work returned six original articles that meet the inclusion and exclusion criteria (Table 1). The articles were published between 2016 and 2021. Five articles were on human subjects, whereas one used mouse. The process of finding articles, filtering, eligibility, and inclusion following PRISMA diagrams and PICOS framework can be observed in Figure 1.

Study summary: This study included six reports of research findings on the association between exposure to incense smoke and impaired lung function and respiratory diseases. Incense smoke is known to have a terrible impact on human health, mainly resulting in chronic diseases whose symptoms have been known and felt for a long time. This review obtained studies that used human objects as much as 5 (83.33%) and only used the test animal model 1 (16.67%). The length of time of the study varied from 3, 4, 6, 12, and 24 months. Studies to determine the effects of exposure were dominated by cohort studies 3 (50%), cross-sectional studies 2 (33.33%), and experimental studies 1 (16.67%).

Furthermore, the use of incense in the community serves various needs such as a means of worship, a medium of meditation, and traditional medicine based on USADA and *Ayurveda* in the form of aromatherapy and room fragrance.[2,4,28] People who use incense in the house reach 100% (6), while the use of incense outside the house is only 5 (83.33%). The high use of incense in the house indicates the ease of polluting particulates carried by air and contained in incense smoke into the human body and causing damage to the respiratory tract, including the lungs. The accumulation of air in the house can reduce lung capacity resulting in respiratory disorders and diseases.

The danger caused by exposure to incense smoke in the room indicates pollutants trapped in the house and will stick to objects in the room.[29,30] Furthermore, the person or individual in the room will inhale the existing constituents, resulting in respiratory disorders and diseases.[17,31] Moreover, a puff of smoke in space can alter the temperature, relative humidity, and air exchange rate. It will accelerate the rate at which carcinogenic chemicals from incense smoke enter the human body.[10,32] Quickly smoke from burning incense into the body through the respiratory tract will produce various symptoms and diseases in the respiratory system. In this study, it was reported that people experienced symptoms of respiratory disorders such as reported shortness of breath, experiencing wheezing, asthma, and inflammation of the lungs, the presence of COPD and had chronic rhinitis. These results show a risk of being affected by incense smoke to impaired lung function and respiratory diseases both indoors and outdoors.[16,33,34] This study reported that smoke from burning incense harms respiratory tract health, mainly resulting in impaired lung function.[28,35] Table 2 displays a decline in lung function based on FVC, FEV, PEFR, and FEF 25-75%. In addition, incense smoke particles with a tiny size of <1 μm decrease the value of FEV1 and FVC in lung function. This can cause clogged airways and increase inflammation in the bronchi and alveoli due to the lung's capacity to receive oxygen, presented in table 2.

Discussion

The lungs become a very vital organ for human life. Exposure to pollutants with high intensity can cause disruption, damage, and failure of respiratory system function [17]. Incense smoke has small particles and ash that can harm human health and significantly change lung organs' shape and function.[28,30] Several studies indicate that incense smoke can irritate the airway, increase inflammation in the lung organs, decrease oxygen intake into the lungs as a result of alveolar thickening and necrosis in the bronchi, and trigger cytokine and chemokine expression in the epithelium of the airway, resulting in a decrease in lung function and respiratory diseases [18]. Research conducted by Zhang et al.[36] involving 4,041 children in 27 elementary schools exposed to incense smoke continuously showed that exposure to incense smoke adversely affected lung function by reducing work power and improving symptoms of respiratory diseases. Incense burning smoke is 1.39 times higher risk of causing bronchitis in boys (OR = 1.39). Exposure to smoke is the risk of causing bronchiolitis 1.72 higher in girls (OR = 1.72) and wheezing, and asthma is 1.49 higher in all treatment groups (OR = 1.49). This indicates that exposure to incense smoke is toxic to the lung organs, especially the bronchi and alveoli, and decreases pulmonary function, triggering the disease. Studies on the high risk of disease in one gender are not explained openly and explicitly. However, the odds ratio (OR) value indicates that exposure to incense smoke is associated with lower lung function.

