Effect of Second-hand smoke exposure on Pulmonary Function Test and predictors of abnormal PFT in children attending a tertiary care center in a semiurban area in South India

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ABSTRACT: Objectives: To determine the effect of secondhand smoke (SHS) exposure on pulmonary function tests (PFT) and study the predictors of abnormal PFT in these children.
Methods: Descriptive cross-sectional study was undertaken at a semi-urban tertiary care hospital in India from November 2019 to May 2021. 60 consecutive children from the age of 8-15 years exposed to SHS who visited the pediatric department and fitted the inclusion and exclusion criteria were enrolled. An interview schedule was used for data collection. Pulmonary function was assessed by spirometry. Qualitative (categorical) variables were represented by frequency and percentage analysis. Quantitative variables (continuous) were represented by mean and standard deviation. Logistic regression was performed to find the relationship between pulmonary function tests with other variables. A p-value of < 0.05 was taken as statistically significant.
Results: 50% (30/60) of the SHS-exposed children had an abnormal PFT. Spirometric indices in 25/30 of those with abnormal PFT, FEV1/FVC was <85% of the predicted value suggestive of an obstructive pattern. (p-value 0.000) The predictors for an abnormal PFT that was statistically significant were variables like sociodemographic factors, smoking habit, and type of biofuel.
Conclusion: SHS exposure can cause abnormal PFT of an obstructive pattern. Most of the predictors for an abnormal PFT are related to SHS exposure at home and are preventable.

KEYWORDS: Second-hand smoking, pulmonary function tests, children, India

INTRODUCTION:

The most prevalent but preventable environmental factor that affects the pediatric lung is cigarette smoke. According to India Global Youth Tobacco Survey (GYTS)2019, exposure to secondhand smoke (SHS) in youth occurs in enclosed public places (21%), and at home (11%). The World Health Organization (WHO) Global Burden of Disease Study 2017 estimates that around 700 million children are exposed to and 65 000 die each year from illnesses attributable to SHS. A systematic review and meta-analysis of 60 studies concluded that SHS exposure increases the risk of pediatric lower respiratory tract infections [1], exacerbates symptoms of pre-existing diseases such as asthma, and has detrimental effects on pulmonary function tests (PFT) [2]. On review of the literature, there are very few studies from India addressing the pulmonary effect of SHS exposure in children and almost none looked into the factors that predict an abnormal PFT in these children [3,4]. The aim of this study was to determine the effect of SHS exposure on PFT and study the predictors of abnormal PFT in these children.

METHODS

This descriptive cross-sectional study was undertaken at a semi-urban tertiary care hospital in India from November 2019 to May 2021. After being approved by the institutional ethics committee informed consent from parents was taken. Consecutive children between the age of 8-15 years who were exposed to SHS who visited the pediatric OPD and/or got admitted to the pediatric ward, were enrolled in the study. Definition of SHS(WHO): It is a mixture of exhaled mainstream smoke and sidestream smoke released from a smoldering cigarette or other smoking device and diluted with ambient air. SHS exposure is defined as family members smoking greater than or equal to 1 cigarette per day.

Exclusion criteria were children with significant respiratory infection in the last 6 months, children with acute asthma in the last 6 months, children with chronic diseases (heart, lung, liver, immunocompromised), and children with Asthma on relievers if taken short-acting β agonist within 6 hours or if taken long-acting β agonist within 24 Hours.

The sample size was estimated using a previous study by Rogelio Perez-Padilla et al [5]. At a significance level of 5%, with 20% relative precision, and power of the study of 80%, and a prevalence of respiratory symptoms following SHS exposure of 66.3% the sample size was calculated as 49. To allow for attrition, 75 children were assessed for eligibility. An interview schedule was used for data collection using a standard questionnaire which included parents reported sociodemographic data, smoking habits, and respiratory diseases (asthma, pneumonia, ear infection, recurrent respiratory infection, history of tonsillectomy) based on standard questions utilized in respiratory epidemiology [6]. Pulmonary function was assessed by spirometry conducted using by MIR intermedical Spirolab diagnostic spirometer with Winspiro Pro PC software. Model: IPX1. To obtain three acceptable tests, multiple maneuvers were conducted for each child according to 1994 American Thoracic Society (ATS) criteria [7]. The predicted value was calculated based on the age, sex, height, and race of the patient which was why no control group was used. We analyzed forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), and their ratio (FEV1/FVC).

Statistical analysis: The data were entered into an excel worksheet, and analysis was performed using SPSS23. Frequency and percentage analyses of the qualitative (categorical) variables was done. Quantitative (continuous) variables were represented by mean and standard deviation. Logistic regression was performed to find the relationship between pulmonary function tests with other variables. A *p*-value of < 0.05 was taken as statistically significant. Logistic regression would also factor in various confounding factors in the variables.

