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Is There an Association between Environmental Tobacco Smoke Exposure and the Risk of Wheezing among Rural and Urban Preschool Children in Mpumalanga Province, South Africa?

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Abstract: Background: The study aimed to investigate the association between environmental tobacco smoke exposure and the risk of wheezing among rural and urban preschool children in Mpumalanga province, South Africa, an area associated with poor air quality. **Methods:** In this study, parents/caregivers of preschool children (n=3145) completed a modified International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire. Data were analysed using multiple logistic regression models. **Results:** The overall prevalence of Wheeze ever was 15.14%, with a higher prevalence in urban pre-schoolers than rural pre-schoolers (20.71% vs 13.30 %, P<0.000). Moreover, the total prevalence of asthma ever was 2.34%. The prevalence was greater in urban pre-schoolers than in rural pre-schoolers (3.92% vs 1.81%, P<0.001). In the final adjusted model, both urban and rural area children who lived with one or more people who smoked in the same household (WE: OR 1.44, 95% CI 1.11-1.86) (CW: OR 2.09, 95% CI 1.38-3.16) and (AE: OR 2.49, 95% CI 1.12-5.54) were found to have an increased likelihood of having Wheeze Ever, Current Wheeze and Asthma Ever as compared to those who lived with non-smokers. **Conclusions:** The implementation of smoking limits and prohibition is crucial in areas that are frequented or utilized by children. Hence, it is imperative for healthcare providers to actively champion the rights of those who do not smoke within the society, while also endorsing legislative measures aimed at curtailing the extent of tobacco smoke exposure.

Keywords: environmental tobacco smoke exposure; the risk of wheezing; POOR air quality; Preschool children

1. Introduction

Wheeze can be described as a persistent high-pitched sound characterized by a melodic tone that originates from the chest during the act of exhaling [1]. Wheezing throughout early childhood is a prevalent yet intricate symptom characterized by multiple aetiologies and potential consequences. [2,3] It is common for children who exhibit wheezing symptoms before the age of three and persist with wheezing until the age of six to possess atopic tendencies and subsequently develop asthma over the period of eleven to thirteen years [4–6]. Moreover, it has been observed that the respiratory capacity of children experiencing wheezing tends to enhance as they grow older; however, their respiratory capacity never reaches the level observed in children who have never experienced wheezing [4].

The association between wheezing and asthma remains uncertain during the early stages of life. Asthma is a persistent inflammatory ailment affecting respiratory passages, exhibiting fluctuating symptoms such as wheezing, dyspnoea, thoracic constriction, and coughing [7]. Asthma has emerged

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as a significant public health concern on a global scale, with a particular impact on the paediatric population [8–13]. Despite the potential for asthma to manifest clinically at a later stage, [14] investigating asthma in young children holds the potential to mitigate and pre-empt the development of established asthma symptoms [14]. Asthma is considered an incurable condition, and recent research has revealed that recurrent asthma attacks can lead to irreversible lung damage. Asthma management can be effectively achieved by the implementation of proper healthcare interventions. Due to the diverse nature of asthma in the paediatric population, several scholars propose that the term "asthma" should not be employed to characterize episodes of wheezing in preschool-aged children. [1]

Children's asthma has been linked to frequent indoor exposure to environmental tobacco smoke (ETS) [15,16]. ETS possess comparable toxic components to those found in conventional tobacco smoke, consequently resulting in similar detrimental consequences akin to those observed in individuals who engage in active smoking [17]. The symptoms of asthma may exhibit temporary remission following therapy interventions and/or avoidance of triggers associated with the condition. Hence, it is advisable to enact legislation aimed at the elimination and regulation of children's exposure to ETS.

According to the Tobacco Products Control Act of 1993 in South Africa, specifically Section 2(1)(a)(iii), it is prohibited for individuals to engage in smoking any tobacco product within a motor vehicle in the presence of a child under the age of 12 years. This provision has been subject to amendments. The act of smoking is now prohibited within buildings designated for commercial childcare services. Sweets and toys resembling cigarettes are likewise prohibited. The implementation of new tobacco regulations was officially announced in September 2022 through the publication of Government Gazette Staats koerant, Regulation Gazette No. 11494, Vol. 68729, September No. 469942022. Regulation number R. 2560.

The following are highlights that will be considered in risk for childhood exposure to ETS:

- In the event that a residence is utilized for educational purposes, tutoring services, or commercial childcare, the act of smoking would likewise be prohibited.
- The implementation of a prohibition on smoking within motor vehicles in the presence of a minor under the age of 18, provided that there is more than one individual occupying said vehicle.
- The proposed legislative expansion involves not only traditional cigarettes, but also embraces any devices used in connection with tobacco-related goods and electronic delivery systems, such as pipes, water pipes, and electronic devices.

There is a tendency for asthma prevalence to be lower in rural areas, with some evidence suggesting the presence of an urban-rural gradient. The rural-urban gradient of wheeze in preschool children is examined to determine whether this indicator differs along an urban-rural gradient. A study was undertaken by Lawson et al. to examine the relationship between asthma and its indicators throughout the rural-urban gradient. The findings revealed that the prevalence of children with smoking parents was lower in the large urban center [18].

The current tobacco control laws are introduced in a baseline and impact of the regulations will be seen in later years. This study presents the baseline of prevalence of wheeze and asthma in Mpumalanga where children are exposed to polluted air including ETS. The aim is to evaluate the association between exposure to environmental tobacco smoke and the occurrence of wheezing, a symptom commonly associated with asthma, among preschool children residing in rural and urban areas of Mpumalanga Province, South Africa.

2. Methods

2.1. Study Design and Settings

An analytical cross-sectional survey was conducted between November 2020 and April 2021. The objective of our study was to assess the association between environmental tobacco smoke exposure and the occurrence of wheezing, a common symptom of asthma, among preschool children residing in rural and urban areas. The research was carried out within the Mpumalanga province,

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specifically in the Gert Sibande district municipality, which is situated within the Highveld Priority Area. In accordance with the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), the Minister of Environmental Affairs named this region as a priority area for air pollution in 2007.

The Gert Sibande district municipality was purposively selected because it is in the Highveld priority area. The Highveld Priority Area has substandard air quality and heightened levels of pollutants originating from both industrial and non-industrial origins. The district encompasses a diverse range of sectors, such as power generating, petrochemical, primary metallurgy, and open cast mining. The district municipality comprises seven local municipalities, specifically Dipaleseng, Govan Mbeki, Lekwa, Msukukaligwa, DR Pixley ka Seme, all of which are situated within the Highveld priority area. The Chief Albert Luthuli and Mkhondo municipalities are not encompassed under the Highveld priority area. Figure 1 illustrates the geographical distribution of seven local district municipalities, with Gert Sibande being visually distinguished by the use of a light-yellow highlighting.

