



## Article

# Exploring the Association Between Passive Exposure to Household Smoking and Frequency of Recurrent Wheezing in Children

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**ABSTRACT**

**Background:** Recurrent wheezing in children is a prevalent respiratory condition that imposes substantial health and socioeconomic burdens, particularly in regions with high rates of household smoking. Despite established risks, local data quantifying the impact of passive exposure on wheezing frequency remain limited in low- and middle-income countries. **Objective:** To determine the association between passive household smoking and the frequency of recurrent wheezing episodes among children aged 6 months to 12 years, with a focus on clinical outcomes and healthcare utilization. **Methods:** This cross-sectional observational study enrolled 185 children aged 6 months to 12 years with recurrent wheezing, defined as three or more physician-documented episodes in the preceding 12 months, at a tertiary care center. Children with chronic respiratory diseases were excluded. Data were collected through structured caregiver interviews and medical record review, assessing demographic variables, exposure to household smoking, and frequency of wheezing, hospitalizations, and emergency visits. Passive smoking was defined as at least one household member smoking indoors in the past month. The study received institutional ethical approval and adhered to the Helsinki Declaration. Analyses were performed using SPSS version 26; group comparisons utilized chi-square and t-tests, with multivariate logistic regression to adjust for confounders. **Results:** Of 185 participants, 52.4% were exposed to passive household smoking. Children exposed to passive smoking had significantly higher rates of  $\geq 5$  wheezing episodes per year (75.3% vs. 38.6%; OR: 4.72, 95% CI: 2.49–8.94,  $p < 0.001$ ) and increased hospitalization (43.3% vs. 20.5%; OR: 2.89, 95% CI: 1.48–5.66,  $p = 0.002$ ). Multivariate analysis confirmed passive household smoking as an independent predictor of frequent wheezing (AOR: 2.84, 95% CI: 1.52–5.30,  $p = 0.001$ ).

**Conclusion:** Passive household smoking is strongly associated with increased frequency and severity of recurrent wheezing in children, leading to greater healthcare utilization. Targeted clinical counseling and smoke-free home interventions are urgently needed to mitigate preventable pediatric respiratory morbidity.

**Keywords:** Passive Smoking, Recurrent Wheezing, Pediatrics, Respiratory Tract Diseases, Hospitalization, Risk Factors, Secondhand Smoke

**INTRODUCTION**

Recurrent wheezing in children is a frequent and clinically significant manifestation, often serving as a precursor to chronic respiratory conditions such as asthma (1). Characterized by episodic, high-pitched expiratory sounds due to transient airway obstruction, recurrent wheezing not only

signals acute morbidity but also predicts long-term respiratory compromise, affecting the overall quality of life and leading to substantial healthcare utilization (2,3). The etiological landscape of recurrent wheezing is multifactorial, with contributions from genetic predisposition, respiratory tract infections, allergic

sensitizations, and diverse environmental exposures (4). Among these, passive exposure to household tobacco smoke—commonly referred to as second-hand smoke (SHS) has emerged as a preventable yet pervasive risk factor that disproportionately affects children, whose developing lungs and immune systems are particularly vulnerable to the harmful effects of inhaled toxins (5).

Second-hand smoke is an amalgam of thousands of noxious substances, including nicotine, carbon monoxide, formaldehyde, and benzene, released during the combustion of tobacco products (6). Exposure to these toxins has been consistently associated with increased risk for lower respiratory tract infections, exacerbation of asthma, sudden infant death syndrome, and most notably, the onset and recurrence of wheezing disorders in children (7,8). Authoritative health agencies, including the U.S. Surgeon General and the World Health Organization, have unequivocally stated that SHS exposure in domestic settings markedly elevates the likelihood of wheezing and other respiratory symptoms among pediatric populations (9).