RESULTS

A total of 75 children with SHS exposure were assessed for eligibility to be enrolled in the study (Fig. 1). A total of 60 children were finally included in the study. The sociodemographic characteristics, clinical characteristics, and pulmonary function test results are shown in Table 1. The average age was 10.33 with a standard deviation of 1.820. The average weight was 25.53 Kg with a standard deviation of 3.412. The average height was 130.5 cm with a standard deviation of 6.521. The average FEV1 was 1.30 Litre (L)with a standard deviation of 0.39. The average FVC was 1.41 L with a standard deviation of 0.34. The average FEV1/FVC ratio was 91% with a standard deviation of 8.72. The average FEV25-75 was 1.88L with a standard deviation of 0.36. The PFT done showed that 50% of the SHS exposed children had an abnormal PFT. Spirometric indices in 25 of the 30 with abnormal PFT, FEV1/FVC was <85% of the predicted value suggestive of an obstructive pattern. In 5 out of the 30 abnormal PFTs FVC was <80% of the predicted value suggestive of a restrictive pattern. Among the abnormal PFTs, an obstructive pattern (83.3%) was more compared to a restrictive pattern (16.7%) (*p*-value 0.000). The predictors for an abnormal PFT were analyzed (Table 2) which showed variables like sociodemographic factors, smoking habit, and type of biofuel as statistically significant.

DISCUSSION

Though there have been studies describing the pulmonary effect of SHS exposure in literature our study looked into the predictors of an abnormal PFT in these children too. In our study, out of the 60 study subjects, 50% had abnormal PFTs of which, an obstructive pattern on PFT (83.3%) was statistically significant. Merghani et al. who studied 135 young male students in Sudan, also found the FEV1 and FVC to be significantly lower in the SHS-exposed children
[8]. In our study socio-economic status was a significant predictor of abnormal PFT. The obstructive pattern was significantly more in the upper-lower (100.0%) and lower-middle (47.1%) classes. Raju et al. found that FEV1, FVC, and peak expiratory flow (PEF) were within the normal range in children of the high-income group [9]. Our study reveals that abnormal PFT was significantly higher in children whose parents only finished high school (69.2%) and were working as skilled workers (71.4%). In a study by Iva Zaloudíková et al, children living in families with middle and low levels of parents' education were significantly more exposed to environmental tobacco smoke at home[10]. In our study the relationship between abnormal PFT and years of exposure to SHS was significantly higher in cases with exposure of 6-10 years (52.5%) and more than 10 years (40.0%). In addition, the relationship between abnormal PFT and the exposure to number of smokes per day was significantly more in cases with 11-20 smokes per day (87.5%) and more than 20 smokes per day (60.0%). Our study also showed that abnormal PFT was significantly higher in children of unemployed smokers (60.9%). In our study abnormal PFT was significantly lower in beedi (25.0%) compared to cigarette (46.2%) and beedi + cigarette (57.1%) exposure. Also, an association between abnormal PFT and type of biofuel reveals that obstructive type PFT was significantly lower in children with gas stoves at home (26.3%) and both gas stove and firewood (38.7%) compared to firewood alone (80.0%). In a study by Shiyas et al. children coming from homes with firewood being used as fuel had more respiratory symptoms and low peak expiratory flow rate [11].

Considering respiratory diseases as a predictor of abnormal PFT, our study revealed that the obstructive type PFT was significantly higher in cases with a history of recurrent respiratory infection (56.1%). Gupta D et al, and Yelena Bird et al. found that passive smoking increases the risk of lower respiratory tract infections such as bronchitis, pneumonia, and bronchiolitis in children but the effect on PFT was not studied [12,13]. We found that the relationship between pulmonary function test and history of asthma was not statistically significant contrary to studies by Wang etal and Neophytou et al which showed that passive smoking had a greater effect on the early prognosis of asthma and respiratory symptoms and was an independent risk factor for physician-diagnosed asthma and exercise-induced breathlessness in adulthood [14,15]. Finally, the association between PFT and history of pneumonia, history of ear infection, and history of tonsillectomy was not found to be statistically significant in our study.

The strength of our study was that it represents a well-characterized group of children studied repeatedly with high-quality spirometry measurements. The respiratory diseases were assessed by standard questions utilized in respiratory epidemiology to classify them as recurrent respiratory infections. [6]. However, this may have been affected by recall which is a limitation. Another limitation was the questionnaire method for collecting sociodemographic data reported by parents, which may result in deficiencies in the data collected on the amount of exposure. This could have been partly resolved by measuring the level of urinary cotinine, still the most valid marker for tobacco smoke exposure, which was not done in our study. We also did not do reversibility testing in these children due to covid guidelines regarding nebulizer use during the period of study.