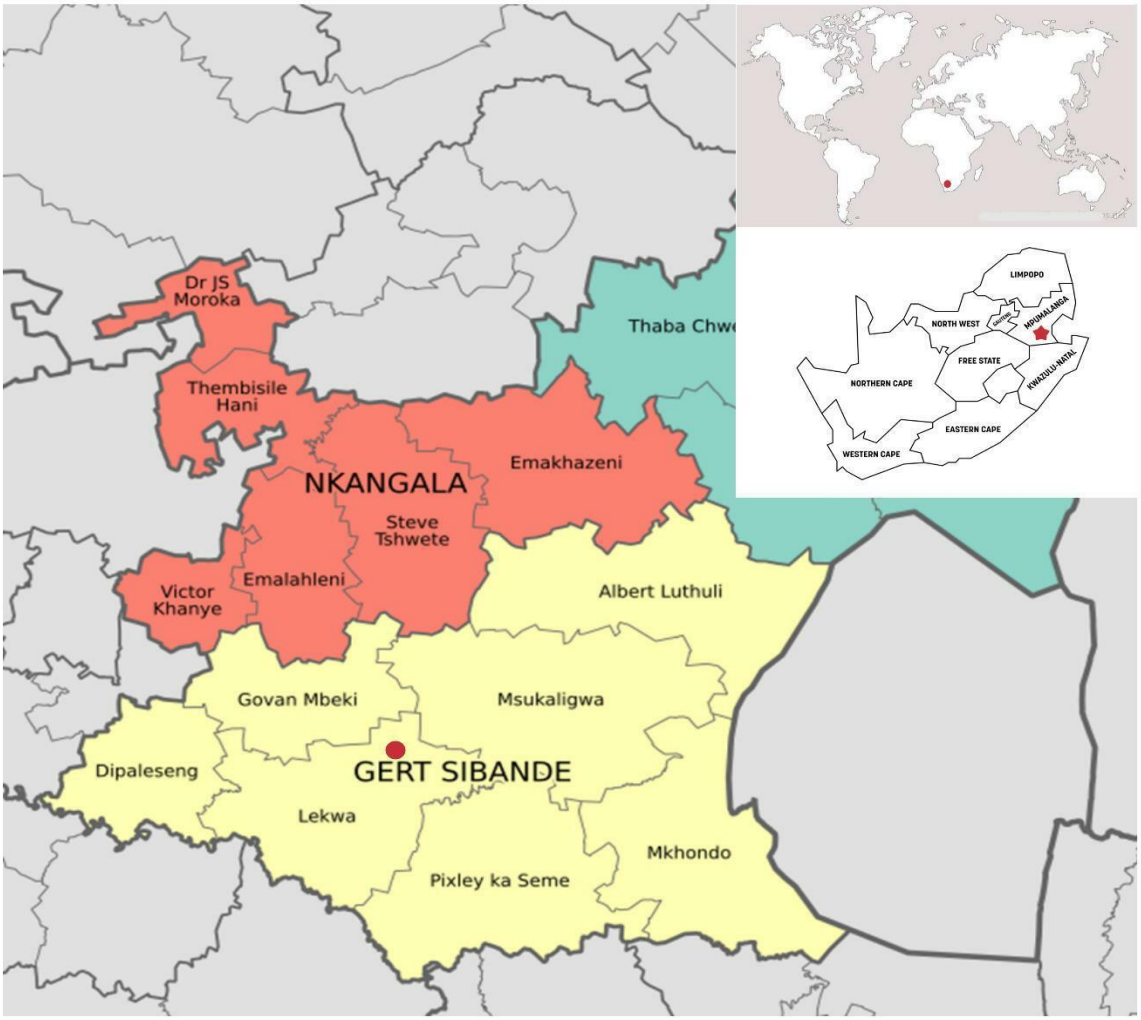

Figure 1. Geographical distribution of preschools within the Gert Sibande District Municipality. a) Provides a visual representation of the global location of the preschools within the Gert Sibande municipality. b) Present the spatial distribution of the Gert Sibande municipality in the province of Mpumalanga within the broader context of the nine provinces of South Africa. c) An illustration depicting the inclusion of all seven local municipalities within the Gert Sibande district, wherein preschools were identified, highlighted in a light-yellow colour. Source: https://en.wikipedia.org/wiki/List_of_municipalities_in_Mpumalanga.

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2.2. Study Population, Sample Size Estimation and Sampling Procedure

The participants in this study consisted of preschool-aged children, ranging from one to eight years old, who resided in and attended preschools located in either rural or urban areas within the Mpumalanga province, specifically in the Gert Sibande district municipality. Based on the data from the 2019 Gert Sibande database, the number of children enrolled in preschool was recorded as 13,485 [19]. The overall sample size required for this study was determined to be 3,900, assuming a response rate of 70%. A study power of 80% was used for the investigation, with a significance level of 5%. The sample size was determined using the sample size calculator in Microsoft Excel.

A probability sample design was employed in order to achieve equitable representation of all preschool children throughout seven local municipalities. Preschools were identified in the northern, southern, eastern, and western regions of each of the seven municipalities within the Gert Sibande district (Figure 1). A representative sample of preschools was chosen from each of the four areas within each municipality. Preschool children were selected in a random manner from a class roster obtained from each designated preschool. Selected pre-schoolers were then given participant information leaflets inviting their parents to be part of the study. Parents, who consented to let their children participate, were then given a questionnaire to complete and return to the preschool. All necessary COVID-19 protocols were implemented.

2.3. Study Tools

Data was collected using the adapted International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire.[9] The questionnaire was divided into two sections: namely demographic data and health outcomes. The questionnaire was in English, which is the common language in a region with multiple local languages. In order to evaluate the data collection procedure and the quality of the survey questions in light of COVID-19 limitations, a pre-test of the instrument was conducted with environmental health practitioners. These professionals were chosen owing to their regular interaction with parents and carers, which provides them with insights into the educational background of these individuals.

2.4. Health Outcomes of the Study

The following central questions on asthma symptoms were used in order to evaluate health outcomes: (1) Has your child ever experienced chest wheezing or whistling in the past? (**Wheeze Ever**) (2) Has he or she had chest wheezing or whistling in the previous 12 months? (**Current Wheeze**) (3) How many wheezing episodes did your child have in the last 12 months? (4) How frequently, on average, during the previous 12 months was your child's sleep interrupted by wheezing? (5) Has your child's wheezing ever been sufficiently severe to prevent them from speaking more than a few phrases at any time between breathing in the last 12 months? (6) Did the child ever suffer from asthma? **(Asthma Ever)** (7) Did a physician or nurse diagnose the asthma? (8) Has your child's chest ever made a wheezy noise while playing or right after? (9) Besides from a cough brought on by a cold or chest illness, has your child experienced a cough that is dry at night in the last 12 months?

The classification of **Current Severe Wheeze** was determined if parents provided affirmative responses to every one of the subsequent questions: 1) If children have severe wheezing, with a frequency of 4-12 bouts or over 12 episodes throughout the preceding 12-month period. 2) If the children experience disrupted sleep as a result of wheezing at least once a week or more. 3) In the event that children experienced a wheezing episode within the last 12 months, resulting in a restriction of their ability to speak to just a few phrases at a time due to intermittent breaths. 4) If the children have experienced wheezing symptoms during or following physical activity throughout the preceding 12-month period.

2.5. Environmental Tobacco Smoke Exposure

Parents and caregivers were requested to provide responses pertaining to risk factors associated with wheezing, a symptom commonly observed in individuals with asthma. The questions

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encompassed the following: Does the male parent engage in smoking behaviour? (yes/no), Is the female parent engaged in the act of smoking? (yes/no).

The present study examines the extent of children's exposure to smoking inside their household during the past 30 days, categorized into several frequency levels: never, 1-6 days, 7-10 days, 16-20 days, and more than 20 days. The present study examines the prevalence of children's exposure to smoking inside the school environment over a period of 30 days.

The duration of the observed time intervals ranges from never through 1-6 days, 7-10 days, 16-20 days, and more than 20 days. The present study examines the extent to which children have been exposed to smoking in cars or other modes of transportation within the preceding 30 days. The duration of the event might vary, ranging from less than a week to over three weeks. The present study examines the frequency of children being subjected to smoking within the past 30 days in a restaurant setting. Parents/caregivers were asked to indicate the number of days in which children were exposed to smoking, with response options ranging from never to more than 20 days. In addition, what is the number of individuals residing in the household of your child that engages in smoking?

2.6. Confounders

Parents and caregivers were asked to answer a series of questions about the following topics: Gender of the child (male/female), Location of the child (rural/urban), and How long has the child lived in the area? (6 to 12 months/1 to 2 years/3 years or longer), Was the child born in the area? (Hospital/Clinic/Home/does not apply), What kind of residence does the child live in? (Brick/Mud/Corrugated Iron/Mixture/Other), In the last 12 months, the child used analgesics/antibiotics (Never/At least once a year/At least once per month. What type of fuel is utilized for cooking and heating (electricity/gas/paraffin/coal/wood/other)? How does the child get to and from school? (walks/taxi/bus/motor vehicle/combination/other). How frequently do trucks, buses, and taxis pass through your neighbourhood? (Never/rarely/frequently throughout the day/almost the entire day. Other questions focused on pet ownership, education for parents/caregivers, Job occupation of parents/caregivers and family health history.

2.7. Data Processing and Analysis

The data were captured using EpiData version 3.1[20] for the purpose of ensuring quality and subsequently analysed using STATA 17. Descriptive statistics were computed, utilizing means and standard deviations for continuous data, and frequencies expressed as percentages for categorical data. Observations that were labelled as "not recorded" were designated as missing. Consequently, there were variations in the sample sizes utilized to address each respective question.

