# **Original Research Article**

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# Risk factors for bronchial asthma among children in Medina city, Saudi Arabia: an ecological approach

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# **ABSTRACT**

**Background:** Asthma is a common disease in Saudi Arabia that affects many individuals. Children are profoundly affected, and the impact of the disease is noticeable in the frequent visits to the emergency departments, missed school days, recurrent hospitalizations, and high death rates. Our study is aimed at identifying the determinant of bronchial asthma risk factors based on the ecological model.

**Methods:** A case-control study was conducted. Samples were randomly selected from two major hospitals in Medina Region, Saudi Arabia, including children aged between 1-14 years. A chi-square test was used to see any differences across categories between cases and control. Significant factors associated with asthma in bivariate analysis were submitted to conditional multivariate logistic regression analysis.

**Results:** Factors significantly associated with asthma were being obese (OR=5.10; 95% CI 2.09-12.42), having a history of allergic rhinitis (OR=7.10; 95% CI 3.24-15.52), born preterm (OR=6.06; 95% CI 2.05-17.87), living in a carpeted home (OR=3.06; 95% CI 1.41-6.64), using a gas stove (OR=9.09; 95% CI 3.93-21.03), playing with plush toys (OR=4.58; 95% CI 2.04-10.30), living in a home distanced less than 500 meters from the main traffic road (OR=3.68; 95% CI 1.27-10.70), less than 500 meters from a plant farm (OR=3.78; 95% CI 1.68-10.70), and less than 500 meters from an electric station (OR=5.57; 95% CI 1.73-17.93).

**Conclusions:** This study confirms the associations between individual, outdoor-indoor environmental factors, and bronchial asthma among children in Medina. This study is a step forward into the future of interventional programs to control bronchial asthma among children.

Keywords: Bronchial asthma, Ecological model, Saudi Arabia, Risk factors, Children

### **INTRODUCTION**

Asthma is a chronic inflammatory disease that affects millions of individuals worldwide. The prevalence is variable globally, and it affects both children and adults. Childhood asthma harbors various multifactorial diseases with common clinical aspects. The condition is a common heterogeneous chronic disorder that affects one's airways, and it is characterized by symptoms such as bronchial hyper-responsiveness, airflow barriers, and inflammation.

The adverse effects of the disease are exemplified in the patients, their families, and the community at large. Children are profoundly affected, and the impact of the disease is noticeable in the frequent visits to the emergency departments (ED), missed school days, recurrent hospitalizations, and high death rates. The prevalence of asthma has augmented globally, especially among children. About 7 to 12% of the world's children had asthma, and the leading cause of emergency visits among children was an asthmatic attack. In Italy, the prevalence

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of asthma has increased by 38% during the past 20 years.<sup>3</sup> A study in Malaysia stated that the prevalence of children diagnosed with bronchial asthma in Kuala Lumpur was 13.8%.4 Furthermore, in Shanghai city, China, the total number of asthma admission among children under the age of 4 years was higher than children 5 to 14 years of age.<sup>5</sup> According to the middle east, asthmatic children's prevalence was 7.57%.6 On the other hand, Bagdad in Iraq had the highest prevalence, which was 22.3%.7 In conclusion, middle eastern countries had a lower prevalence of asthmatic children than the developed country as in (United Kingdom 25.9%, Australia 31% and Turkey 17.8%), contrarily, middle eastern countries had a higher prevalence of asthma among children in contrast with some developing countries as in India 4.9% and Taiwan 6%.8

Asthma is a common disease in Saudi Arabia that has affected many individuals. The prevalence of asthma among Saudi children varies from region to region in Saudi Arabia. The Saudi initiative for asthma (SINA) states that the prevalence of asthma among children in the country ranges from 8% to 25%.9 The inferences were made from studies carried out in the past three decades. Asthma has been considered the most dominant chronic illness in Saudi Arabia. Local studies indicate that the prevalence rates among children are steadily increasing on annual basis. Additionally, elements such as knowledge level of caregivers, socio-economic status, and family incomes heighten the magnitude of the disease burdens. Many children with asthma in Saudi Arabia tend to be undertreated, under-diagnosed, and are susceptible to acute complications. The aspects result in increased costs of acute care services, missed school opportunities, and deteriorated quality of life. There are many causes of bronchial asthma pathogenesis in children. Genetic predisposition, asthmatic parents, exposure to different environmental factors, indoor-outdoor air pollution, prenatal and early childhood, smoking during pregnancy, maternal infections, and mode of birth delivery are all some of the common causes of bronchial asthma pathogenesis in children. In terms of genetics, children whose parents are asthmatic tend to have asthma by three years due to lower airway obstruction. <sup>10</sup> Asthma morbidity is strongly related to children with positive family history, especially in first-degree relatives than those with negative family history. 11 Furthermore, breastfeeding plays a significant role in the protection of infants from asthma and other allergic diseases.<sup>12</sup> The prevalence of asthma in breastfed children was 6.8% compared with those not breastfed 11%. 12 The integration of environmental factors with genetic predisposition plays an important role in asthma etiology. 13