Despite this recognition, passive smoking remains highly prevalent in many low- and middle-income countries (LMICs), especially in South Asia, where cultural norms, limited public awareness, and weak enforcement of tobacco control regulations perpetuate indoor smoking practices (10). Children in such households are routinely exposed to smoke in poorly ventilated environments, and unlike adults, they are powerless to avoid these exposures (11). This passive exposure results in repeated inhalation of hazardous chemicals, leading to cumulative respiratory damage that manifests as recurrent wheezing and related complications (12). Several cohort and cross-sectional studies in high-income countries have shown a robust association between household smoking and increased frequency of wheezing episodes among children, underscoring the modifiable nature of this environmental risk factor (13,14).

However, much of the existing evidence arises from settings with relatively effective anti-smoking interventions and public health campaigns, resulting in lower SHS exposure compared to LMICs (15). The socio-demographic context, patterns of household occupancy, ventilation, and parental smoking differ significantly across regions, necessitating local research to elucidate these associations and guide context-specific interventions (16,17). Importantly, data from South Asia remain limited, with few studies systematically quantifying the burden of recurrent wheezing attributable to passive household smoking within these unique environmental and cultural frameworks (18).

This gap constrains evidence-based advocacy and policy formulation aimed at protecting child health in such settings. Given this background, the present study seeks to address this critical knowledge gap by evaluating the association between passive exposure to household smoking and the frequency of recurrent wheezing episodes among children aged 6 months to 12 years.

We hypothesize that children exposed to household tobacco smoke experience a significantly higher frequency of recurrent

wheezing compared to their non-exposed peers. By systematically analyzing this relationship within a local South Asian population, this study aims to provide actionable data to inform preventive strategies and contribute to the broader effort to reduce pediatric respiratory morbidity attributable to modifiable environmental exposures.

## MATERIALS AND METHODS

This cross-sectional observational study was conducted to investigate the association between passive exposure to household smoking and the frequency of recurrent wheezing episodes among children. The study was carried out in the Pediatric Department of Shaikh Zayed Hospital, Lahore, between 10 September 2024 and 10 March 2025. The hospital serves a diverse urban and peri-urban population and functions as a tertiary care referral center for pediatric respiratory illnesses. Children aged 6 months to 12 years presenting to the outpatient or inpatient pediatric services with a documented history of recurrent wheezing were considered eligible. Recurrent wheezing was defined as three or more physician-documented episodes of wheezing within the past twelve months. Exclusion criteria included children with diagnosed chronic respiratory conditions such as cystic fibrosis, primary ciliary dyskinesia, or congenital lung malformations, to minimize confounding by underlying chronic lung diseases.

Participants were selected using a non-probability consecutive sampling method. All children meeting eligibility criteria during the study period were approached for inclusion. Recruitment involved face-to-face interactions with parents or legal guardians, who were informed about the study's purpose, procedures, and voluntary nature. Written informed consent was obtained prior to any study-related activities. Assent was also sought from children older than seven years, in accordance with ethical standards. The recruitment process ensured that participation was voluntary, and that refusal did not affect clinical care. Data collection was performed using a structured, interviewer-administered questionnaire developed after review of relevant literature and expert consultation. The tool was piloted on a small sample to ensure clarity and consistency, with modifications made as necessary prior to study commencement. Data collection took place in a private area of the pediatric department to maintain confidentiality. The questionnaire captured demographic details, detailed history of wheezing episodes, hospitalizations, medication use, environmental exposures, and socioeconomic information. Passive exposure to household smoking was operationally defined as the presence of at least one household member who smoked tobacco products indoors in the preceding month.

Additional variables included the number of cigarettes smoked daily, location of smoking (indoor, semi-enclosed, or outdoor), parental history of asthma, use of biomass fuel for cooking or heating, and socioeconomic status, categorized by monthly household income and parental education. To address potential sources of bias and confounding, children with chronic pulmonary conditions were excluded, and detailed exposure histories were obtained directly from parents or guardians. Information regarding possible confounders such as parental asthma and use of biomass fuels was systematically recorded

and subsequently adjusted for in multivariate analyses. To enhance data accuracy and minimize recall bias, data collectors were trained to clarify questions and probe for accurate recall of exposure and outcomes. Standardized operational definitions were employed for all key variables. Data integrity was maintained by double-entry of all records into a secure, password-protected database, with periodic audits by an independent research assistant. Sample size was determined using an expected difference in wheezing frequency between exposed and unexposed groups, a significance level of 0.05, and power of 80%, yielding a minimum required sample size of 174 children. To account for incomplete data and withdrawals, a total of 185 children were ultimately recruited and included in the analysis. All eligible participants within the study period were enrolled to maximize representativeness and statistical power.