In this study, we assessed the association between demographic factors, including gender, age, location, and family history, with four outcome variables: **Wheeze Ever**, **Current Wheeze**, **Current Severe Wheeze** and **Asthma Ever**. Statistical comparisons were conducted using the chi-square test for independent samples. The researchers employed multiple logistic regression to account for any confounding variables, assessing the strength of the relationship using the odds ratio (OR) and 95% confidence intervals (CI). For outcomes with two categories, binary multiple logistic regression was utilized.

3. Results

Description of Study Participants

We identified 3900 pre-schoolers and invited their parents using participant information leaflets to be part of the study. Three thousand one-hundred and forty-five parents permitted their children and consented to participate, which was a participation rate of 80.6%. The pre-schoolers were, on average, 4.05 (SD=1.22) years old. Most pre-schoolers were within the age range of 3 to 5 years, which fell within the 50th percentile. There were 1 605 (51%) boys and 1 540 (48.9%) girls. Most pre-schoolers (75%) resided in rural areas, while 774 (25%) lived in urban areas. Moreover, a significant majority of

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pre-school-aged children (87%) were born in hospitals located in suburbs or township areas. Additionally, a substantial proportion of these children (80%) resided in these suburban or township regions for a duration of three years or more.

Table 1 provides a concise overview of the basic characteristics exhibited by children while Table 2 presents the environmental tobacco smoke exposure sources and health outcomes of the study participants. Study findings revealed that 23.56% of pre-school children had male parents who engaged in smoking, whereas just 3.10% of pre-school children had female parents who engaged in smoking. According to Table 2, a total of 28.86% of pre-schoolers resided in households where one or more individuals engaged in smoking activities within the same living space.

Table 1. The demographic characteristics of the participants in the study (n=3145).

Variables	N	Percentage (%)
1. **Gender of the child**		
Female	1540	48.97
Male	1605	51.03
2. **Age group of children**		
< 3 years	414	13.16
3-5 years	1779	56.57
≥ 5 years	952	30.27
3. **Child location**		
Rural	2372	75.42
Urban	773	24.58
4. **Time lived in Suburb/township**		
Less than 6 months	107	3.40 (3.49)
6 to 12 months	99	3.14 (3.23)
1 to 2 years	408	12.9 (13.32)
3 years or longer	2450	77.90 (79.96)
Missing	81	2.57
5. **Type of house the child lives in**[a]		
Brick	2547	80.98 (82.37)
Mud	116	3.68 (3.75)
Corrugated iron	255	8.10 (8.25)
Combination	93	2.95 (3.01)
Other	81	2.57 (2.62)
Missing	53	1.68
6. **Fuel used for cooking in the house**[b]		
Electricity	2476	78.72 (78.78)
Gas	100	3.17 (3.18)
Paraffin	19	0.60 (0.60)
Coal	254	8.07 (8.08)
Wood	292	9.28 (9.29)
Other	2	0.06 (0.06)
Missing	2	0.06
7. **Fuel used for heating in the house**[c]		
Electricity	2008	63.84 (64.44)

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Gas	198	6.29 (6.35)
Paraffin	27	0.85 (0.87)
Coal	484	15.38 (15.53)
Wood	380	12.08 (12.20)
Other	19	0.60 (0.61)
Missing	29	0.92
8. **Child used Analgesic/antibiotic in the past 12 months**		
Never	445	14.14 (14.59)
At least once a year	921	29.28 (30.21)
At least once per month	1683	53.51 (55.20)
Missing	96	3.05
9. **How does the child get to school**[d]		
Walk	1666	52.97 (53.41)
Taxi/bus	848	26.96 (27.19)
Motor car	525	16.69 (16.83)
Combination	57	1.81 (1.83)
Other	23	0.73 (0.74)
Missing	26	0.82
10. **How often has your child been absent from school (past 6 months)**		
Never or occasionally	1854	58.95 (61.51)
Once or twice per week	904	42.14 (29.99)
Three or more times a week	256	8.13 (8.49)
Missing	131	4.1
11. **Child Ever Breastfed**		
No	974	30.96 (31.43)
Yes	2125	67.46 (68.57)
Missing	46	1.46
12. **Truck traffic pass through the street on weekend**		
Never	518	16.47 (16.99)
Seldom	735	23.37 (24.11)
Frequent through the day	713	22.67(23.38)
Almost all day	1083	34.43 (35.52)
Missing	96	3.0
13. **Female parent: Highest level of school completed**		
Primary	246	7.82 (8.18)
Secondary	1884	59.90 (62.67)
University	454	14.43 (15.10)
Other	422	13.41 (14.04)
Missing	139	4.41
14. **Female parent job industry**		

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Government sector	351	11.16 (11.76)
Private sector	580	18.44 (19.44)
Self-employed	308	9.79(10.32)
Not employed	1745	55.48 (58.48)
Missing	161	5.11
15. **Female parent ever asthma**		
No	2487	79.09 (96.92)
Yes	79	2.51 (3.08)
Missing	579	18.41
16.**Cat inside the house**		
No	2885	91.17 (92.82)
Yes	223	7.09 (7.18)
Missing	37	1.17
17.**Dog inside the house**		
No	2780	88.39 (89.36)
Yes	331	10.52 (10.64)
Missing	34	1.08

( ) *Missing data was excluded from the data analysis.* [a] Combination includes Brick & Corrugated iron: Other includes wood. [b] Other include generator. [c] Other include Solar energy/electricity. [d] Combination includes motorcar and Taxi/bus: Other includes animal cart.

Table 2. Environmental tobacco smoke exposure sources and health outcomes of the study participants (n=3145).

Variables	N	Percentages (%)
1. Female parent smokes		
Yes	94	2.98 (3.10)
No	2934	93.29 (96.90)
Missing	117	3.72
2. Male parent smokes		
Yes	451	14.34 (23.56)
No	1463	46.51 (76.44)
Missing	1231	39.14
3. How many people living in the same house as your child smoke?		
Zero	2051	65.21 (71.14)
One or more	832	26.45 (28.86)
Missing	262	8.33
4. Child exposure to smoking at home (past 30 days)		
Never	1947	61.90 (83.10)
One or more days*	396	12.59 (16.90)
Missing	802	25.50

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5. Child exposure to smoking at school (past 30 days)		
Never	1444	45.91 (97.30)
One or more days*	40	1.27 (2.70)
Missing	1661	52.81
6. Child exposure to smoking in car/transport (past 30 days)		
Never	1390	44.19 (95.21)
One or more days*	70	2.25 (4.79)
Missing	1685	53.57
7. Child exposure to smoking at the restaurant (past 30 days)		
Never	1387	44.10 (94.61)
One or more days*	79	2.51 (5.39)
Missing	1678	53.35
8. Wheeze ever		
Yes	467	14.8 (15.14)
No	2617	83.2 (84.86)
Missing	61	1.9
9. Current wheeze		
Yes	292	9.2 (9.45)
No	2799	88.9 (90.55)
Missing	54	1.7
10. Current severe wheeze		
Yes	40	1.27 (1.28)
No	3076	97.8 (98.72)
Missing	29	0.92
11. Ever had asthma		
Yes	66	2.09 (2.34)
No	2810	89.34 (97.65)
Missing	269	8.55
12. Wheeze attack in the past 12 months		
Yes	274	8.71(8.87)
No	2815	89.50 (91.13)
Missing	56	1.78
13. Sleep disturbed due to wheeze in the past 12 months		
Yes	199	6.32 (6.45)
No	2888	91.82 (93.55)
Missing	58	1.82
14. Wheeze severe enough to limit speech in the past 12 months		
Yes	59	1.87 (1.92)

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No	3016	95.89 (98.08)
Missing	75	2.38
15. Asthma diagnosed by a medical Doctor or Nurse		
Yes	54	1.71 (1.81)
No	2929	93.13 (98.19)
Missing	162	5.15
16. Chest ever sounded wheezy during/after playing		
Yes	232	7.37 (8.82)
No	2398	76.24 (91.18)
Missing	515	16.37
17. Dry cough at night apart from cough associated with cold or chest infection		
Yes	650	20.66 (22.58)
No	2229	70.87 (77.42)
Missing	266	8.45

( ) Missing data was excluded from the data analysis. * One or more days include the following days range:1-6 days;7-10 days;16-20 days; more than 20 days.

