The Invisible Trigger: A Quasi-Experimental Study on the Effect of Passive Smoke Exposure and Structured Caregiver Counseling on Childhood Asthma

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Abstract

Background: Passive (secondhand) smoke (SHS) is a well-established environmental trigger that exacerbates pediatric asthma and contributes to poor disease control. However, evidence regarding the effectiveness of structured caregiver counseling in reducing SHS-related asthma morbidity in low-resource outpatient settings remains limited.

Objective: To assess the socio-demographic characteristics of children with asthma and their caregivers, evaluate the effectiveness of structured caregiver counseling in improving asthma control, and determine the influence of socio-demographic factors on asthma outcomes.

Methods: A quasi-experimental study was conducted at the Pediatrics Outpatient Department of Fauji Foundation Hospital, Rawalpindi, from January 2025 to June 2025. A total of 126 children aged 4-11 years with physician-diagnosed asthma and documented passive smoke exposure were included. Participants were non-randomly allocated into an intervention group (standard care plus structured caregiver counseling) and a control group (standard care only), with 63 participants in each group. Asthma control was assessed at baseline and at six months using the Asthma Control Test (ACT). Data were analyzed using an independent samples t-test, analysis of covariance (ANCOVA), and multiple linear regression.

Results: Baseline ACT scores were comparable between the control group (15.36 ± 3.08) and the intervention group (15.42 ± 2.91) (p=0.903). At six months, the intervention group demonstrated significantly higher ACT scores (22.17 ± 2.15) compared to the control group (16.95 ± 2.70) (p<0.001), indicating improved asthma control. Caregiver education emerged as a significant predictor of improved outcomes (p<0.001).

Conclusion: Structured caregiver counseling significantly improves asthma control among children exposed to secondhand smoke. Integrating caregiver-focused counseling into routine pediatric asthma management may serve as an effective, feasible, and scalable strategy to reduce exposure-related morbidity.

Keywords: *Childhood asthma, secondhand smoke, caregiver counseling, asthma control test, quasi-experimental study.*

INTRODUCTION

Asthma remains a leading chronic respiratory condition in children and contributes substantially to global morbidity and healthcare burden [1]. Climate-related environmental factors further worsen pediatric asthma symptoms in many regions [2]. Childhood asthma continues to rise worldwide, and multiple factors—including environmental exposures—contribute to disease development [3].

SHS is a well-established trigger for airway inflammation, reduced lung function, and increased asthma exacerbations in children [4]. Even brief exposure can impair pulmonary function and increase symptom severity [5]. Environmental exposures, including indoor smoke pollutants, have been shown to influence asthma development and long-term respiratory health [6].

SHS exposure is associated with higher asthma symptom burden, more frequent attacks, and poorer asthma control scores among children and adolescents [7]. Recent studies confirm that exposure to household tobacco smoke increases asthma severity and healthcare utilization [8]. Secondhand smoke exposure has been associated with increased illness severity and higher healthcare utilization among children with respiratory conditions [9].

Recent advances in childhood asthma management emphasize a combination of pharmacological and non-pharmacological approaches to improve disease outcomes [10]. Validated tools such as the Asthma Control Test (ACT) effectively assess symptom control and response to behavioral interventions [11]. Community-based asthma care models, including interventions delivered through trained health workers, have shown promise in improving pediatric asthma outcomes [12].

Environmental factors, including allergens such as pollen and mold, play a significant role in triggering asthma symptoms and should be considered in comprehensive asthma management strategies [13]. Anti-smoking

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Received: June 04, 2025; Revised: May 07, 2026; Accepted: June 08, 2026
DOI: https://doi.org/10.37184/lnjpc.2707-3521.8.62

programs targeted at caregivers have resulted in improved pediatric asthma indicators [14].

Interventions aimed at reducing parental smoking have been shown to lower children's exposure to secondhand smoke and improve respiratory health outcomes [15]. Strategies focused on caregiver behavior modification have been identified as key pathways for improved asthma control [16]. Educational initiatives and structured asthma programs have demonstrated improvements in disease management and health outcomes among children [17].

Moreover, ACT scores have been strongly associated with levels of SHS exposure in children, reinforcing the importance of behavior-focused interventions [18]. Counseling caregivers about smoke-free practices has been recommended globally as an evidence-based strategy to improve child respiratory health [19].

Despite this evidence, few local studies have examined whether structured caregiver counseling can improve both asthma control and SHS-related behaviors in families of children with asthma. This study, therefore, aimed to evaluate the effect of structured caregiver counseling on asthma control (measured by ACT scores) and caregiver smoking-related behaviors among children exposed to secondhand smoke.