However, no definite factor can account for the augmenting rates of childhood asthma in Saudi Arabia over the past decades. It is considered that the aggregation of environmental changes can slightly account for the increased prevalence of asthma. <sup>14</sup> Environmental risk factors include indoor and outdoor air pollution

responsible for 3% of disability-adjusted life years lost in 2010.<sup>15</sup> Air pollution and mold considered risk factors for asthma, according to a study conducted in Taiwan.<sup>16</sup> Children had the highest risk of exposure to outdoor environmental pollution because they spent most of their time playing outside their homes.<sup>17</sup> Besides, children, who lived near to traffic road they exposed to particulate matter (PM) 2.5 and had a higher probability of developing asthma.<sup>18</sup> The presence of carpet in the home increases the risk of asthma to the double (OR=2.06, 95% CI=1.19-3.58).<sup>17</sup>

Different factors are associated with asthma aggravation. Tobacco smoke, incense, sandstorm, and seasonal variation are all known to exaggerate childhood asthma. In Canada, England, and Wales, the prevalence of children's hospitalization was high during autumn; however, in Greece, the Athena region, asthma hospital admission was higher in winter and spring. 19 Overall, various studies have been conducted to ascertain the increased prevalence of asthma in Saudi Arabia and worldwide. However, less has been achieved in regards to the genetics, immunology, and environmental factors that propel the development of childhood asthma. According to SINA, the increase rate is influenced by different factors, such as community modernization and environmental changes. Over the past decades, the prevalence of childhood asthma has rapidly increased due to asthma awareness campaigns that have allowed more individuals to be diagnosed. Other factors include lifestyle changes associated with changing diets, modernization of the Saudi society, and the presence of harmful environmental aspects such as climate changes, sandstorms, factory smoke, dust, and tobacco.<sup>20</sup> Risk factors of asthma are multifactorial, and researches that focus on recognizing risk factors using an ecological framework are limited. Our study fills the gap by identifying the determinant of bronchial asthma based on the ecological model. This theoretical framework focuses on identifying early childhood risk factors for bronchial asthma, including individual and environmental factors, family, and community. Ecological system theory is essential to understand individual, environmental, and interactive effects in determining the risk factors of asthma.

#### **METHODS**

A case-control study was conducted among 338 participants (169 cases and 169 controls). The study was done from January 2019 to December 2019. The following assumptions and inputs were used to calculate the sample size; 2 level confidence of 95%, a power of 80% and 1:1 ratio of cases to controls, the estimated prevalence of exposure among controls is 40%, a wanted odds ratio of 2.0, the total required sample size was 270 (135 cases and 135 controls). However, taking into account the uncertainty of our assumptions, we increased the sample size by 25%. Data were collected via personal interviews with cases and controls. Parents of children aged 1-14 years participated in this study. The participants were

recruited from two major pediatric department hospitals in Medina, Kingdom of Saudi Arabia. Eligible participants for cases had to be a Saudi child, presented with an asthma attack to the emergency department, aged 14 years old and younger, and living in the Medina area. Eligible participants for control had to be a Saudi child, nonasthmatic; no history of asthma diagnosis, respiratory diseases or asthma medication, no history of asthmatic symptoms that exacerbated by asthma triggering factors, aged 14 years old and younger, and living in Medina area. Exclusion criteria were: chronic respiratory diseases, immunocompromised child, child with congenital anomalies, non-Saudi child, and living outside the area of Medina. All participants that met the criteria were participated in this study after being informed about its purpose. Consent was obtained from all participants. The study received ethical approval from the institutional review board (IRB) at King Abdulaziz University for Health Sciences (KSAU-HS), King Abdullah International Medical Research Center (KAIMRC). Children were recruited randomly during their visit to the emergency department and other pediatric departments for both cases and controls, respectively. Eligible cases were matched to controls by gender and age (±6 months).