The study found that the overall prevalence of wheeze ever among the pre-schoolers was 15.14%, with a greater prevalence observed among urban pre-schoolers compared to their rural counterparts (20.7% vs 13.3%, p<0.001). Moreover, the total prevalence of asthma ever was 2.34% The prevalence was also greater in urban pre-schoolers compared to rural pre-schoolers (3.9% vs 1.8%, P<0.001). The prevalence of Current Wheeze was found to be higher than that of Current Severe Wheeze and Asthma ever, as indicated in Table 2.

The prevalence rates of Wheeze ever, Current wheeze, and Asthma ever among urban pre-schoolers residing in households with one or more individuals who engage in smoking were found to be 23.11%, 14.14%, and 5.97%, respectively. In comparison, their rural counterparts exhibited prevalence rates of 17.15%, 12.93%, and 2.32% for the same respiratory conditions.

Furthermore, urban pre-school children exposed to smoking at restaurants in the past 30 days had a 37.50% prevalence rate of Current wheeze, while their rural counterparts had a prevalence of 11.32% for the same exposure days. Contrary to the above, it was observed that rural pre-school children who had a female parent or caregiver who smoked exhibited a significantly higher prevalence of current wheeze, with a rate of 26.31%. The data presented in Table 3 illustrates the relevant information pertaining to the topic at hand.

Table 3. Participants' prevalence of wheeze ever, current wheeze, current severe wheeze and asthma ever for rural and urban areas with their respective odds ratios.

	Rural						Urban					
Variable	**Total[a]**	**Prevalence (%)**	**Crude OR[b] (95% CI)**	**P**	**Adjusted OR[b] (95% CI)**	**P**	**Total[a]**	**Prevalence (%)**	**Crude OR[b] (95% CI)**	**P**	**Adjusted OR[b] (95% CI)**	**P**
Wheeze ever[c]												
Child ever breastfed												
No	736	13.99	1		1		221	18.09	1		1	
Yes	1557	13.10	1.01 (0.82-1.26)	0.869	1.27 (0.96-1.67)	0.082	529	21.92	1.01 (0.82-1.26)	0.869	1.27 (0.96-1.67)	0.082
How often have you given your												

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child medication (past 12 months)?												
Never	351	4.55	1		1		84	8.33	1		1	
At least once a year	611	12.43	2.78 (1.75-4.41)	**0.000**	2.24 (1.32-3.81)	0.003	298	18.45	2.78 (1.75-4.41)	**0.000**	2.24 (1.32-3.81)	0.003
At least once per month	1300	16	3.98 (2.56-6.17)	**0.000**	2.83 (1.70-4.49)	0.000	350	36.18	3.98 (2.56-6.17)	**0.000**	2.83 (1.70-4.49)	0.000
People living in the same house as your child smoke?												
Zero	1500	11.4	1		1		511	20.15	1		1	
One or more	618	17.15	1.46 (1.17-1.82)	**0.001**	1.44 (1.11-1.86)	**0.006**	199	23.11	1.46 (1.17-1.82)	**0.001**	1.44 (1.11-1.86)	**0.006**
Truck traffic where your child lives on weekdays												
Never	389	13.11	1		1		120	15.83	1		1	
Seldom	492	12.19	1.05 (0.76-1.46)	0.76	1.10 (0.73-1.64)	0.636	237	21.09	1.05 (0.76-1.46)	0.76	1.10 (0.73-1.64)	0.636
Frequently	517	14.89	1.32 (0.95-1.81)	0.08	1.40 (0.94-2.07)	0.092	187	25.13	1.32 (0.95-1.81)	0.08	1.40 (0.94-2.07)	0.092
Almost all day	854	12.99	1.07 (0.78-1.45)	0.65	1.10 (0.75-1.63)	0.601	199	19.59	1.07 (0.78-1.45)	0.65	1.10 (0.75-1.63)	0.601
Cat inside the house (past 12 months)												
No	2143	13.06	1		1		687	19.65	1		1	
Yes	156	16.02	1.54 (1.09-2.17)	**0.012**	1.39 (0.90-2.15)	0.136	64	34.37	1.54 (1.09-2.17)	**0.012**	1.39 (0.90-2.15)	0.136
Female parent level of school completion												
Primary	222	18.01	1		1		19	23.31	1		1	
Secondary	1523	11.81	0.59 (0.41-0.84)	**0.004**	0.76 (0.46-1.25)	0.284	323	16.09	0.59 (0.41-0.84)	**0.004**	0.76 (0.46-1.25)	0.284
University	212	16.50	1.03 (0.68-1.55)	0.871	1.64 (0.97-2.80)	0.064	237	28.27	1.03 (0.68-1.55)	0.871	1.64 (0.97-2.80)	0.064
Other	286	15.73	0.82 (0.54-1.24)	0.354	0.99 (0.59-1.73)	0.982	127	21.25	0.82 (0.54-1.24)	0.354	0.99 (0.59-1.73)	0.982
Female parent ever had Asthma												
No	1852	12.41	1		1		599	18.19	1		1	
Yes	43	25.58	3.65 (2.28-5.85)	**0.000**	3.25 (1.97-5.35)	**0.000**	36	55.55	3.65 (2.28-5.85)	**0.000**	3.25 (1.97-5.35)	**0.000**
Current wheeze[d]												
Female parent ever had Asthma												
No	1853	8.04	1		1		600	9.33	1		1	
Yes	43	23.25	3.82 (2.26-6.45)	**0.000**	5.59 (2.77-11.26)	**0.000**	36	30.55	3.82 (2.26-6.45)	**0.000**	5.59 (2.77-11.26)	**0.000**
Child used Analgesic/antibiotic in the past 12 months												
Never	354	1.97	1		1		86	1.16	1		1	
At least once a year	609	7.38	3.85 (1.82-8.12)	**0.000**	3.41 (1.17-9.95)	0.024	297	6.06	3.85 (1.82-8.12)	**0.000**	3.41 (1.17-9.95)	0.024
At least once per month	1307	11.40		**0.000**		0.003	349	18.33	7.94 (3.89-16.22	**0.000**		0.003

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			7.94 (3.89-16.22)		4.74 (1.68-13.40)						4.74 (1.68-13.40)	
Truck traffic where your child lives on weekdays												
Never	388	8.76	1		1		120	8.33	1		1	
Seldom	489	8.58	0.99 (0.66-1.48)	0.978	1.04 (0.55-1.94)	0.902	238	9.24	0.99 (0.66-1.48)	0.978	1.04 (0.55-1.94)	0.902
Frequently	516	10.07	1.40 (0.95-2.06)	0.084	1.13 (0.60-2.11)	0.695	186	16.66	1.40 (0.95-2.06)	0.084	1.13 (0.60-2.11)	0.695
Almost all day	865	8.43	1.02 (0.70-1.48)	0.905	0.86 (0.45-1.64)	0.653	199	10.05	1.02 (0.70-1.48)	0.905	0.86 (0.45-1.64)	0.653
Female parent job industry												
Government sector	183	11.47	1		1		164	14.63	1		1	
Private sector	371	7.27	0.62 (0.40-0.96)	**0.034**	0.72 (0.38-1.36)	0.317	196	10.20	0.62 (0.40-0.96)	**0.034**	0.72 (0.38-1.36)	0.317
Self-employed	199	9.04	0.76 (0.46-1.25)	0.292	0.85 (0.42-1.71)	0.660	102	11.76	0.76 (0.46-1.25)	0.292	0.85 (0.42-1.71)	0.660
Not employed	1476	9.01	0.73 (0.50-1.06)	0.103	0.50 (0.28-0.87)	**0.016**	245	10.20	0.73 (0.50-1.06)	0.103	0.50 (0.28-0.87)	**0.016**
Dog inside the house (past 12 months)												
No	2103	8.13	1		1		639	10.79	1		1	
Yes	205	15.60	1.74 (1.24-2.44)	**0.001**	1.27 (0.70-2.32)	0.419	115	13.04	1.74 (1.24-2.44)	**0.001**	1.27 (0.70-2.32)	0.419
Female parent smoke												
No	2186	8.26	1		1		698	11.31	1		1	
Yes	76	26.31	3.19 (1.94-5.24)	**0.000**	0.65 (0.20-2.12)	0.488	17	11.76	3.19 (1.94-5.24)	**0.000**	0.65 (0.20-2.12)	0.488
People living in the same house as your child smoke?												
Zero	1497	7.34	1		1		511	9.39	1		1	
One or more	626	12.93	1.77 (1.36-2.30)	**0.000**	2.09 (1.38-3.16)	**0.000**	198	14.14	1.77 (1.36-2.30)	**0.000**	2.09 (1.38-3.16)	**0.000**
Child exposure to smoking at the restaurant (past 30 days)												
Never	984	8.23	1		1		381	11.81	1		1	
One or more days	53	11.32	2.35 (1.29-4.26)	**0.005**	2.27 (1.17-4.38)	**0.014**	24	37.5	2.35 (1.29-4.26)	**0.005**	2.27 (1.17-4.38)	**0.014**
Child ever breastfed												
No	738	8.40	1		1		221	9.50	1		1	
Yes	1561	9.22	1.14 (0.87-1.49)	0.312	1.40 (0.88-2.23)	0.154	529	11.72	1.14 (0.87-1.49)	0.312	1.40 (0.88-2.23)	0.154
Current severe wheeze[e]												
Female parent ever had Asthma												
No	1866	0.96	1		1		603	1.16	1		1	
Yes	43	0.0	2.34 (0.53-10-19)	0.256	2.40 (0.19-29.90)	0.494	36	5.55	2.34 (0.53-10-19)	0.256	2.40 (0.19-29.90)	0.494
Child used Analgesic/antibiotic in the past 12 months												
	355	0.28			1		85	0.0				
	617	1.45	1	0.134	1.43 (0.33-6.09)		300	0.33	1	0.134	1	
Never	1315	1.36		0.057		0.624	351	0.02		0.057		0.624