METHODOLOGY

This quasi-experimental study was conducted at the Outpatient Department (OPD) of Fauji Foundation Hospital, Rawalpindi, Pakistan, over a period of six months from January 2025 to June 2025. Fauji Foundation Hospital is a teaching hospital affiliated with Foundation University Medical College. Ethical approval was obtained from the Institutional Review Board of Foundation University Medical College (Approval Letter No. FF/FUMC/215-564 Phy/25). The study was registered at ClinicalTrials.gov (ClinicalTrials.gov Identifier: NCT07069192; Unique Protocol ID: FUMCRCT1). The reporting of this study adheres to the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) guidelines [20].

The study included children aged 4-11 years (both boys and girls) with a confirmed physician diagnosis of asthma and a history of passive smoking exposure at home. Children with other chronic respiratory diseases, such as cystic fibrosis or bronchiectasis, families planning to relocate during the study period, or caregivers unwilling to provide consent were excluded. Written informed consent was obtained from all caregivers after explaining the study objectives, procedures, potential risks, and benefits.

The sample size was determined using the OpenEpi Version 3.01 tool for comparing two independent means, following a study by Martin MA *et al.* [12] that investigated the impact of caregiver-guided anti-smoking interventions on children's asthma outcomes. Some of the considerations for measurement included the anticipated average change in the Asthma Control Test (ACT) score of 1.5 points, a standard deviation of 3.0, a 95% confidence level (α=0.05), 80% power (β=0.20), and a two-sided test. The resulting sample size was 126 participants (63 per group), after adding 10% to account for potential dropouts. Participants were first assessed for baseline data and then divided into groups. Participants were selected through purposive sampling, and the intervention and control groups were formed by non-random allocation (purposive assignment).

Asthma control assessment is recommended as a key component of management according to international guidelines [21]. The treatment group received the structured counseling intervention, while the control group received standard care only. The final evaluation was conducted at the six-month mark, with a predetermined follow-up plan to measure the overall impact of the intervention. Standard care, provided to both groups, consisted of physician consultation, prescription of asthma medications as needed, and verbal education on asthma management during OPD visits. Follow-up under standard care was scheduled at six months. In addition to this, the treatment group received structured counseling sessions delivered by a trained health educator, focusing on the harmful effects of passive smoking, the benefits of smoke-free environments, and practical strategies to reduce exposure at home. Counseling was conducted once every two weeks throughout the six-month intervention period, resulting in a total of twelve structured sessions. Each session lasted approximately 20-25 minutes and was delivered in person during OPD visits, with follow-up reminders or reinforcement provided *via* phone calls when necessary.

Data were collected using validated questionnaires administered to the caregivers of eligible children in a separate consultation room within the Pediatrics OPD. The main instrument for the study was the Asthma Control Test (ACT). This well-established five-item questionnaire measures symptoms, activity limitation, and rescue medication use over the past four weeks, with scores ranging from 5 (poor control) to 25 (complete control). Additional information on demographics, household smoking exposure, caregiver knowledge regarding passive smoking, and ventilation status was also collected.

Data analysis was carried out with IBM SPSS Statistics for Windows, Version 25. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Differences between the intervention and control groups were examined using the independent samples t-test. To explore factors associated with ACT scores, a multiple linear regression analysis was conducted, including variables such as the number of smokers in the household, smoking restrictions at home, caregiver knowledge, and exposure to counseling. In addition, one-way ANCOVA was applied to compare post-intervention ACT scores between the two groups after adjusting for baseline measurements. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 126 children with asthma were included in the study, with 63 participants in the control group and 63 in the intervention group. The baseline demographic characteristics of participants in both groups are presented in Table **1**. Overall, the two groups were comparable across most variables, except caregiver education, which showed a statistically significant difference (p = 0.034). Most participants in both groups belonged to families with Middle income (≤ 50,000 PKR). However, a higher proportion of low-income households was observed in the intervention group than in the control group. The age distribution was similar across groups, with the majority of children falling within the early childhood category (4-7 years). Gender distribution was nearly equal between groups. A statistically significant difference was observed in caregiver education (p = 0.034), with a higher proportion of caregivers in the intervention group having primary-level education. In contrast, comparatively higher education levels (graduation and post-graduation) were more frequent in the control group. No statistically significant differences were observed in socioeconomic status, family system, living environment, or home ventilation status (p > 0.05 for all variables), confirming baseline comparability between the groups.

Table 1: Demographic characteristics of participants (n = 126).