Data were collected using a structured questionnaire by personal interviews with cases and controls. The survey was extracted from similarly conducted studies worldwide. targeted variables consisted of personal characteristics, medical history, family history, and environmental exposures (indoor and outdoor). The questionnaire consisted of four domains; sociodemographic data, child asthma history, family history, and sources of indoor-outdoor air pollution. The first part of the questionnaire included demographic and residence information. The demographic data included; age, gender, level of education, and monthly income. The residence information covered the region of residence and the type of housing. The second part of the questionnaire covered child asthma history, which includes: birth history, feeding history, history of allergic diseases, food allergy, and flu vaccination. The third part of the questionnaire covered the family history, which includes: total number of siblings, number of asthmatic siblings, parents, and sibling history of asthma or other allergic diseases. The fourth part of the questionnaire covered the sources of indoor and outdoor air pollution, which include; information about the residence and how it is far from main traffic road, public park, plant farm, animal farm, gas stations, electricity station, and factories. Also, it included: questions about exposure to a sandstorm, climate instability, use of air fresheners and incense, smoking, the presence of carpets, use of air filter or dehumidifiers, kerosene heater, gas stove, and plush/stuffed materials.

The validity of the questionnaire was confirmed by content validation as the questionnaire covered the relevant scientific area for the topic according to experts' opinions. Face validity did, and all questionnaire questions were clear, understandable, and measured what it rationales to

measure. The internal consistency of the instrument was good, and overall, Cronbach's coefficient alpha of 0.85.

To assess reliability, test-retest reliability was completed with 20 participants, and the assessment tool gave consistent results for the second time after ten days, indicating that the questionnaire has achieved stable reliability (kappa was 0.8875 and agreement of 91.58%). Data were analyzed with STATA software program, version 14. Continuous data presented as mean and standard deviation and categorical data presented as frequencies. Besides, a chi-square test was done to see any differences across categories between cases and control. Significant factors associated with asthma in bivariate analysis were submitted to multivariate logistic regression analysis for cases and control. Conditional regression analysis was done for the study variables to assess the likelihood of these risk factors on asthmatic outcomes. In addition, stepwise backward elimination was done. A confidence interval of 95% and a p-value of 0.05 were used as a significant value.

#### **RESULTS**

A total of 338 (169 cases and 169 controls) parents were asked to take part in this study. The sample of participating children was approximately equally divided between males (49.7%) and females (50.3%), with the majority (52.7%) of children between the ages of 1 to 5 years. The mean ages for cases and control were 1.68 ( $\pm 0.8020$ ). In terms of monthly household income, 55.9% of cases reported an income of more than 15,000 Saudi Riyals (SAR), and 53.1% of controls reported an income between 5000 and 10,000 SAR per month. Most (84.9%) of the participating children were classified as obese. Among cases, 63.41% were obese, whereas 36.7% of controls were obese (p<0.001). There was a significant difference in the cases and controls regarding living in apartment buildings versus a house, participating cases living in an apartment building at higher proportions than controls (45.5% versus 42.6%; p<0.001). There was no significant association between bronchial asthma and gender (p-value), parent's education (p-value), and income (p-value) (Table 1). According to the child's medical history, 72.8% of children were born full-term, whereas 48.52% were born preterm. Regarding breastfeeding, 72.8% of participating children were exclusively breastfed for six months. Approximately 15.4% of the children had a positive history of food allergy, a positive history of allergic rhinitis (38.2%), and early life use of antibiotics (47.1%). Additionally, a high percentage of participants (74.3%) had a history of eczema. There was a significant difference by bronchial asthma status (cases versus controls) and preterm childbirth (67.5% versus 29.6%; p=0.025), exclusive breastfeeding for 6 months (79.4% versus 20.7%; p<0.001), history of bronchitis (91.3% versus 8.7%; p<0.001), history of allergic rhinitis (50.9% of versus 25.4%; p<0.001), history of eczema (37.9% versus 62.2%; p<0.001), and use of antibiotic before the age of one year (88.3% versus 11.7%; p<0.001). According to family history, 60.0% of participants had an

asthmatic sister or brother, 53.84% of them had parents with bronchial asthma, and 55.0% had a parent's history of allergic diseases. A significantly higher proportion of parents had a history of bronchial asthma (79.4% versus 37.3%; p<0.001) and history of allergic diseases (72.2% versus 39.6%; p<0.001) among bronchial asthma cases compared to non-asthmatic control children. Furthermore, the proportion of cases who had an asthmatic sister or brother was significantly higher than that of controls (77.5% versus 22.5%; p<0.001). The results for this section are presented in Table 1.