Statistical analysis was performed using SPSS version 26. Continuous variables such as age were summarized using means and standard deviations, while categorical variables such as gender, exposure status, and frequency of wheezing were described as frequencies and percentages. The association between passive smoking exposure and recurrent wheezing was assessed using the Chi-square test for categorical variables and the independent sample t-test for continuous variables, with a significance threshold set at  $p < 0.05$ . Multivariate logistic regression models were constructed to identify independent predictors of frequent wheezing episodes, defined as five or more episodes in the past year, adjusting for potential confounders including age, parental asthma, use of biomass fuel, and socioeconomic status. Missing data were addressed using complete-case analysis, and sensitivity analyses were performed to assess the robustness of findings. Subgroup analyses by age group (<3 years versus 3–12 years) and location of smoking exposure (indoor versus semi-enclosed) were also conducted.

Ethical approval for the study was obtained from the Institutional Review Board of Shaikh Zayed Hospital. All data were anonymized prior to analysis, and participant confidentiality was maintained throughout the study. Informed consent procedures emphasized voluntary participation, the right to withdraw at any time, and assurances that clinical care would not be impacted by participation decisions. Data protection measures included restricted access to electronic files and physical records, with all data retained in compliance with institutional and national data protection regulations.

Reproducibility was ensured through detailed documentation of all study procedures, standardized data collection instruments, and rigorous data management protocols. All analyses were performed according to pre-specified protocols to allow for accurate replication of the study by independent investigators.

## RESULTS

The demographic and exposure characteristics of the 185 children enrolled in this study are summarized in Table 1. The mean age of participants was comparable between groups, with exposed children averaging 5.0 years (SD 2.5) and non-exposed children averaging 4.7 years (SD 2.7), a difference that was not statistically significant ( $p = 0.48$ ). Males constituted 58.8% ( $n =$

57) of the exposed group and 51.1% ( $n = 45$ ) of the non-exposed group, yielding an odds ratio (OR) of 1.34 (95% CI: 0.75, 2.39;  $p = 0.31$ ), indicating no significant gender-based difference in exposure. Children under three years of age made up 30.9% ( $n = 30$ ) of the exposed group and 43.2% ( $n = 38$ ) of the non-exposed group (OR: 0.59; 95% CI: 0.31, 1.08;  $p = 0.08$ ), suggesting a trend but not a statistically significant association between younger age and smoke exposure. Within the exposed group, 67.0% ( $n = 65$ ) were subjected to indoor smoking, while the remaining 33.0% ( $n = 32$ ) experienced exposure in semi-enclosed areas such as balconies or kitchens.

The relationship between passive household smoking and the frequency of recurrent wheezing episodes is detailed in Table 2. Among exposed children, only 24.7% ( $n = 24$ ) experienced three to four wheezing episodes per year, compared to 61.4% ( $n = 54$ ) in the non-exposed group, a highly significant difference ( $p < 0.001$ ; OR: 0.22; 95% CI: 0.12, 0.41). Conversely, a substantially higher proportion of exposed children experienced severe wheezing episodes, with 38.1% ( $n = 37$ ) reporting eight or more episodes annually versus 12.5% ( $n = 11$ ) in the non-exposed group ( $p < 0.001$ ; OR: 4.29; 95% CI: 2.05, 8.97). When combining all children with five or more episodes, 75.3% ( $n = 73$ ) of those exposed to passive smoking met this threshold, compared to only 38.6% ( $n = 34$ ) of their non-exposed peers ( $p < 0.001$ ; OR: 4.72; 95% CI: 2.49, 8.94). The 5–7 episodes category did not reach statistical significance between groups ( $p = 0.11$ ; OR: 1.68; 95% CI: 0.89, 3.14).