The use of incense in the house is a greater risk of smoke being inhaled into the body through the respiratory tract. Tran et al.[32] revealed that exposure to incense smoke increases particulate matter concentrations 2.5 ($PM_{2.5}$) indoors by 120% more than those who do not use it. The frequency of using incense with high intensity (daily) is at risk of 61.6% higher than using incense sometimes. In addition, daily use of incense had an 18.5% higher risk of increased particulate matter concentrations. This happens because incense smoke particles are microscopic and easily in and out of the respiratory tract; houses that have poor ventilation can accelerate inflammatory processes in the lung organs and decrease pulmonary function and cause respiratory diseases.[33,37,38] Another study revealed that people who grow incensed 2-4 times daily indoors result in incense smoke containing carbon monoxide concentration in the lungs, subsequently interacting with inflammatory cells and exacerbating chronic respiratory conditions that cause asthma, COPD, rhinitis, and pneumonia.[12]

Decreased lung function and increased respiratory diseases are closely related to the content of pollutants contained in incense smoke.[9] Burned incense releases toxic compounds that cannot directly degrade the environment.[9,11] Burning incense for various purposes produces exhaust gases from imperfect combustion. Carbon monoxide content has been reported to cause poisoning from long-term use of incense that can damage the alveoli organs and reduce lung function and capacity.[12] Symptoms of CO gas poisoning in incense smoke are shortness of breath, vomiting, and headaches.[38] Furthermore, particulate matter ($PM_{1, 2.5, 10}$) in incense smoke can worsen respiratory diseases, damage tissues, and be concentrated in the lungs resulting in necrosis and impaired lung function.[14] The condensed concentration of sulfur dioxide and nitrogen dioxide in the lungs induces inflammation, the release of the bronchi, and modifications to the pulmonary system's defenses, resulting in a significant risk of necrosis, hyperresponsiveness (AHR), and impaired bronchial epithelial barrier function. In addition, VOCs and PAHs found in incense smoke have been associated with asthma exacerbations, irritation of the barrier epithelium, rhinitis, decreased oxygen absorption capacity to the lungs, and alveolar obstruction.[13,39,40] Exposure to incense smoke induces respiratory diseases including wheezing, asthma, COPD, shortness of breath, chest tightness, lung inflammation, and rhinitis.[16,18,37] Figure 2 briefly explains incense smoke can hurt lung function and cause respiratory diseases.

Although reports of exposure to incense smoke can significantly reduce lung function and the capacity to receive oxygen delivered throughout the body, the presence of confounding variables or other components may support or lead to a similar prognosis. Several studies also reported that the environment is less clean, there are high levels of pollution, and the habits of individuals in areas with daily exposure to dirty air can increase the risk of decreased lung function and possibly cause respiratory diseases.[41–45] The symptoms caused may be the same, making the effects of incense smoke exposure on lung function not directly and tangibly visible. In addition, the smoke and ash content from burning incense is known to contain sulfate particles, which will indirectly be able to increase emissions and exhaust gases into the environment and have implications for decreasing the respiratory function of each individual.[46]

The identified limitation of this study is that the measurement of effects that are not described in all studies in detail and comprehensively results in results that cannot be obtained but can only be obtained in the form of evidence-based study summaries from previous studies. However, it cannot be used to formulate definitive conclusions. In the future, similar studies that identify the effects of incense smoke exposure are expected to be able to report the amount of risk, or odds ratio (OR), or prevalence ratio (PR), which can then be used for policymakers to strive for incense smoke exposure in the community to be minimized even though it is used for daily activities.