Variables	Category	Control Group f n(%)	Intervention Group f n(%)	p-value
Net Income	Low (≤ 20,000)	10 (15.9)	16 (25.4)	0.124
	Middle(≤ 50,000)	49 (77.8)	42 (66.7)	
	High (> 50,000)	4 (6.3)	5 (7.9)	
Age	Early Childhood (4-7 years)	34 (54.0)	32 (50.8)	0.683
	Late Childhood (8-11 years)	29 (46.0)	31 (49.2)	
Education of Caregiver	Primary	13 (20.6)	25 (39.7)	0.034*
	Matric	27 (42.9)	22 (34.9)	
	Graduation	17 (27.0)	11 (17.5)	
	Post-graduation	6 (9.5)	5 (7.9)	
Socioeconomic Status	Lower	12 (19.0)	10 (15.9)	0.401
	Middle	48 (76.2)	45 (71.4)	
	Upper	3 (4.8)	8 (12.7)	
Gender	Male	32 (50.8)	30 (47.6)	0.714
	Female	31 (49.2)	33 (52.4)	
Family System	Joint	55 (87.3)	50 (79.4)	0.264
	Nuclear	8 (12.7)	13 (20.6)	
Living Environment	Urban	43 (68.3)	41 (65.1)	0.702
	Rural	20 (31.7)	22 (34.9)	
Ventilation at Home	Poor	47 (74.6)	39 (61.9)	0.113
	Adequate	16 (25.4)	24 (38.1)	

*p<0.05 indicates a statistically significant difference between groups.

Table 2: Comparison of ACT scores between control and intervention groups (n=126).

Variables	Control (Mean ± SD)	Intervention (Mean ± SD)	t-value	p-value	Cohen's d
Baseline ACT Score	15.36 ± 3.08	15.42 ± 2.91	-0.12	0.903	0.02
Post-intervention ACT Score	16.95 ± 2.70	22.17 ± 2.15	-12.84	<0.001	1.98

Table 3: ANCOVA for post-intervention ACT scores (n=126).

Source	Type III SS	df	Mean Square	F	p-value	Partial η²
Corrected Model	52.384	2	26.192	18.62	<0.001	0.232
Intercept	14.217	1	14.217	10.11	0.002	0.076
Baseline ACT (Covariate)	1.284	1	1.284	0.91	0.341	0.007
Group (Intervention *vs* Control)	49.876	1	49.876	35.48	<0.001	0.224
Error	172.96	123	1.406	—	—	—

The comparison of Asthma Control Test (ACT) scores between the control and intervention groups at baseline and post-intervention is presented in Table **2**. At baseline, there was no statistically significant difference in ACT scores between the control group (Mean ± SD: 15.36 ± 3.08) and the intervention group (15.42 ± 2.91), indicating that both groups were comparable prior to the intervention (p>0.05). Following the intervention, ACT scores improved significantly in the intervention group (22.17 ± 2.15) compared with the control group (16.95 ± 2.70), with a highly significant difference between groups (p < 0.001). This indicates that structured counseling had a substantial positive effect on asthma control among children exposed to passive smoking. The effect size was large (Cohen's d = 1.98), suggesting a clinically meaningful improvement in asthma control in the intervention group.

Analysis of covariance (ANCOVA) was performed to compare post-intervention ACT scores between groups while controlling for baseline ACT scores. The overall model was statistically significant (p<0.001), indicating a good fit. After adjusting for baseline scores, a statistically significant difference was observed between the intervention and control groups (p<0.001), demonstrating that the counseling intervention had an independent and significant effect on improving asthma control. The baseline ACT score was not a significant covariate, suggesting that post-intervention outcomes were primarily influenced by the intervention rather than initial differences (**Table 3**).

Multiple linear regression analysis was conducted to identify predictors of post-intervention ACT scores. The overall model was statistically significant (F=2.83, p=0.005), explaining 18% of the variance in ACT scores (R^2=0.18). Group allocation emerged as a statistically

Table 4: Multiple linear regression predicting ACT scores (n=126).

Predictors	Univariate analysis			Multivariable analysis		
	Crude β	95% CI	p-value	Adjusted β	95% CI	p-value
Constant	12.84	—	—	—	—	0.001
Group Allocation	1.51	(0.80, 2.22)	<0.001	1.77	(1.01, 2.53)	<0.001
Age	-0.16	(-0.92, 0.61)	0.688	0.16	(-0.67, 1.00)	0.699
Caregiver Education	0.09	(-0.35, 0.52)	0.701	-0.34	(-0.79, 0.11)	0.137
Socioeconomic Status	0.11	(-0.71, 0.94)	0.784	0.90	(-0.03, 1.82)	0.057
Gender	-0.18	(-0.93, 0.58)	0.649	0.05	(-0.69, 0.79)	0.897
Family System	-0.68	(-1.73, 0.37)	0.204	-0.35	(-1.40, 0.71)	0.518
Living Environment	0.56	(-0.25, 1.37)	0.174	1.05	(0.04, 2.06)	0.041
Ventilation	0.16	(-0.68, 0.99)	0.712	0.32	(-0.47, 1.11)	0.421

significant predictor (p=0.021), indicating that participants in the intervention group had significantly better asthma control. Caregiver education was significant in the crude analysis (p<0.001) but not after adjustment (p=0.137). Other variables, including age, gender, socioeconomic status, family system, living environment, and ventilation at home, were not statistically significant predictors (p>0.05) (**Table 4**).