According to exposure to outdoor air pollution, almost half (54.1%) of participants had a backyard, and 24.9% reported living close to livestock farms. Almost half (48.9%) of the participants' homes were situated near an electric station, a major traffic road (53.9%), a public park (52.9%), a gas station (49.4%), or near factories and refineries (48.8%). Asthmatic children cases varied significantly from non-asthmatic controls according to reporting having a backyard (74.9% versus 25.1%, p<0.001), being close to an animal farm (88.1% versus 11.9%; p<0.001), living in a home near a main traffic road (78.1% versus 29.6%; p<0.001) or near an electric station (92.1% versus 7.9% %, p<0.001). The prevalence of asthma was significantly associated with the distance of the home to plant farm; 65.7% of respondents with asthma lived near to plant farm compared with 13.6% of control. Furthermore, the prevalence of asthma was significantly associated with the distance of the home to public parks and factories, and refineries (76.3% versus 29.6%; p<0.001). The presence of factories or refineries near to home, less than 500 m, significantly varied among cases and control (69.1% versus 30.9%; p<0.001). Participants who reported that the distance of the home to the gas station less than 500 m were more likely to have bronchial asthma than those living far away (70.4% versus 28.4%, p<0.001) (Table 2).

According to exposure to indoor air pollution, almost half of participants living with a smoker (52.5%) and having a carpet at home (52.1%). A high percentage of children used plush toys (57.4%). 47.4% of participants using incense, which considers a habit among Saudis since ancient times. A significantly greater proportion of asthmatic children who used plush toys compared to non-asthmatic children (81.4% versus 18.6%; p<0.001). The prevalence of asthma was significantly associated with the presence of carpet at home (75.7% versus 38.4%; p<0.001). Besides, there was a significant association between bronchial asthma and children who lived with

smokers compared to those whom none (75.1% versus 24.9%; p<0.001). Participants who reported that usually using air fresheners and incense more likely to have bronchial asthma than those who did not use them. (77.1% versus 22.9%, p<0.001). Using firewood inside the home was significantly vary among cases and control (90.1% versus 9.0%; p<0.001). Furthermore, the prevalence of asthma was significantly associated with using a gas stove (54.4% versus 5.9%; p<0.001) (Table 2).

To assess the independent factors that are associated with bronchial asthma among children, all significant factors related to bronchial asthma in bivariate analysis were entered into a multivariate logistic model. Being obese (OR=5.10, 95% CI 2.09-12.42), having a history of allergic rhinitis (OR=7.10, 95% CI 3.24-15.52), born preterm (OR=6.06, 95% CI 2.05-17.87), having a carpeted home (OR=3.06, 95% CI 1.41-6.64), using a gas stove (OR=9.09, 95% CI 3.93-21.03), playing with plush toys (OR=4.58, 95% CI 2.04-10.30), living less than 500 meters away from the main traffic road (OR=3.68, 95% CI 1.27-10.70), less than 500 meters from a plant farm (OR=3.78, 95% CI 1.68-10.70), and less than 500 meters from an electric station (OR=5.57, 95% CI 1.73-17.93) were all independent risk factors for bronchial asthma among children in this study. The results for this section are presented in Table 3.

Approximately 87.6% of an asthma attack in children with asthma occurs in winter. Climate instability also triggers asthma attacks among 131 (77.5%) of participants. Additionally, exposure to sandstorm exaggerates asthmatic symptoms among 57.4% of participants. Furthermore, spending days in industrial cities exacerbate asthma attack among 50.4% of asthmatic cases. Moreover, using incense and air fresheners increases asthma attacks among 65.1% of asthmatic children. Living with a smoker exacerbates asthmatic attacks among 66.3% of asthmatic participants. On the other hand, receiving the flu vaccine plays a significant role in controlling asthma among 53.3% of asthmatic children, having an air filter, dehumidifier, and exhaust fan in-home help to control asthma attacks among asthmatic participants 50.3%, 77.5% and 68.0% respectively. Using pillow cover and mattress cover plays a significant role in controlling asthma attacks among 57.1% of asthmatic participants. The frequent use of protective masks in sandstorm conditions protects 65.1% from an asthmatic attack (Table 4). The control behavioral factor on the children in observation and the exacerbating factor on the children in observation is represented in Figures 1 and 2 respectively.

Table 1: Characteristics of study participants by bronchial asthma status.