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At least once a year			4.8 (0.61-37.98)		-				4.8 (0.61-37.98)		1.43 (0.33-6.09)	
At least once per month			6.95 (0.94-51.42)						6.95 (0.94-51.42)		-	
Dry cough at night apart from cough associated with cold or chest infection												
No	1664	0.30	1		1		564	0.17	1		1	
Yes	492	4.06	16.75 (6.90-40.64)	**0.000**	53.19 (7.64-370.0)	**0.000**	156	5.12	16.75 (6.90-40.64)	**0.000**	53.19 (7.64-370.0)	**0.000**
Truck traffic where your child lives on weekdays												
Never	392	1.53	1		1		121	0.82	1		1	
Seldom	493	1.01	0.59 (0.19-1.77)	0.348	0.04 (0.00-0.57)	**0.018**	238	0.42	0.59 (0.19-1.77)	0.348	0.04 (0.00-0.57)	**0.018**
Frequently	522	0.57	0.82 (0.29-2.28)	0.707	1.19 (0.20-7.09)	0.847	187	2.67	0.82 (0.29-2.28)	0.707	1.19 (0.20-7.09)	0.847
Almost all day	869	1.72	1.24 (0.51-3.00)	0.626	0.32 (0.05-1.84)	0.204	201	1.49	1.24 (0.51-3.00)	0.626	0.32 (0.05-1.84)	0.204
Male parent job industry												
Government sector	153	0.65	1		1		126	0.79	1		1	
Private sector	505	1.18	1.96 (0.43-8.95)	0.381	3.07 (0.40-23-15)	0.276	282	1.77	1.96 (0.43-8.95)	0.381	3.07 (0.40-23-15)	0.276
Self-employed	189	1.05	1.56 (0.25-9.51)	0.625	1.84 (0.17-19.07)	0.606	80	1.25	1.56 (0.25-9.51)	0.625	1.84 (0.17-19.07)	0.606
Not employed	473	2.11	2.66 (0.56-12.64)	0.217	0.23 (0.14-4.01)	0.319	61	0.0	2.66 (0.56-12.64)	0.217	0.23 (0.14-4.01)	0.319
Dog inside the house (past 12 months)												
No	2119	1.13	1		1		642	0.93	1		1	
Yes	209	2.39	2.60 (1.21-5.55)	**0.014**	2.62 (0.38-18.03)	0.326	116	3.44	2.60 (1.21-5.55)	**0.014**	2.62 (0.38-18.03)	0.326
Male parent smoke												
No	1017	0.98	1		1		431	0.92	1		1	
Yes	321	2.49	2.57 (1.15-5.70)	**0.020**	1.52 (0.28-8.11)	0.624	128	2.34	2.57 (1.15-5.70)	**0.020**	1.52 (0.28-8.11)	0.624
People living in the same house as your child smoke?												
Zero	1515	0.99	1		1		513	0.97	1		1	
One or more	628	2.22	2.23 (1.17-4.24)	**0.014**	2.58 (0.55-11.95)	0.225	199	2.01	2.23 (1.17-4.24)	**0.014**	2.58 (0.55-11.95)	0.225
Child exposure to smoking at the restaurant (past 30 days)												
Never	994	1.20	1		1		383	2.08	1		1	
One or more days	54	3.70	2.67 (0.77-9.21)	0.119	1.54 (0.10-21.38)	0.748	24	4.16	2.67 (0.77-9.21)	0.119	1.54 (0.10-21.38)	0.748
Child exposure to smoking at the car (past 30 days)												
Never	990	1.11	1	0.079	1	0.065	390	2.30	1		1	
	47	6.38					22	0.00	3.03 (0.87-10.50)	0.079		0.065

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One or more days			3.03 (0.87-10.50)		9.44 (0.86-102.93)					9.44 (0.86-102.93)		
Child exposure to smoking at the home (past 30 days)												
Never	1406	1.20	1		1		523	1.72	1	1		
One or more days	295	1.69	1.13 (0.46-2.77)	0.783	0.33 (0.04-2.65)	0.302	100	1.00	1.13 (0.46-2.77)	0.783	0.33 (0.04-2.65)	0.302
Child exposure to smoking at the school (past 30 days)												
Never	1045	1.24	1		1		389	1.79	1	1		
One or more days	30	3.333	1.82 (0.23-13.95)	0.562	0.13 (0.00-6.36)	0.311	10	0.00	1.82 (0.23-13.95)	0.562	0.13 (0.00-6.36)	0.311
Child ever breastfed												
No	742	1.21	1		1		221	0.90	1	1		
Yes	1575	1.33	1.20 (0.60-2.42)	0.596	2.11 (0.35-12.251)	0.408	533	1.50	1.20 (0.60-2.42)	0.596	2.11 (0.35-12.251)	0.408
How does the child get to school[g]												
Walk	1527	1.50	1		1		126	0.79	1	1		
Taxi/bus	554	0.72	0.62 (0.27-1.45)		0.46 (0.08-2.50)		283	1.41	0.62 (0.27-1.45)	0.46 (0.08-2.50)		
Motor car	201	1.49	0.84 (0.32-2.23)	0.276	0.31(0.05-1.87)	0.375	320	1.25	0.84 (0.32-2.23)	0.276	0.31(0.05-1.87)	0.375
Combination	39	0.00	0.738	0.738	0.203	0.203	18	5.55	0.738	0.738	0.203	0.203
Other	14	0.00	1.16 (0.15-8.87)	0.883	27.48 (1.47-511.9)	0.026	9	0.00	1.16 (0.15-8.87)	0.883	27.48 (1.47-511.9)	0.026
			-						-			
Asthma ever[f]												
People living in the same house as your child smoke?												
Zero	1364	1.31	1		1		479	3.54	1	1		
One or more	558	2.32	175 (1.03-2.98)	**0.036**	2.49 (1.12-5.54)	**0.024**	184	5.97	175 (1.03-2.98)	**0.036**	2.49 (1.12-5.54)	**0.024**
Child exposure to smoking at the car (past 30 days)												
Never	915	1.85	1		1		371	4.31	1	1		
One or more days	45	0.00	0.56 (0.07-4.21)	0.577	0.58 (0.07-4.53)	0.605	21	4.76	0.56 (0.07-4.21)	0.577	0.58 (0.07-4.53)	0.605
Child ever breastfed												
No	683	1.75	1		1		212	2.83	1	1		
Yes	1393	1.86	1.22 (0.70-2.12)	0.465	1.13 (0.48-2.68)	0.769	485	4.32	1.22 (0.70-2.12)	0.465	1.13 (0.48-2.68)	0.769
Child used Analgesic/antibiotic in the past 12 months												
Never	314	0.31	1		1		76	1.31	1	1		
At least once a year	557	1.97	3.14 (0.71-13.85)	0.130	1.35 (0.14-12.40)	0.788	277	1.44	3.14 (0.71-13.85)	0.130	1.35 (0.14-12.40)	0.788
At least once per month	1176	0.22		**0.012**		0.178	328	6.40		**0.012**		0.178