Our study concludes that SHS exposure can cause abnormal PFT of an obstructive pattern. Most of the predictors for an abnormal PFT are related to SHS exposure at home and are preventable. Healthcare providers have a major role to play in educating parents on this point to provide a smoke-free home for all children.

What this study adds

SHS exposure in children can cause PFT abnormalities of obstructive pattern.

Most of the predictors for an abnormal PFT are preventable by educating parents.

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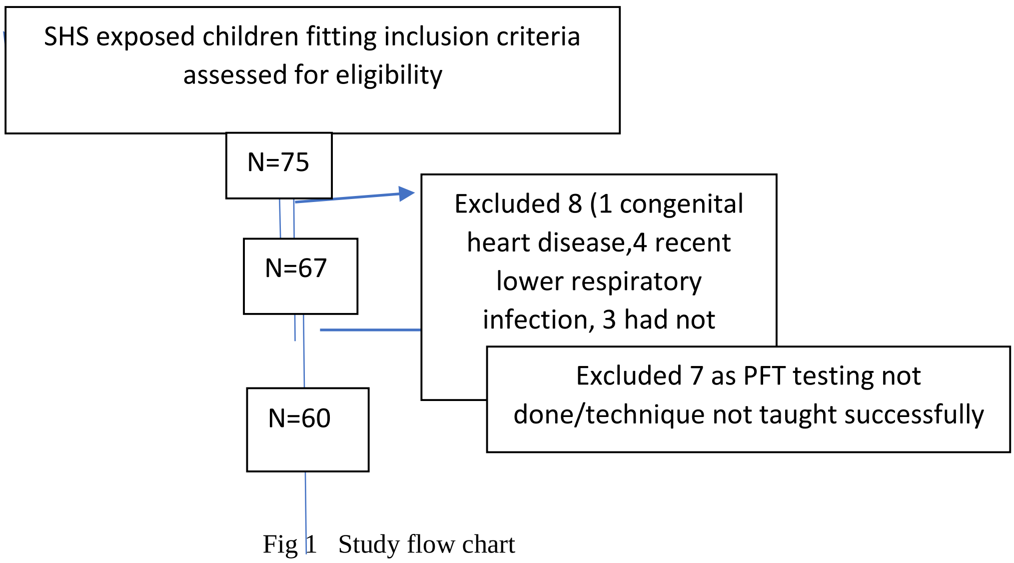

Fig 1 Study flow chart

Table I Sociodemographic characteristics,Clinical Profile, Pulmonary function tests of Children With SHS exposure

Characteristics		Frequency N (60)	Percentage
1. Age (years)	8-9	24	40%
	10-11	18	30%
	11-12	18	30%
2. Sex	male	42	70%
	female	18	30%
3. Weight (Kg)	20-25	32	53.3%
	26-30	23	38.3%
	31- 35	5	8.3%
4. Height (cm)	120-125	12	20%
	126-130	28	46.7%
	131-135	8	13.3%
	>135	12	20%
5. Socioeconomic status	Upper	4	6.7%
	Upper middle	14	23.3%
	Lower middle	34	56.7%
	Upper lower	8	13.3%
6. Education of parents	Professional	3	5%
	Graduate	9	15%
	Intermediate	22	36.7%
	High school	26	43.3%
7. Occupation	Professional	7	11.7%
	Semi-professional	7	11.7%
	Clerical/shop/farm	18	30%
	Skilled work	28	46.6%
8. Family structure	Nuclear	39	65%
	Joint	21	35%
9. Employment Status of smoker	Employed	37	61.7%
	Not employed	23	38.3%
10. Years of SHS exposure	Up to 5	10	16.7%
	6-10	40	66.6%
	>10	10	16.7%
11. Type of smoke	Beedi	20	33.3%
	Cigarette	14	23.4%
	Both	26	43.3%
12. Number of smokes per day	Up to 10	29	48.3%
	11-20	16	26.7%
	>20	15	25%
13. Type of biofuel	Firewood	10	16.7%
	Gas stove	19	31.7%
	Both	31	51.6%
14. History of Asthma	Yes	12	20%
	No	48	80%
15. Asthma status	Controlled	8	13.4%
	Partially controlled	2	3.3%
	Uncontrolled	2	3.3%
	No Asthma	48	80%
16. History of Rec Respiratory infection	Yes	41	68.3%
	No	19	31.7%
17. History of Pneumonia	Yes	13	21.7%
	No	47	78.3%
18. History of ear infection	Yes	16	26.7%
	No	44	73.3%
19. History of Tonsillectomy	Yes	7	11.7%
	No	53	88.3%
20. PFT	normal	30	50%
	abnormal	30	50%
	1 Obstructive	25	83.3%
	2 Restrictive	5	16.7%