Participants' characteristics	Total N (%)	Bronchial asthma N (%)	Non-bronchial asthma N (%)	P value
Age in years (μ=5.87; SD=4.0)				< 0.001
1-5	178 (52.75)	89 (50.00)	89 (50.00)	
6-10	88 (26.03)	44 (50.00)	44 (50.00)	
11-14	72 (21.30)	36 (50.00)	36 (50.00)	

Continued.

Participants' characteristics	Total	Bronchial asthma	Non-bronchial asthma	P
Gender	N (%)	N (%)	N (%)	value <0.001
Male	168 (49.70)	84 (50.00)	84 (50.00)	<0.001
Female	170 (50.29)	85 (50.00)	85 (50.00)	
Childhood obesity	170 (30.29)	85 (50.00)	83 (30.00)	< 0.001
Normal weight	51 (15.10)	15 (29.41)	36 (70.67)	<0.001
Overweight/obese	287 (84.91)	182 (63.41)	105 (36.67)	
Mother education	267 (64.91)	102 (03.41)	103 (30.07)	0.826
High school or less	196 (57.10)	97 (49.49)	99 (50.51)	0.820
More than high school	142 (42.01)	72 (50.70)	70 (49.30)	
Father education	142 (42.01)	12 (30.10)	70 (49.30)	0.584
High school or less	196 (57.10)	72 (48.32)	77 (51.68)	0.564
More than high school	149 (44.12)	97 (51.32)	92 (48.68)	
Income	149 (44.12)	71 (31.32)	92 (48.08)	< 0.001
<5000 SR	89 (26.33)	42 (47.18)	47 (52.81)	<0.001
5000 SR 5000-10 000 SR	113 (33.43)	53 (46.90)	60 (53.10)	
10 100-15 000 SR	102 (30.20)	55 (53.92)	47 (46.08)	
>15 000 SR	34 (10.11)	19 (55.88)	15(46.12)	
	34 (10.11)	19 (33.88)	13(40.12)	<0.001
Housing	165 (49.91)	75 (15 15)	00 (54.55)	< 0.001
Apartment building House	165 (48.81)	75 (45.45)	90 (54.55)	
	173 (51.23)	94 (42.64)	79 (57.79)	
Child medical history				0.025
Baby birth	164 (49 52)	114 (67 50)	50 (20 (0)	0.025
Preterm	164 (48.52)	114 (67.50)	50 (29.60)	
Full-term	246 (72.82)	55 (32.50)	191 (76.40)	0.001
Breastfed	246 (72.02)	0.6 (20, 02)	150 (60 00)	< 0.001
Yes	246 (72.82)	96 (39.02)	150 (60.98)	
No	92 (27.21)	73 (79.35)	19 (20.65)	0.762
Food allergy	70 (17.11)	25 (40.00)	25 (51 02)	0.763
Yes	52 (15.44)	25 (48.08)	27 (51.92)	
No	286 (84.62)	144 (50.35)	142 (49.65)	0.001
Bronchitis	120 (10.01)	125 (01.20)	12 (0.70)	< 0.001
Yes	138 (40.91)	126 (91.30)	12 (8.70)	
No	200 (59.21)	43 (21.50)	157 (78.50)	
Allergic rhinitis				< 0.001
Yes	129 (38.24)	86 (50.90)	43 (25.40)	
No	209 (61.92)	83 (49.10)	126 (74.60)	
Eczema				< 0.001
Yes	251 (74.34)	95 (37.85)	156 (62.15)	
No	86 (25.44)	73 (84.88)	13 (15.12)	
Antibiotic use <1 year				< 0.001
Yes	162 (47.01)	143 (88.27)	19 (11.73)	
No	176 (52.11)	26 (14.77)	150 (85.23)	
Family history				
Sibling	,			0.992
≤2	105 (31.10)	52 (49.52)	53 (50.48)	
3-4	163 (48.22)	82 (50.31)	81 (49.69)	
≥5	70 (20.01)	35 (50.00)	35 (50.00)	
Asthmatic child				< 0.001
Have asthmatic sister or brother	206 (60.04)	131 (77.50)	75 (44.40)	
No asthmatic sister or brother	132 (39.05)	38 (22.50)	94 (55.60)	
Parents bronchial asthma				< 0.001
Yes	182 (53.84)	119 (70.40)	63 (37.30)	
No	156 (46.23)	50 (29.60)	106 (62.70)	

Continued.