Conclusion

Six articles published between 2016 and 2021 discuss the impact of incense smoke inhalation, which is linked to impaired lung function and respiratory diseases. There is a high risk of respiratory disease and

capacity associated with the short- and long-term usage of incense at home and everywhere else. Incense burning does not significantly affect lung function. Epidemiological studies reveal that Nitrogen dioxide, Carbon monoxide, Sulfur dioxide, Hydrogen Sulfide, Particulate Matter, Ozone, Total Suspended Particulate, VOCs, and PAHs are the main constituents responsible for the decreased function, capacity, and structure of the lungs associated with a decrease of FVC, FEV, PEFR, and FEF values of 25-75%. Exposure to incense smoke causes various respiratory diseases: wheezing, asthma, COPD, shortness of breath, chest tightness, lung inflammation, and rhinitis. In the future, an in-depth study is needed regarding exposure and the impact caused by the habit of burning incense on changes in the lungs' capacity, function, and ability to minimize the occurrence of respiratory diseases.

Acknowledgement

The author should thank Prodia Educational and Research Institute (PERI Scholarship) for funding his master's degree at Universitas Airlangga.

References

1. Goel A, Wathore R, Chakraborty T, Agrawal M. Characteristics of exposure to particles due to incense burning inside temples in Kanpur, India. Aerosol Air Qual Res. 2017 Feb 1;17(2):608–15.
2. Sudaryati NLG, Adnyana IMDM, Suarda IW. Effectiveness of Galuhayu Incense Kluwih Flower (Artocarpus camansi), Pandan Wangi (Pandanus amaryllifolius), Wood Powder as an Insecticide to Minimize Aedes aegypti Mosquito. In: 4th International Conference of Interreligious and Intercultural Studies (ICIIS) Community. Denpasar: UNHI Press; 2020. p. 90–9.
3. Tsou MCM, Lung SCC, Shen YS, Liu CH, Hsieh YH, Chen N, et al. A community-based study on associations between PM2.5 and PM1 exposure and heart rate variability using wearable low-cost sensing devices. Environmental Pollution. 2021;277:116761.
4. Qin Z, Song Y, Jin Y. Green worship: The effects of devotional and behavioral factors on adopting electronic incense products in religious practices. Int J Environ Res Public Health. 2019;16:3618.
5. Lin TC, Krishnaswamy G, Chi DS. Incense smoke: clinical, structural and molecular effects on airway disease. Clinical and Molecular Allergy. 2008 Dec 25;6(1):3.
6. Mertha Adnyana IMD, Sudiartawan IP, Sudaryati NLG. Toxicity of Tangiayu Incense Smoke as an Insecticide Against Aedes aegypti Mosquito Mortality. Media Ilmu Kesehatan. 2022;10(3):280–9.
7. Yamamoto N, Kan-o K, Tatsuta M, Ishii Y, Ogawa T, Shinozaki S, et al. Incense smoke-induced oxidative stress disrupts tight junctions and bronchial epithelial barrier integrity and induces airway hyperresponsiveness in mouse lungs. Nature. 2021;11:7222.
8. Mertha Adnyana IMD, Sudaryati NLG, Sitepu I. Toxicity of Legiayu incense as Insecticide and Larvicide against Aedes aegypti Mosquitoes Mortality. Indonesian Journal of Pharmacy. 2021;32(4):514–21.
9. Vardoulakis S, Giagloglou E, Steinle S, Davis A, Sleeuwenhoek A, Galea KS, et al. Indoor exposure to selected air pollutants in the home environment: A systematic review. Int J Environ Res Public Health. 2020;17:8972.