DISCUSSION

The findings of the present study demonstrate that structured caregiver counseling has a significant positive impact on asthma control among children exposed to secondhand smoke (SHS). At baseline, Asthma Control Test (ACT) scores were comparable between the intervention and control groups, indicating initial equivalence. Following six months of intervention, children in the intervention group showed statistically and clinically significant improvements in ACT scores compared with the control group, highlighting the effectiveness of structured counseling in improving asthma outcomes.

These results are in line with previous studies showing that exposure to secondhand smoke (SHS) significantly contributes to greater asthma severity and poorer disease control among children [4, 7]. Secondhand smoke exposure has been associated with increased illness severity and healthcare utilization in children with respiratory conditions [9]. Non-pharmacological approaches, including structured community-based interventions, have been shown to improve pediatric asthma outcomes [12]. Additionally, targeted interventions to reduce secondhand smoke exposure have demonstrated benefits for respiratory health [14].

The improvement in asthma management observed in this study may be linked to increased caregiver awareness and behavioral changes following multiple counseling sessions. Earlier research indicates that decreasing exposure to secondhand smoke, especially *via* interventions aimed at reducing parental smoking, is linked to better respiratory health in children with asthma [14, 15]. Asthma interventions focused on education and community involvement have shown benefits in improving asthma management and symptom control in children [12, 17]. The counseling sessions in this study may have motivated caregivers to adopt healthier smoke-free habits and to enhance asthma management practices in the home setting.

The majority of socio-demographic factors, such as household income, living conditions, and family dynamics, showed no significant correlation with post-intervention ACT scores, suggesting that the observed improvement was likely attributable to the counseling intervention rather than socioeconomic disparities. Nonetheless, comparable findings have been documented in asthma intervention research within education [17].

All things considered, the results suggest potential benefits of using organized care counseling in routine pediatric asthma treatment. In outpatient and resource-constrained settings, such approaches might be feasible and useful. As part of comprehensive asthma management for children exposed to secondhand smoke, caregiver-focused smoking reduction counseling is also supported by prior intervention studies and guidelines [14, 19, 21].

LIMITATIONS

This study has several limitations. First, the quasi-experimental design with non-random allocation may introduce selection bias and limit generalizability. Second, SHS exposure was assessed through caregiver self-report, which may be affected by recall or social desirability bias [5]. Third, asthma control was measured at only two time points—baseline and six months—potentially overlooking longer-term symptom variability or seasonal fluctuations. Finally, unmeasured confounding factors, such as differences in medication adherence or unrecorded environmental exposures, may have influenced the outcomes [4].

CONCLUSION

Structured caregiver counseling significantly improves asthma control among children exposed to secondhand smoke and represents a feasible, cost-effective, and scalable addition to routine pediatric asthma care. The intervention produced meaningful behavioral and clinical improvements, demonstrating that targeted education and motivational guidance for caregivers can effectively complement pharmacological management. Incorporating caregiver-focused counseling into routine pediatric asthma programs is a feasible, cost-effective, and scalable strategy to improve respiratory health outcomes, particularly among children exposed to SHS.

ETHICS APPROVAL

The study was approved by the Institutional Review Board of Foundation University Medical College, Islamabad (Reference Number: FF/FUMC/215-564 Phy/25). All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional research committee and the 1964 Declaration of Helsinki and its later amendments.

CONSENT FOR PUBLICATION

Before data collection, written informed consent was obtained from the caregivers of all participating children after explaining the purpose of the study, the confidentiality of the data, and the voluntary nature of participation.

AVAILABILITY OF DATA

The data supporting the findings of this study are not publicly available due to institutional data protection policies. However, the data may be available from Foundation University Medical College upon reasonable request to the corresponding author.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the pediatric clinic staff and participating caregivers for their cooperation and support during data collection.

AUTHORS' CONTRIBUTION

Sana Waheed made substantial contributions to the conception and design of the work, acquisition, analysis, and interpretation of data, and drafting of the manuscript.

Naila Azam contributed to the design of the work and the interpretation of data, and was involved in critically revising the manuscript for important intellectual content.

Munir Akmal Lodhi made contributions to the acquisition and interpretation of data and critically revised the manuscript for important intellectual content.

Noshaba Razzaq made substantial contributions to the analysis and interpretation of data, and to the drafting of the manuscript.

Shaista Zulfiqar made substantial contributions to the data analysis and the drafting of the manuscript.

Sarah Baksh made valuable contributions to data interpretation, drafting, and revision of the manuscript.

All authors gave final approval for the version to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors meet the criteria for authorship as recommended by the ICMJE.

GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT (GPT-4, OpenAI) only to obtain language suggestions and to perform minor proofreading in some parts of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the published article.

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