Participants' characteristics	Total N (%)	Bronchial asthma N (%)	Non-bronchial asthma N (%)	P value
Parents allergic diseases				< 0.001
Yes	189 (55.02)	122 (72.20)	67 (39.60)	
No	149 (44.12)	47 (27.80)	102 (60.40)	

Table 2: Outdoor and indoor exposures by bronchial asthma status (cases versus controls).

Participants' characteristics	Total N (%)	Bronchial asthma N (%)	Non-bronchial asthma N (%)	P-value
Outdoor exposure			•	
Backyard				< 0.001
Yes	183 (54.14)	137 (74.86)	46 (25.14)	
No	155 (45.94)	32 (20.65)	123 (79.35)	
Electric station				< 0.001
<500 m*	165 (48.90)	152 (92.12)	13 (7.88)	
≥500 m	173 (51.10)	17 (9.83)	156 (90.17)	
Animal farm				< 0.001
<500 m	84 (24.92)	74 (88.10)	10 (11.90)	·
≥500 m	254 (75.14)	95 (37.40)	159 (62.60)	
Traffic road				< 0.001
<500 m	182 (53.93)	132 (78.10)	50 (29.60)	
≥500 m	156 (46.20)	37 (21.90)	119 (70.40)	
Public park				< 0.001
<500 m	179 (52.94)	129 (76.30)	50 (29.60)	·
≥500 m	159 (47.04)	40 (23.70)	119 (70.40)	
Plant farm	•			< 0.001
<500 m	134 (39.64)	111 (65.70)	23 (13.60)	
≥500 m	204 (60.34)	58 (34.30)	146 (86.40)	
Gas station				< 0.001
<500 m	167 (49.40)	119 (70.40)	48 (28.40)	
≥500 m	171 (50.60)	50 (29.60)	121 (71.60)	
Factories and refineries				< 0.001
<500 m	165 (48.81)	114 (69.09)	51 (30.91)	
≥500 m	173 (51.20)	55 (31.79)	118 (68.21)	
Indoor exposure				
Living with smoker	-		-	< 0.001
Yes	177 (52.45)	133 (75.14)	44 (24.86)	
No	161 (47.63)	36 (22.36)	125 (77.64)	
Air fresheners and incense				< 0.001
Yes	157 (46.44)	121 (77.07)	36 (22.93)	
No	181 (53.60)	48 (26.52)	133 (73.48)	
Using firewood in the home	- , , , , , , , , , , , , , , , , , , ,			< 0.001
Yes	144 (42.60)	131 (90.97)	13 (9.03)	
No	194 (57.40)	38 (19.59)	156 (80.41)	
Floor covering	, ,		,	< 0.001
Carpeting	176 (52.10)	128 (75.70)	48 (38.40)	
No carpet	162 (47.92)	41 (24.30)	121 (71.60)	
Gas stove	`	<u>, , , , , , , , , , , , , , , , , , , </u>	, , , , , , , , , , , , , , , , , , ,	< 0.001
Yes	102 (30.17)	92 (54.40)	10 (5.90)	
No	236 (69.82)	77 (45.60)	159 (94.10)	
Plush toys		,	,	< 0.001
Yes	194 (57.40)	158 (81.44)	36 (18.56)	
No	144 (42.60)	11 (7.64)	133 (92.36)	
	, /		` /	

<sup>\*</sup>Meter

Table 3: Result of multivariate logistic regression for factors associated with bronchial asthma.

Variables	OR	95% CI	Wald	P-value
Rhinitis		•		< 0.001
Yes	7.10	3.24-15.52	4.91	
No (Ref.)*				
Childhood obesity				< 0.001
Overweight/ obese	5.10	2.09-12.42	3.59	
Normal weight (Ref.)				
Baby birth				< 0.001
Preterm	6.06	2.05-17.87	3.27	
Full-term (Ref.)				
Floor covering				0.004
Carpet	3.06	1.41-6.64	2.84	
No carpet (Ref.)				
Gas stove				< 0.001
Yes	9.09	3.93-21.03	5.16	
No (Ref.)				
Plush toys				< 0.001
Yes	4.58	2.04-10.30	3.69	
No (Ref.)				
Traffic road				0.016
<500 m**	3.68	1.27-10.70	2.40	
≥500 m (Ref.)				
Plant farm				< 0.001
<500 m	3.78	1.68-8.51	3.21	
≥500 m (Ref.)				
Electric station				0.004
<500 m	5.57	1.73-17.93	2.88	
≥500 m (Ref.)				

<sup>\*</sup>Reference; \*\*Meter

Table 4: Exacerbating factors and control behavioral measures associated with asthmatic attacks.