10. Manoukian A, Buiron D, Temime-Roussel B, Wortham H, Quivet E. Measurements of VOC/SVOC emission factors from burning incenses in an environmental test chamber: influence of temperature, relative humidity, and air exchange rate. Environmental Science and Pollution Research. 2016;23(7):6300–11.
11. Niu X, Jones T, BéruBé K, Chuang HC, Sun J, Ho KF. The oxidative capacity of indoor source combustion derived particulate matter and resulting respiratory toxicity. Science of the Total Environment. 2021;767:144391.
12. Alabdouli A, Alkaabi M, Alao D, Jiaganesh T. "Bakhoored" recurrent carbon monoxide poisoning from burning incense. J Emerg Med. 2020;58(5):848.
13. Lu F, Li S, Shen B, Zhang J, Liu L, Shen X, et al. The emission characteristic of VOCs and the toxicity of BTEX from different mosquito-repellent incenses. J Hazard Mater. 2020 Feb;384:121428.
14. Shrestha O. Incense stick: An overlooked source of health hazard. Journal of the Nepal Medical Association. 2020;58(230):823–5.
15. Mertha Adnyana IMD, Sumarya IM, Sudaryati NLG. Efficacy and Toxicity of Parasayu incense ash as a Larvicide for the Eradication of Aedes aegypti (Diptera: Culicidae) Mosquito Larvae. Journal of Research in Pharmacy. 2022;26(6):1805–13.
16. Wang J, Zhang Y, Li B, Zhao Z, Huang C, Zhang X, et al. Asthma and allergic rhinitis among young parents in China in relation to outdoor air pollution, climate and home environment. Science of the Total Environment. 2021;751(2):141734.
17. Cai WH, Wong PPY. Associations between incense-burning temples and respiratory mortality in Hong Kong. Atmosphere (Basel). 2021;12:774.
18. Lee CWW, Vo TTT, Wee Y, Chiang YCC, Chi MCC, Chen MLL, et al. The adverse impact of incense smoke on human health: From mechanisms to implications. J Inflamm Res. 2021;14:5451–72.
19. Navasumrit P, Arayasiri M, Hiang OMT, Leechawengwongs M, Promvijit J, Choonvisase S, et al. Potential health effects of exposure to carcinogenic compounds in incense smoke in temple workers. Chem Biol Interact. 2008;
20. Norbäck D, Lu C, Zhang Y, Li B, Zhao Z, Huang C, et al. Sources of indoor particulate matter (PM) and outdoor air pollution in China in relation to asthma, wheeze, rhinitis and eczema among pre-school children: Synergistic effects between antibiotics use and PM10 and second hand smoke. Environ Int. 2019;125(October 2018):252–60.
21. Tung JC, Huang WC, Yang JC, Chen GY, Fan CC, Chien YC, et al. Auramine O, an incense smoke ingredient, promotes lung cancer malignancy. Environ Toxicol [Internet]. 2017;32(11):2379–91. Available from: http://www.rcsb.org/pdb/
22. Dalibalta S, Elsayed Y, Alqtaishat F, Gomes I, Fernandes N. A health risk assessment of Arabian incense (Bakhour) smoke in the United Arab Emirates. Science of the Total Environment. 2015 Apr 1;511:684–91.
23. Tu CY, Wang BW, Cheng FJ, Chen CH, Hsia TC, Wei YL, et al. Incense burning smoke sensitizes lung cancer cells to EGFR TKI by inducing AREG expression. Am J Cancer Res. 2018;8(12):2575–89.
24. Hussain T, Al-Attas OS, Alrokayan SA, Ahmed M, Al-Daghri NM, Al-Ameri S, et al. Deleterious effects of incense smoke exposure on kidney function and architecture in male albino rats. Inhal Toxicol. 2016;28(8):364–73.