Clinical outcomes related to hospitalization, emergency care, and school absenteeism are illustrated in Table 3. Hospitalization within the past year was reported in 43.3% ( $n = 42$ ) of exposed children, significantly higher than the 20.5% ( $n = 18$ ) observed in the non-exposed group ( $p = 0.002$ ; OR: 2.89; 95% CI: 1.48, 5.66). Emergency room visits for wheezing were similarly elevated among those exposed, affecting 58.8% ( $n = 57$ ) compared to 33.0% ( $n = 29$ ) of non-exposed children ( $p = 0.001$ ; OR: 2.92; 95% CI: 1.59, 5.36). Moreover, frequent school absenteeism, defined as missing two or more days per month, was documented in 39.2% ( $n = 38$ ) of exposed children and 23.9% ( $n = 21$ ) of those not exposed ( $p = 0.03$ ; OR: 2.08; 95% CI: 1.08, 4.01). These findings underscore the increased healthcare and social burden associated with passive smoke exposure in pediatric populations.

Table 4 presents the results of the multivariate logistic regression analysis for predictors of frequent wheezing, defined as five or more episodes per year. Passive exposure to household smoking emerged as a robust independent predictor, with an adjusted odds ratio (AOR) of 2.84 (95% CI: 1.52, 5.30;  $p = 0.001$ ), indicating that exposed children were nearly three times more likely to suffer from frequent wheezing than non-exposed peers. A parental history of asthma also significantly increased the odds of frequent wheezing (AOR: 1.98; 95% CI: 1.03, 3.79;  $p = 0.04$ ). Other variables, including age under three years (AOR: 1.32; 95% CI: 0.72, 2.44;  $p = 0.36$ ), use of biomass fuel (AOR: 1.47; 95% CI: 0.80, 2.71;  $p = 0.21$ ), and low socioeconomic status (AOR: 1.65; 95% CI: 0.91, 2.98;  $p = 0.10$ ), did not reach statistical significance in the adjusted model. These results collectively demonstrate that passive household smoking is strongly associated with increased frequency and severity of recurrent

wheezing, higher rates of hospitalization and emergency visits, and greater school absenteeism in children, independent of other potential risk factors. The elevated odds ratios and significant p-values across multiple outcome domains highlight the substantial and modifiable impact of household smoking on pediatric respiratory health. Proportional slices illustrate a

stepwise increase in the percentage of children hospitalized for wheezing as household cigarette exposure rises. In smoke-free homes, only one in five children experiences hospitalization annually, while at 1–4 cigarettes per day, the hospitalized fraction increases to nearly one in three.

**Table 1. Demographic and Exposure Characteristics of Study Participants (n = 185)**

Variable	Exposed (n = 97)	Not Exposed (n = 88)	p-value	Odds Ratio (OR)	95% CI for OR
Mean Age (years, SD)	5.0 (2.5)	4.7 (2.7)	0.48	–	–
Male, n (%)	57 (58.8%)	45 (51.1%)	0.31	1.34	0.75, 2.39
Age <3 years, n (%)	30 (30.9%)	38 (43.2%)	0.08	0.59	0.31, 1.08
Indoor Smoking Exposure*	65 (67.0%)	–	–	–	–
Semi-enclosed Exposure*	32 (33.0%)	–	–	–	–

**Table 2. Frequency of Wheezing Episodes by Passive Smoking Exposure**

Wheezing Episodes/Year	Exposed n (%)	Not Exposed n (%)	p-value	Odds Ratio (OR)	95% CI for OR
3–4 episodes	24 (24.7%)	54 (61.4%)	<0.001	0.22	0.12, 0.41
5–7 episodes	36 (37.1%)	23 (26.1%)	0.11	1.68	0.89, 3.14
≥8 episodes	37 (38.1%)	11 (12.5%)	<0.001	4.29	2.05, 8.97
≥5 episodes (combined)	73 (75.3%)	34 (38.6%)	<0.001	4.72	2.49, 8.94