Participants' characteristics	N	%	95% CI
Exacerbating factors			
Seasonal variation			
Summer	3	1.78	00.40-05.10
Winter	148	87.57	81.61-92.12
Autumn	4	2.37	00.60-05.90
Spring	14	8.28	04.11-12.40
Climate instability	·		
Yes	131	77.51	71.22-83.84
No	38	22.49	16.24-28.85
Sandstorm			
Yes	97	57.40	49.93-64.92
No	72	42.60	35.10-50.14
Industrial cities*	·		
Yes	85	50.30	42.80-57.81
No	84	49.70	42.29-57.25
Air freshener and incense			
Yes	110	65.08	57.94-72.32
No	59	34.91	27.78-42.16
Living with smoker			
Yes	112	66.27	59.61-73.44
No	57	33.72	26.66-40.94

Continued.

Participants' characteristics	N	%	95% CI
Control behavioral measures			
Flu vaccine	·	- -	
Yes	90	53.25	45.74-60.81
No	79	46.74	39.20-54.36
Air filter			
Yes	85	50.30	42.80-57.81
No	84	49.70	42.29-57.25
Dehumidifier		·	
Yes	131	77.51	71.22-83.84
No	38	22.49	16.24-28.85
Pillow cover			
Yes	98	57.99	50.52-65.45
No	71	42.00	34.65-49.58
Mattress cover	·	•	•
Yes	98	57.99	50.52-65.45
No	71	42.00	34.65-49.58
Protective mask			
Yes	110	65.08	57.94-72.32
No	59	34.91	27.78-42.16
Exhaust fan			
Yes	115	68.04	61.04-75.15
No	54	31.95	24.90-39.06

<sup>\*</sup> Spending days per week in industrial cities

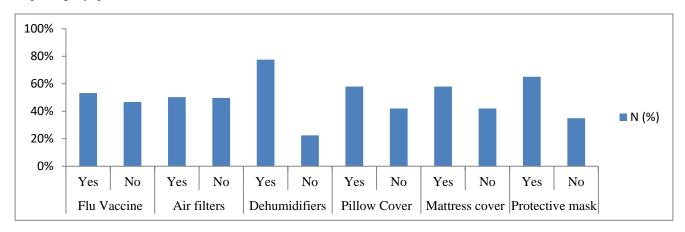


Figure 1: Graph representing control behavioral factor on the children in observation.

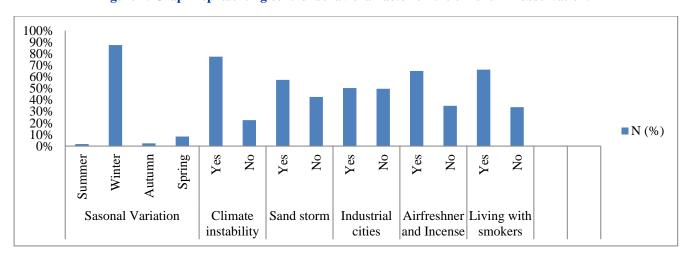


Figure 2: Graph representing the exacerbating factor on the children in observation.

# **DISCUSSION**

This study assessed a variety of risk factors contributing to bronchial asthma among children in a sample of asthmatic children as cases and non-asthmatic children as controls residing in Medina, Saudi Arabia. There was a significant association between the prevalence of bronchial asthma and a history of rhinitis, being overweight/obese, and born preterm. In addition, there was a significant association between bronchial asthma and living in a carpeted home, using a gas stove and plush materials. Furthermore, the prevalence of asthma was associated significantly with the distance of house to congested traffic road, plant farm, and electric station. This is consistent with our hypothesis and the result of preceding researches. In this study, the odds of children being asthmatic are almost 5.1 times higher among obese children compared to non-obese children. These findings coincide with other studies that reported that obesity considers as a risk factor for asthma among children, and it affects asthma management.<sup>21</sup> Another study reported that there was a significant association between overweight/obesity and asthma (RR= 1.19; 95% CI: 1.03-1.37; RR= 2.02; 95% CI= 1.16-3.50; respectively) compared with non-overweight/ non-obese children.<sup>22</sup> Furthermore, the incidence of asthma increased by 20% among overweight children and a two-fold higher risk among obese children.<sup>23</sup> Our findings showed children who born preterm had a higher risk of developing asthma than those born full-term. Similar to our finding, a study in the literature reported that children born preterm had a significantly higher odds of asthma than children born term.<sup>24</sup> Studies conducted wherever reported that children born preterm had high odds of asthma compared with children born full-term.<sup>25</sup> Allergic rhinitis, a risk factor for bronchial asthma, has been established among this population living in Medina. Children with a history of allergic rhinitis seven times more likely to be asthmatic than those without a history of rhinitis. This is consistent with the study that reported children with a history of allergic rhinitis had a higher risk of asthma.<sup>26</sup> Many other studies in literature support these findings and have shown the co-existence of allergic rhinitis and asthma.<sup>27</sup> Additionally, findings from this study suggested that living in a carpeted home consider a risk factor for bronchial asthma. This finding is consistent with the previous study that reported living in a carpeted home, double the risk of asthma due to sensitization to dust mites.9