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			6.14 (1.48-25.42)		4.03 (0.53-30.7)				6.14 (1.48-25.42)		4.03 (0.53-30.7)	
Truck traffic where your child lives on weekdays												
Never	351	2.56	1		1		110	5.45	1		1	
Seldom	452	1.32	0.49 (0.22-1.07)	0.075	0.63 (0.18-2.15)	0.464	222	2.70	0.49 (0.22-1.07)	0.075	0.63 (0.18-2.15)	0.464
Frequently	480	2.29	0.86 (0.43-1.72)	0.680	1.05 (0.34-3.24)	0.921	175	4.57	0.86 (0.43-1.72)	0.680	1.05 (0.34-3.24)	0.921
Almost all day	755	1.58	0.63 (0.32-1.26)	0.201	0.55 (0.163-1.89)	0.350	184	3.80	0.63 (0.32-1.26)	0.201	0.55 (0.163-1.89)	0.350
Cat inside the house (past 12 months)												
No	1937	1.70	1		1		636	3.30	1		1	
Yes	145	3.44	2.7 (1.44-5.25)	**0.002**	1.44 (0.38-5.34)	0.584	62	11.29	2.7 (1.44-5.25)	**0.002**	1.44 (0.38-5.34)	0.584
Female parent level of school completion												
Primary	171	3.50	1		1		149	4.69	1		1	
Secondary	338	1.47	0.54 (0.24-1.23)	0.146	1.06 (0.22-5.04)	0.936	185	3.24	0.54 (0.24-1.23)	0.146	1.06 (0.22-5.04)	0.936
University	178	2.24	1.03 (0.45-2.36)	0.930	1.16 (0.21-6.47)	0.858	101	6.93	1.03 (0.45-2.36)	0.930	1.16 (0.21-6.47)	0.858
Other	1321	1.66	0.54 (0.27-1.09)	0.090	1.48 (0.27-7.96)	0.647	224	2.67	0.54 (0.27-1.09)	0.090	1.48 (0.27-7.96)	0.647
Female parent ever had Asthma												
No	1730	1.56	1		1		560	3.21	1		1	
Yes	39	15.3	7.63 (3.72-15.66)	**0.000**	4.05 (1.25-13.15)	**0.020**	35	14.28	7.63 (3.72-15.66)	**0.000**	4.05 (1.25-13.15)	**0.020**

[a]The Totals for each risk factor are different due to difference in missing values. [b]The Values that are statistically significant for the crude OR and less than 0.05 for the adjusted OR are highlighted. [c]The Model was adjusted for: people living in the same house as your child smoke, child ever breastfed, use of analgesic/antibiotics, Truck traffic during weekdays, cat in the house, female parent education & female parent ever had asthma. [d]The Model was adjusted for: female parent ever had asthma, use of analgesic/antibiotics, Truck traffic during weekdays, female parent job, dog in the house, female parent smoke, Child exposure to smoking in the restaurant & child ever breastfed. [e]The Model was adjusted for: female parent ever had asthma, use of analgesic/antibiotics, dry cough at night, Truck traffic during weekdays, male parent job, dog in the house, male parent smoke, people living in the same house as your child smoke, Child exposure to smoking in the restaurant, Child exposure to smoking in the car/transport, child ever breastfed, How the child get to school, Child exposure to smoking at home, Child exposure to smoking at school. [f]The Model was adjusted for: people living in the same house as your child smoke, Child exposure to smoking in the car/transport, child ever breastfed, use of analgesic/antibiotics, Truck traffic during weekdays, Cat in the house, female parent education, female parent ever had asthma. [g]Combination includes motorcar and Taxi/bus: Other includes animal cart. -: variable contains !=0, which predicts failure perfectly. Therefore, were omitted and observations not used.

The prevalence of wheeze ever in both rural and urban areas combined exhibited a greater incidence among boys (16.73%) compared to girls (13.49%). The data presented in Table 4 and Table 6 indicate that there is a larger prevalence of current severe wheeze among boys (1.75%) compared to girls (0.78%) in both rural and urban areas.

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Table 4. Participants (combined Rural and Urban areas) prevalence of wheeze ever with their respective odds ratios.

Variable	Total[a]	Prevalence (%)	Crude OR[b] (95% CI)	P	Adjusted OR[b,c] (95% CI)	P
People living in the same house as your child smoke?						
Zero	2011	13.60	1			
One or more	817	18.60	1.44 (1.16-1.40)	**0.001**	1.37 (1.08-1.74)	**0.009**
Female parent smoke						
No	2878	14.62	1		1	
Yes	92	34.78	3.11 (2.00-4.83)	**0.000**	2.58 (1.57-4.23)	**0.000**
Sex of child						
Female	1512	13.49	1		1	
Male	1572	16.73	1.28 (1.05-1.57)	**0.012**	1.35 (1.08-1.70)	**0.008**
Child ever breastfed						
No	957	15.10	1		1	
Yes	2086	15.34	1.03 (0.83-1.27)	0.777	1.10 (0.86-1.40)	0.436
Child used Analgesic/antibiotic in the past 12 months						
Never	435	5.28	1		1	
At least once a year	909	14.41	3.01 (1.90-4.77)	**0.000**	2.29 (1.41-3.71)	**0.001**
At least once per month	1650	18.24	3.99 (2.57-6.19)	**0.000**	3.04 (1.92-4.81)	**0.000**
Truck traffic where your child lives on weekdays						
Never	509	13.75	1		1	
Seldom	729	15.08	1.11 (0.80-1.54)	0.512	1.00 (0.69-1.45)	0.966
Frequently	704	17.61	1.34 (0.97-1.84)	0.071	1.22 (0.85-1.75)	0.270
Almost all day	1053	14.24	1.04 (0.76-1.41)	0.793	1.00 (0.71-1.42)	0.960
Cat in the house (past 12 months)						
No	2830	17.18	1		1	
Yes	220	21.36	1.58 (1.12-2.21)	**0.008**	1.83 (0.65-5.12)	0.246
Female parent level of school completion						
Secondary	1846	12.56	1			
University	449	22.71	2.04 (1.57-2.65)	**0.000**	1.84 (1.36-2.49)	**0.000**
Other	413	17.43	1.46 (1.10-1.96)	**0.009**	1.30 (0.94-1.80)	0.106
Primary	241	18.67	1.59 (1.12-2.27)	**0.009**	1.39 (0.90-2.16)	0.129
How does the child get to school[g]						
Walk	1633	13.16	1		1	
Taxi/bus	828	15.57	1.21 (0.96-1.54)	0.103	1.31 (1.00 -1.71)	**0.048**
Motor car	518	21.62	1.81 (1.41-2.34)	**0.000**	1.74 (1.27-2.38)	**0.000**
Combination	57	12.28	0.92 (0.41-2.06)	0.846	1.07 (0.46-2.49)	0.863
Other	23	4.34	0.29 (0.04-2.23)	0.240	0.32 (0.04-2.48)	0.279

[a] The Totals for individual risk factors differ owing to the absence of values. [b] The statistically significant values for the crude OR and less than 0.05 for the adjusted OR are highlighted. [c] Model adjustments were made for all the variables in the table. 1: Unless declared in another manner, the referent category for individual risk factors is the lack of the risk factor.

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Table 3 shows the multiple logistic regression analysis of risk factors for Wheeze ever, Current Wheeze, Current Severe Wheeze and Asthma ever for rural and urban areas, with their respective odds ratios. Both urban and rural area children who lived with one or more people who smoked in the same house (WE: OR 1.44, 95% CI 1.11-1.86) (CW: OR 2.09, 95% CI 1.38-3.16) and (AE: OR 2.49, 95% CI 1.12-5.54) were found to have an increased likelihood for having Wheeze ever, Current Wheeze and Asthma ever as compared to those who lived with non-smokers. Moreover, those children exposed to smoking at the restaurant for one or more days in the past 30 days (CW: OR 2.27, 95% CI 1.17-4.38) were more likely to present with current wheeze as compared to those who lived with non-smokers.