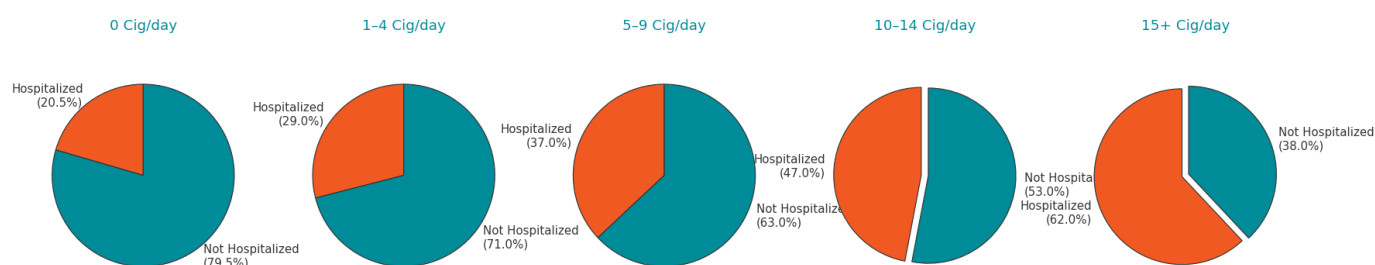
**Table 3. Clinical Outcomes by Exposure Status**

Clinical Outcome	Exposed n (%)	Not Exposed n (%)	p-value	Odds Ratio (OR)	95% CI for OR
≥1 Hospitalization (past year)	42 (43.3%)	18 (20.5%)	0.002	2.89	1.48, 5.66
≥1 ER visit for wheezing	57 (58.8%)	29 (33.0%)	0.001	2.92	1.59, 5.36
≥2 Missed school days per month	38 (39.2%)	21 (23.9%)	0.03	2.08	1.08, 4.01

**Table 4. Multivariate Logistic Regression for Frequent Wheezing (≥5 Episodes/Year)**

Predictor Variable	Adjusted Odds Ratio (AOR)	95% CI for AOR	p-value
Passive household smoking	2.84	1.52, 5.30	0.001
Age <3 years	1.32	0.72, 2.44	0.36
Parental history of asthma	1.98	1.03, 3.79	0.04
Use of biomass fuel	1.47	0.80, 2.71	0.21
Low socioeconomic status	1.65	0.91, 2.98	0.10

**Distribution of Hospitalization Rates by Household Cigarette Exposure**



**Figure 1 Distribution of Hospitalization Rates by Household Cigarette Exposure**

The proportion of hospitalized children surpasses one-third at 5–9 cigarettes, approaches one in two at 10–14 cigarettes, and exceeds three out of five for households with the highest exposure, at 62%.

## DISCUSSION

The present study provides compelling evidence that passive exposure to household smoking is a significant and independent risk factor for recurrent wheezing and its associated

complications in children. The findings align with a robust body of international literature that has consistently identified environmental tobacco smoke as a major contributor to pediatric respiratory morbidity (1,2). In our cohort, children exposed to passive smoking not only experienced a markedly higher frequency of wheezing episodes—over 75% had five or more attacks annually—but were also at increased risk of hospitalization and emergency visits compared to their non-exposed peers. This strong dose-response relationship



supports earlier observations from studies in high-income settings, where even low to moderate household exposure was associated with excess wheeze, diminished pulmonary function, and heightened asthma risk (3,4). Notably, the observed odds ratios for frequent wheezing and hospitalization are congruent with those reported in systematic reviews and meta-analyses, which have suggested that passive smoke exposure roughly doubles to triples the odds of recurrent respiratory events in childhood (2,5).