Table 2 Predictors for an abnormal PFT

Variables		Pulmonary Function Test			P value
		Normal	Obstructive	Restrictive	
1Socio economic status	Upper	4(100%)	0(0%)	0 (0.0%)	0.000
	Upper middle	13(92.9%)	1 (7.1%)	0 (0.0%)	
	Lower middle	13(38.2%)	16 (47.1%)	5 (14.7%)	
	Upper lower	0(0%)	8 (100.0%)	0 (0.0%)	
2 Education of parents	Professional	3 (100.0%)	0 (0.0%)	0 (0.0%)	0.000
	Graduate	9 (100.0%)	0 (0.0%)	0 (0.0%)	
	Intermediate / Diploma	14 (63.6%)	7 (31.8%)	1 (4.5%)	
	High School	4 (15.4%)	18 (69.2%)	4 (15.4%)	
3Occupation of Parents	Professional	7 (100.0%)	0 (0.0%)	0 (0.0%)	0.000
	Semi-professional	7 (100.0%)	0 (0.0%)	0 (0.0%)	
	Clerical / Shop / Farm	12 (66.7%)	5 (27.8%)	1 (5.6%)	
	Skilled Work	4 (14.3%)	20 (71.4%)	4 (14.3%)	
4.Family Structure	Nuclear	27 (69.2%)	10 (25.6%)	2 (5.1%)	0.000
	Joint	3 (14.3%)	15 (71.4%)	3 (14.3%)	
5. Employment status	Employed	25(67.6%)	11(29.7%)	1(2.7%)	0.001
	Not employed	5(21.7%)	14(60.9%)	4(17.4%)	
6. Years of Exposure	Up to 5	10 (100.0%)	0 (0.0%)	0 (0.0%)	0.002
	6 - 10	15 (37.5%)	21 (52.5%)	4 (10.0%)	
	> 10	5 (50.0%)	4 (40.0%)	1 (10.0%)	
7. Type of Smoke	Beedi	15 (75.0%)	5 (25.0%)	0 (0.0%)	0.012
	Cigarette	3 (21.4%)	8 (57.1%)	3 (21.4%)	
	Both	12 (46.2%)	12 (46.2%)	2 (7.7%)	
8 Number of Smokes per Day	Up to 10	27 (93.1%)	2 (6.9%)	0 (0.0%)	0.000
	11 - 20	1 (6.3%)	14 (87.5%)	1 (6.3%)	
	> 20	2 (13.3%)	9 (60.0%)	4 (26.7%)	
9 Biofuel	Fire Wood	1 (10.0%)	8 (80.0%)	1 (10.0%)	0.006
	Gas Stove	14 (73.7%)	5 (26.3%)	0 (0.0%)	
	Both	15 (48.4%)	12 (38.7%)	4 (12.9%)	
10 History of Asthma*	Yes	5 (41.7%)	6 (50.0%)	1 (8.3%)	0.796
	No	25 (53.2%)	19 (40.4%)	4 (8.5%)	
11.Asthma Status*	Controlled	4 (50.0%)	3 (37.5%)	1 (12.5%)	0.915
	Partially Controlled	4 (66.7%)	2 (33.3%)	0 (0.0%)	
	Uncontrolled	1 (50.0%)	1 (50.0%)	0 (0.0%)	
	Not Asthmatic	21 (47.7%)	19 (43.2%)	4 (9.1%)	
12. History of Rec Respiratory Infection*	Yes	14 (34.1%)	23 (56.1%)	4 (9.8%)	0.001
	No	16 (84.2%)	2 (10.5%)	1 (5.3%)	
13. History of Pneumonia*	Yes	5 (38.5%)	6 (46.2%)	2 (15.4%)	0.496
	No	25 (53.2%)	19 (40.4%)	3 (6.4%)	
14. History of Ear Infection*	Yes	6 (37.5%)	8 (50.0%)	2 (12.5%)	0.474
	No	24 (54.5%)	17 (38.6%)	3 (6.8%)	
15. History of Tonsillectomy*	Yes	1 (14.3%)	5 (71.4%)	1 (14.3%)	0.109
	No	29 (54.7%)	20 (37.7%)	4 (7.5%)	

*based on standard questions utilized in respiratory epidemiology.