In the context of combined rural and urban areas, Wheeze Ever and Current Wheeze shared similar ETS risk factors. The occurrence of symptoms was shown to be significantly higher in cases when a female parent or caregiver engaged in smoking behaviour. The crude odds ratios (OR) for Wheeze Ever and Current Wheeze were 3.11 (95% CI 2.00-4.83), and 3.12 (95% CI 1.90-5.12), respectively. In addition, there was a notable relationship between the number of smoking individuals residing in the same household as pre-schoolers and the likelihood of developing Wheeze ever, Current Wheeze, and Current Severe Wheeze. The adjusted odds ratios for these associations were 1.37 (1.08-1.74), 2.09 (1.38-3.16), and 2.46 (1.25-4.85), respectively, as indicated in Table 4, Table 5, and Table 6.

Table 5. Participants (combined Rural and Urban areas) prevalence of current wheeze with their respective odds ratios.

Variables	Total[a]	Prevalence (%)	Crude OR[b] (95% CI)	P	Adjusted OR[b,c] (95% CI)	P
Female parent ever asthma						
No	2453	8.35	1		1	
Yes	79	26.58	3.97 (2.36-6.67)	**0.000**	5.59 (2.77-11.26)	0.000
Child used Analgesic/antibiotic in the past 12 months						
Never	440	1.81	1		1	
At least once a year	906	6.95	4.03 (1.91-8.49)	**0.000**	3.41 (1.17-9.95)	0.024
At least once per month	1656	12.86	7.97 (3.90-16.27)	**0.000**	4.74 (1.68-13.40)	0.003
Truck traffic where your child lives on weekdays						
Never	508	8.66	1		1	
Seldom	727	8.80	1.01 (0.68-1.52)	0.931	1.04 (0.55-1.94)	0.902
Frequently	702	11.82	1.41 (0.96-2.07)	0.078	1.13 (0.60-2.22)	0.695
Almost all day	1064	8.74	1.01 (0.69-1.47)	0.958	0.86 (0.45-1.64)	0.653
Female parent job industry						
Private sector	567	8.28	1		1	
Government sector	347	12.96	1.64 (1.06-2.54)	**0.024**	1.38 (0.73-2.60)	0.317
Self-employed	301	9.96	1.22 (0.75-1.98)	0.409	1.18 (0.73-2.32)	0.629
Not employed	1721	9.18	1.11 (0.79-1.57)	0.519	0.69 (0.41-1.17)	0.177
Dog in the house (past 12 months)						
No	2742	8.75	1		1	
Yes	320	14.68	1.79 (1.28-2.51)	**0.001**	1.27 (0.70-2.32)	0.419
Female parent smoke						
No	2884	9.01	1		1	
Yes	93	23.65	3.12 (1.90-5.12)	**0.000**	0.65 (0.20-2.15)	0.488
People living in the same house as your child smoke?						

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Zero	2008	7.86	1		1	
One or more	823	13.12	1.78 (1.36-2.29)	**0.000**	2.09 (1.38-3.16)	**0.000**
Child exposure to smoking at the car (past 30 days)						
Never	1368	9.50	1		1	
One or more days	69	11.59	2.37 (1.31-4.30)	**0.004**	2.27 (1.17-4.38)	**0.014**
Child ever breastfed						
No	959	8.65	1			
Yes	2090	8.65	1.15 (0.88-1.50)	0.293	1.40 (0.88-2.23)	0.154

[a] The Totals for individual risk factors differ owing to the absence of values. [b] The statistically significant values for the crude OR and less than 0.05 for the adjusted OR are highlighted. [c] Model adjustments were made for all the variables in the table. 1: Unless declared in another manner, the referent category for individual risk factors is the lack of the risk factor.

Table 6. Participants (combined Rural and Urban areas) prevalence of current severe wheeze with their respective odds ratios.

Variable	Total[a]	Prevalence (%)	Crude OR[b] (95% CI)	P	Adjusted OR[b,c] (95% CI)	P
People living in the same house as your child smoke?						
Zero	2028	0.98	1		1	
One or more	827	2.17	2.23 (1.17-4.24)	**0.014**	2.46 (1.25-4.85)	**0.009**
Sex of child						
Female	1524	0.78	1		1	
Male	1592	1.75	2.25 (1.14-4.45)	**0.019**	2.30 (1.09-4.84)	**0.027**
Child plays with dogs/cats						
No	2535	1.18	1		1	
Yes	556	1.61	1.27 (0.64-2.91)	0.407	0.95 (0.41-2.22)	0.919
Child used Analgesic/antibiotic in the past 12 months						
Never	440	0.22	1		1	
At least once a year	917	1.09	4.84 (0.61-37.92)	0.133	4.34 (0.54-34.68)	0.166
At least once per month	1666	1.56	6.95 (0.94-51-42)	0.057	6.14 (0.82-45-75)	0.077
Truck traffic where your child lives on weekdays						
Never	513	1.36	1		1	
Seldom	731	0.82	0.59 (0.19-1.79)	0.358	0.46 (0.14-1.48)	0.196
Frequently	709	1.12	0.83 (0.29-2.28)	0.712	0.65 (0.23-1.85)	0.428
Almost all day	1070	1.68	1.23 (0.51-2.98)	0.636	0.89 (0.35-2.23)	0.808
Child ever breastfed						
No	964	1.14	1		1	
Yes	2108	1.37	1.20 (0.60-2.42)	0.595	1.16 (0.55-2.45)	0.690
Female parent job industry	571	0.87	1		1	
Private sector	349	2.29	2.65 (0.86-8.18)	0.089	2.20 (0.68-7.08)	0.185
Government sector	303	1.98	2.28 (0.69-7.55)	0.175	2.23 (0.66-7.47)	0.192
Self-employed	1736	1.15	1.31 (0.49-3.53)	0.581	1.09 (0.39-3.00)	0.859
Not employed						

[a] The Totals for individual risk factors differ owing to the absence of values. [b] The statistically significant values for the crude OR and less than 0.05 for the adjusted OR are highlighted. [c] Model adjustments were made

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for all the variables in the table. 1: Unless declared in another manner, the referent category for individual risk factors is the lack of the risk factor.

Some of the confounders that showed significant associations with Wheeze Ever in both rural and urban areas were children pre-schoolers using analgesic/antibiotics in the past 12 months at least once a year (adjusted OR 2.29, 95% CI 1.41-3.71) and pre-schoolers using a motorcar as their mode of transportation to school (adjusted OR 1.74, 95% CI 1.27-2.38) (refer to Table 4). The male gender was shown to be associated with a higher probability of experiencing both Wheeze ever (OR 1.35, 95% CI 1.08-1.70) and Current Severe Wheeze (OR 2.30, 95% CI 1.09-4.84) according to the data presented in Table 4 and Table 6. Having a female parent or caregiver who worked in the government sector was shown to be associated with an elevated probability of experiencing Current Wheeze, as indicated by an odds ratio of 1.64 (95% CI 1.06-2.54), as presented in Table 5. The presence of a dog in the household during a period of 12 months has been found to be associated with an increased probability of experiencing both Current Wheeze (OR 1.79, 95% CI 1.28-2.51) according to the crude odds ratios reported in Table 5.

4. Discussion

This study aimed to assess the association between environmental tobacco smoke exposure and the occurrence of wheeze, a common symptom of asthma, among pre-school children residing in rural and urban areas of Mpumalanga province, South Africa. The reported prevalence of wheeze in Mpumalanga is similar to that observed in previous research. Based on the findings of the ISAAC Phase Three study, it was determined that the worldwide prevalence of current wheeze among school-aged children was 11.5%. This prevalence showed significant regional variation, varying from 6.8% in the Indian subcontinent to 21% in Oceania [21]. Furthermore, the prevalence of current wheeze (10%) and lifetime asthma (3.4%) in Africa exhibited a comparable pattern to the outcomes observed in our study [21]. Additionally, the findings of Wichmann et al. [22] who conducted a study on the potential risk factors for asthma symptoms in school-aged children from Polokwane Limpopo province in South Africa, using the ISAAC questionnaire, support our study results. The prevalence of wheeze (11.2%) and severe wheeze (5.7%) observed in their study aligns with the findings of our study.