25. Hussain T, Alamery S, Dikshit G, Mohammed AA, Naushad SM, Alrokayan S. Incense smoke exposure augments systemic oxidative stress, inflammation and endothelial dysfunction in male albino rats. Toxicol Mech Methods. 2019;29(3):211–8.
26. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Syst Rev. 2021 Mar 29;10(1):1–11.
27. Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ. 2020 Jan 16;368:l6890.
28. Al Khathlan N, Al-dabbus Z, Al-khdir N, Al-Matar M, Al-Nusaif S, Al Yami B. Incense (bakhour) smoke exposure is associated with respiratory symptoms and impaired lung function among adults: A cross-sectional study in Eastern Province of Saudi Arabia. Indoor Air. 2021;31(5):1577–82.
29. Višić B, Kranjc E, Pirker L, Bačnik U, Tavčar G, Škapin S, et al. Incense powder and particle emission characteristics during and after burning incense in an unventilated room setting. Air Qual Atmos Health. 2018 Jul 11;11(6):649–63.
30. Chen YC, Ho WC, Yu YH. Adolescent lung function associated with incense burning and other environmental exposures at home. Indoor Air. 2017;27(4):746–52.
31. Rana S. Incense Sticks: A Potential Source of Indoor Air Pollution. International Journal of Environmental Engineering and Management. 2018;9(1):1–6.
32. Tran LK, Morawska L, Quang TN, Jayaratne RE, Hue NT, Dat M V., et al. The impact of incense burning on indoor PM2.5 concentrations in residential houses in Hanoi, Vietnam. Build Environ. 2021;205:108228.
33. Elsayed Y, Dalibalta S, Gomes I, Fernandes N, Alqtaishat F. Chemical composition and potential health risks of raw Arabian incense (Bakhour) Chemical composition and potential health risks of Bakhour. Journal of Saudi Chemical Society. 2016;20(4):465–73.
34. Soto-martínez ME. The impact of the enviroment on respiratory outcome. Pediatr Pulmonol. 2017;52(S46):S32–93.
35. Shaikh R, Bhalekar G. Effect of incense burning exposure on pulmonary functions in temple pandits. International Journal of Scientific and Engineering. 2021;12(3):831–40.
36. Zhang Z, Tan L, Huss A, Guo C, Brook JR, Tse L ah, et al. Household incense burning and children's respiratory health: A cohort study in Hong Kong. Pediatr Pulmonol. 2019;54(4):399–404.
37. Guo SE, Chi MC, Lin CM, Yang TM. 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):1–17.
38. Jilla A, Kura B. Particulate Matter and Carbon Monoxide Emission Factors from Incense Burning. Environment Pollution and Climate Change. 2017;1(4):1–7.
39. Bu-Olayan AH, Thomas B V. Exposition of respiratory ailments from trace metals concentrations in incenses. Nature. 2021;11(1):1–10.
40. Eljatin DS, Eljatin MRA, Adnyana IMDM, Hutagalung MBZ, Setyawan MF. Excessive Use of Nipah Leaf Membrane Cigarettes Increases the Severity of Spontaneous Pneumothorax: A Case study from Jambi, Indonesia. Journal of Pharmaceutical and Health Research. 2023;4(1):9–13.
41. Hien TT, Ngo TH, Lung SCC, Ngan TA, Minh TH, Cong-Thanh T, et al. Characterization of Particulate Matter (PM1 and PM2.5) from Incense Burning Activities in Temples in Vietnam and Taiwan. Aerosol Air Qual Res. 2022;22(11):220193.
42. Tran LK, Morawska L, Quang TN, Jayaratne RE, Hue NT, Dat M V., et al. The impact of incense burning on indoor PM2.5 concentrations in residential houses in Hanoi, Vietnam. Build Environ. 2021 Nov;205:108228.
43. Bootdee S, Chantara S, Prapamontol T. Indoor PM 2.5 and its Polycyclic Aromatic Hydrocarbons in Relation with Incense Burning. IOP Conf Ser Earth Environ Sci. 2018 Mar;120:012007.
44. Wei S, Semple S. Exposure to fine particulate matter (PM2.5) from non-tobacco sources in homes within high-income countries: a systematic review. Air Qual Atmos Health. 2023 Mar 28;16(3):553–66.
45. P L, L T. Residential incense smoke exposure and obesity among Hong Kong Chinese Elderly. Environmental Epidemiology. 2019 Oct;3:230.
46. Liang Z, Zhou L, Infante Cuevas RA, Li X, Cheng C, Li M, et al. Sulfate Formation in Incense Burning Particles: A Single-Particle Mass Spectrometric Study. Environ Sci Technol Lett. 2022 Sep 13;9(9):718–25.