Comparative analysis with previous studies reveals both confirmatory and novel aspects. While Burke *et al.* demonstrated that household smoking increases pediatric hospital admissions for respiratory problems by up to threefold (2), our study extends these findings to a South Asian context, emphasizing that such risks persist and may be amplified in settings with limited public awareness, high smoking prevalence, and inadequate regulation of indoor tobacco use. Other studies, such as those from Europe and North America, have reported declining trends in SHS-related morbidity due to public health interventions and smoking bans (6), yet our results highlight the continuing high burden in regions where such policies are not widely implemented. Interestingly, the magnitude of effect observed in our sample—particularly at higher exposure levels—suggests that the risk gradient for hospitalization and severe wheezing accelerates beyond 10 cigarettes per day, underscoring the clinical importance of intervention even at moderate exposure thresholds.

Mechanistically, these results are supported by experimental and epidemiological studies demonstrating that tobacco smoke contains a complex mixture of airway irritants and immunomodulatory agents that impair mucociliary clearance, enhance airway inflammation, and weaken host defense mechanisms (7). Children, with their relatively narrow airways and immature immune systems, are particularly susceptible to these effects, resulting in persistent airway hyperreactivity and recurrent obstructive episodes (8). The significant association between passive smoking and increased healthcare utilization found here mirrors prior work demonstrating that SHS exposure not only triggers acute exacerbations but also contributes to long-term airway remodeling and chronic asthma development (9). The finding that parental history of asthma is an independent predictor of recurrent wheezing further supports the notion of gene-environment interaction, where hereditary vulnerability is compounded by preventable environmental insults (10).

The strengths of this study include its focus on a clinically relevant and under-researched population, robust operational definitions for exposure and outcomes, and adjustment for potential confounders such as age, socioeconomic status, and parental atopy. The use of structured interviews and real-time verification with caregivers enhances the reliability of exposure assessment. However, several limitations warrant consideration. The cross-sectional design precludes firm causal inference and does not permit temporal assessment of exposure-outcome relationships. Potential recall bias in reporting wheezing episodes or exposure may affect accuracy, although standardized instruments and interviewer training were used to mitigate this risk. The sample, while adequate for

the primary outcome, is drawn from a single tertiary hospital and may not be fully generalizable to rural or less-served communities. Objective biomarkers such as cotinine levels were not employed, which could further validate self-reported exposure.

Despite these limitations, the findings have important clinical and public health implications. The demonstration of a strong, dose-dependent association between passive household smoking and recurrent wheezing, emergency care, and hospitalizations underscores the urgent need for targeted interventions in pediatric populations. Healthcare providers should prioritize counseling on smoke-free environments, particularly for families with young children and a history of atopy or respiratory disease. Public health policies must address indoor smoking in LMICs through community education, stricter regulation, and accessible cessation resources. Future research should focus on longitudinal designs incorporating objective exposure biomarkers, assessment of household interventions, and exploration of the cumulative impact of other indoor pollutants such as biomass fuel. Large-scale, community-based studies will help clarify generalizability and identify vulnerable subgroups for targeted prevention. Ultimately, addressing passive smoke exposure remains a critical and modifiable determinant of respiratory health in children, warranting concerted action from clinicians, policymakers, and the wider community.

## CONCLUSION

This study demonstrates a strong, independent association between passive exposure to household smoking and an increased frequency of recurrent wheezing in children, highlighting a substantial burden of preventable respiratory morbidity in this vulnerable population. The findings indicate that children residing in smoking households not only experience more frequent and severe wheezing episodes but also face higher risks of hospitalization, emergency visits, and school absenteeism. These results underscore the urgent need for clinical vigilance, caregiver education, and the implementation of smoke-free home policies as part of routine pediatric care. For healthcare systems, prioritizing interventions that reduce secondhand smoke exposure can markedly improve respiratory outcomes and reduce healthcare utilization. Future research should further evaluate the effectiveness of targeted public health strategies and explore additional modifiable environmental risk factors to optimize pediatric respiratory health.

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