A significant independent association was detected in this study between bronchial asthma and using a gas stove. The gas stove produces a high concentration of nitrogen dioxide (NO<sub>2</sub>), which is one of the commonest pollutant gas found indoors and outdoors, due to the combustion process.<sup>28</sup> A study conducted in 2000 reported that poorly ventilated kitchen and using a gas stove, significantly associated with asthma due to exposure to NO<sub>2</sub> and a high level of NO<sub>2</sub> concentration in the home lead to deterioration asthmatic children's status.<sup>28</sup> On the other hand, the randomized trial reported that the replacement of

gas stove with an electrical one reduce indoor  $NO_2$  concentration by  $40\%.^{29}$ 

In our sample, playing with plush (stuffed) materials increase the risk of a bronchial asthma diagnosis among children by almost fivefold. This was consistent with a study that reported the presence of stuffed animals in children's bedrooms statistically significant with the prevalence of asthma.30 Stuffed materials had been reported as a reservoir for germs and dust mites which trigger the immune system as suggested in another article.31 This current study reported that there was a significant association between bronchial asthma and proximity to traffic road due to pollution and PM 2.5. Asthma prevalence associated significantly with trafficrelated air pollution (OR=1.9). 32 Exposure to PM 2.5 and black carbon emission, which is related to traffic, increases the susceptibility to childhood asthma, but the impact of black carbon in child health is more than those of PM 2.5.<sup>12</sup>

Particularly this study specified a distance less than 500 meters from plant-associated significantly with asthma among this sample. A previous study from literature was reported that crop was a risk factor for respiratory symptoms specifically for bronchial asthma.<sup>32</sup> Also, greenhouse flowers were considered a significant risk factor for asthma in children by other studies.<sup>33</sup> Contrarily to our current findings regarding plant for this sample, the previous study conducted elsewhere has supported the claim that children who lived in a rural area and exposed to agriculture by residing or playing on plant farms had less chance for asthma and other atopic diseases compared to non-farm children.<sup>34</sup> Studies on literature support that exposures to agriculture in early life had a protective effect, while exposures to plant and agriculture in late-life exacerbate asthma symptoms.<sup>35</sup>

One additional outdoor risk factor for bronchial asthma was reported distance less than 500 meters from an electric station significantly associated with bronchial asthma among children. This is consistent with the study done in Canada to assess the distance from the power plant and pediatric emergency asthma visits for children and found an inverse association.<sup>36</sup> There was a significant association between Children living near a major coal-fired power plant and asthma.<sup>37</sup> It is known that coal considers the most utilized source for electricity production worldwide.<sup>37</sup> It releases a high concentration of pollutant gases and particulate matter include coal-fired power plants, sulfur dioxide, mercury arsenic, PM 10, and nitrogen oxide emissions.<sup>37</sup> Short-term exposures to ozone, nitrogen dioxide, sulfur dioxide, PM 2.5, consider as exacerbating factors for bronchial asthma symptoms; however, long-term exposures to air pollution conduce to new-onset asthma among children.<sup>38</sup>

# **CONCLUSION**

Bronchial asthma among children is a serious health concern and has profound negative implications that can

extend into adulthood. Our findings indicate that the main risk factors that contribute to childhood bronchial asthma in a population sample from Medina, are: being overweight, preterm born, history of rhinitis, presence of carpet at home, the use of gas stove, playing with plush toys, and living less than 500 meters away from electrical road station, public park or main traffic road. The evidence from this study suggests the importance of educating and raising awareness about bronchial asthma among children different levels; individual, family, environmental perspective in concordance with policy support. Further research is needed at the national level to better address the risk factors associated with bronchial asthma among children. Furthermore, this study is a step forward into the future of interventional programs to control bronchial asthma among children.

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