The potential influence of various factors on the prevalence of asthma symptoms within a given region can be attributed to several key variables, including the age range of children considered in the study, the prevailing climate conditions, the specific timing of the study, the size of the sampled population, the design of the study itself, and the presence or absence of certain risk factors. Research studies that specifically examine children within similar age groups, as well as children residing in a particular place for a duration beyond six months, have found comparable rates of asthma symptom prevalence. Based on the aforementioned findings, it is evident that the management of asthma symptoms poses a persistent problem. Consequently, it may be necessary to formulate and execute strategies aimed at mitigating these symptoms within this specific demographic promptly.

This study found that there was a higher prevalence of wheeze ever and asthma ever among pre-schoolers living in urban areas compared to those residing in rural areas. Consistent with the results of our study, Chakravarthy et al, [23] Wehrmeister et al, [24] Feng et al, [25] and Kutzora et al [26] conducted research in India, Brazil, China, and Germany respectively, which also indicated a greater prevalence of asthma symptoms among children residing in urban regions compared to those dwelling in rural areas. The present study found that children residing in the Mpumalanga Highveld region were predominantly impacted by wheeze ever, a common symptom of asthma, as well as a history of asthma ever, particularly if they attended an urban pre-school. The results of our study align with the majority of existing literature, which consistently demonstrates that residing in rural areas or on farms, being exposed to livestock, and the hygiene hypothesis confers protective advantages against the development of asthma symptoms in childhood, compared to children residing in urban areas [26–30]. Additionally, our research findings provide support for the notion

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that children residing in urban areas are more prone to increased exposure and heightened sensitivity to several risk factors associated with asthma symptoms [29,31].

The study outcome indicated above may have been influenced by specific environmental factors. The regions of Mpumalanga Highveld exhibit a notable deterioration in air quality, with heightened levels of pollutants stemming from both industrial and non-industrial origins. The district encompasses a variety of sectors, namely power generating, petrochemical, primary metallurgy, and open-cast mining. Urban environments possess a multitude of modifiable exposures that can impact the prevalence and morbidity of asthma symptoms. In the aggregate of both rural and urban areas, boys had a greater propensity for experiencing wheeze ever at any point and current severe wheeze in comparison to their girls' counterparts.

This observation aligns with previous research indicating that boys consistently have a higher incidence of wheezing and/or asthma symptoms relative to girls [32–34].

Risk factors and confounders associated with wheeze, a symptom commonly observed in individuals with asthma, were identified in our study. The risk factors with the highest potential for modification encompassed a female parent who engages in smoking, a male parent who engages in smoking, the number of individuals residing in the same household as a child who engages in smoking, exposure to smoking within the home (within the previous 30 days), exposure to smoking within a motor vehicle or transportation (within the previous 30 days), exposure to smoking within a restaurant (within the previous 30 days), the mode of transportation utilized to commute to school, and ownership of a pet.

This study found that pre-schoolers were more likely to experience wheeze ever and current wheeze in their lives, if they had a female parent or caregiver who smoked and also those who lived in the same household with one or more people who smoked. Those who were exposed to smoking in cars and restaurants in the past 30 days were more likely to present with current wheeze. The results of our study are consistent with existing literature, which indicates that children are primarily exposed to environmental tobacco smoke (ETS) through smoking by adults in environments where children reside and engage in recreational activities. This exposure significantly increases their susceptibility to developing asthma and respiratory symptoms [17,30,35,36].

According to studies conducted by Tsai et.al. [37] and Shahunja et al. [38] there exists a significant relationship between the prevalence of asthma symptoms in children and their exposure to household tobacco smoke. Moreover, Wang et al. [39] conducted a study that revealed a significant relationship between the presence of wheezing symptoms in children and their exposure to second-hand smoke. In addition, Tabuchi et al. [40] and Harju et al. [41] also reported that children who had two smoking parents were more likely to have asthma symptoms and had a greater chance of asthma attacks relative to children with non-smoking parents [42]. Tsai et al [43] provided additional support for the aforementioned results, since they demonstrated that the combined exposure to smoking from both fathers and mothers amplifies the impact of asthma symptoms. According to the findings of Jung et al. [44] there was a notable relationship between parental smoking and an increased incidence of respiratory complaints among children, as compared to those whose parents did not smoke.

Although the presence of second-hand smoke has been identified as a significant indicator of asthma symptoms, there remains a lack of consensus regarding the specific threshold at which exposure to smoking becomes detrimental. It is thus highly advisable to completely refrain from exposure to second-hand smoke and to ensure that household members who smoke confine their smoking activities to isolated areas that are inaccessible to these children [45]. Parents should additionally take into consideration the implementation of a prohibition on smoking within the confines of their residence or its immediate vicinity.

Additionally, our study revealed that preschool-aged children who have been subjected to ETS in cars or transport without a complete physical barrier within the last 30 days were shown to have a higher likelihood of experiencing current wheeze. In addition, our research revealed an association between the utilization of motor vehicles for transportation to school among preschool-aged children and an increased likelihood of experiencing wheeze ever.

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The anticipated outcomes of this study are in line with expectations, as the act of parents or caregivers smoking in the car during the transportation of children to school has been found to elevate exposure to ETS and therefore raise the probability of experiencing symptoms associated with asthma. The existing body of literature on the exposure of children to ETS and its impact on the development of respiratory and asthma symptoms provides substantial data that aligns with the findings of the aforementioned study [15–17,35,46]. Additionally, the use of motor vehicles may contribute to an increased likelihood of experiencing symptoms associated with asthma. Gasana and colleagues [47] conducted a study that corroborated the aforementioned findings, as they concluded that children who are exposed to elevated amounts of air pollution from motor vehicles are more likely to exhibit symptoms of childhood wheezing. It is advisable to prioritize the avoidance of ETS exposure as a crucial factor in mitigating the onset and facilitating the control of asthma and related symptoms [48].

5. Strength and Limitation of the Study

Firstly, the ISAAC questionnaire is a valid tool for data collection for this investigated population group and has been utilized worldwide in studies investigating asthma symptoms. Secondly, this study had a great participation rate with over 3000 children, which is a requirement by ISAAC centres, thus increasing the study's statistical power. Final: The implementation of a standardized and validated tool facilitates the ability to compare study findings with those of other studies conducted at various levels, including local, regional, and international contexts.

The study outcomes may deviate slightly from the actual prevalence of investigated symptoms due to the presence of missing data. Future research endeavours should prioritize the meticulous completion of questionnaires, aiming to minimize the occurrence of missing data to a significant extent. The study gathered data from the past year by using a parental-completed questionnaire. It was anticipated that these parents, who primarily reside with the children, would be able to accurately recall the information requested. The one-year timeframe was considered sufficient for recollection, without posing significant obstacles.

6. Conclusions

The study found that in Mpumalanga, pre-schoolers living in urban areas had a higher prevalence of wheeze ever, current wheeze, current severe wheeze and asthma ever relative to rural pre-schoolers. The presence of ETS exposure among preschool-aged children in various settings, including their homes, restaurants, and during transportation, increased the probability of experiencing wheezing. The implementation of smoking limits and prohibition is crucial in areas that are frequented or utilized by children. Hence, it is imperative for healthcare providers to actively champion the rights of individuals who do not smoke within the society, while also endorsing legislative measures aimed at curtailing tobacco smoke exposure.

Author Contributions: RM: JS, and KV participated in the study's design, RM was involved in the data collection and statistical analysis, and RM, JS, and KV were involved in interpreting the results and drafting and critically revising the manuscript. The published version of the work has been reviewed and approved by all authors.

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Institutional Review Board Statement: The present study received approval from the University of Pretoria Research Ethics Committee (Ethics Number: 766/2019), as well as the Gert Sibande District Municipality - Environmental Health Department and school principals. Consent for participation in the study was obtained from all parents and caregivers of the children.

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Informed Consent Statement: Prior to their participation in the study, parental or caregiver agreement was obtained for the children.

Data Availability Statement: We did not receive ethics approval to share raw field data publicly. The data belong to the University of Pretoria (UP). The raw data analysed in the current study are available from UP on reasonable request.

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Abbreviations

ETS- environmental tobacco smoke
OR- odds ratio
ISAAC- International study of asthma and allergies in childhood
SD- standard deviation
CI- confidence interval
χ^2- chi square
P- *P* value

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