ORIGINAL ARTICLE

Allergic Rhinitis and Atopic Dermatitis in Association with Home Environment among Adolescents from Urban and Suburban Areas

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ABSTRACT

Introduction: This study aimed to determine the associations between home environment exposures and allergic rhinitis (AR) and atopic dermatitis (AD) among adolescents living in Hulu Langat, Selangor, Malaysia. **Method:** This comparative cross-sectional study involved adolescents residing in both suburban and urban areas within Hulu Langat district. Information on allergic rhinitis and home environment exposure was gathered from 546 adolescents aged 14-year-old using the International Study of Asthma and Allergies in Children (ISAAC) questionnaire. **Results:** The prevalence of AR and AD for urban and suburban adolescents were 59.8% and 40.2%, and 64.9% and 35.1%, respectively. A logistic regression analysis showed that frequency ETS exposure (OR=1.12, 95% CI= 1.02-1.24), furry pet (OR=1.20, 95%CI= 1.17-1.24), indoor painting (OR=1.26, 95%CI= 1.01-1.61), floor renovation (OR=1.70, 95%CI= 1.25-2.32), water leakage (OR=1.22, 95%CI= 1.19-1.26) and mold odor in the last 12 months (OR=1.51, 95%CI= 1.06-2.15) were associated with AR among adolescents living in urban areas. Nevertheless, floor renovation (OR=1.91, 95%CI= 1.01-4.04), water leakage exposure (OR=1.81, 95%CI= 1.03-3.19) and other odor last 12 months (OR=2.37, 95%CI= 1.32-4.25) exposures were linked to an increased likelihood of AR among adolescents from the suburban area. **Conclusion:** The findings suggest that various home environmental exposures play a significant role in the occurrence of AR among adolescents, emphasizing the need for improved home environment management to reduce allergy-related health risks.
Malaysian Journal of Medicine and Health Sciences (2026) 22(SUPP3): 62-68. doi:10.47836/mjmhs.22.s3.10

Keywords: Allergic rhinitis, atopic dermatitis, adolescents, urban, suburban

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INTRODUCTION

With a rapid development of economy and infrastructure in urban and suburban regions, allergic diseases have increased worldwide. In developed countries, the prevalence of allergic rhinitis (AR) and atopic dermatitis (AD) estimated in the range from 12% to 20% and 0% to 24%, respectively [1,2]. Review summarised that 2.23% of the world population were suffered from AD in year 2019 [3]. Furthermore, a review estimated the prevalence of AR in Malaysia to be 7.1%, with approximately 16.1% among adolescents aged 13-14 years [4]. Allergic diseases exert a significant clinical and socioeconomic burden on individuals. Studies have demonstrated that AR and AD are linked to a higher likelihood of developing various respiratory diseases conditions like asthma, airway hyperreactivity (AHR), and chronic obstructive pulmonary disease (COPD) [5].

Numerous reviews have shown that exposure to home environmental factors such as indoor painting, renovations, water leakage and dampness, mold, environmental tobacco smoke (ETS) exposure, pets and indoor pollutants can influence the development of AR and AD in adolescents [6,7]. However, the association between these home environmental factors and prevalence of AR and AD in urban and suburban settings has not been widely studied [8–10]. This scarcity of research on the effects of home environmental factors in urban and suburban environments on AR and AD provides an opportunity for further investigation into

these relationships. Moreover, review reported that geographical differentiation influenced the development and exacerbation of AR and AD among children and adults [11]. Additionally, urbanization, lifestyle, home environmental factors, and climate variations can significantly impact these conditions differently across locations and regions [12]. To the best of or knowledge, no previous study has been conducted in tropical country to determine the association between home environmental factors and AR and AD among adolescents from both urban and suburban areas. Therefore, understanding the relationship between these factors is crucial for assessing the impact in the society, planning health service, implementing preventive strategies.

This study aimed to determine the associations between home environment exposures and AR and AD among adolescents living in Hulu Langat Selangor. Investigating these associations in a Malaysian setting, characterized by its diverse urban-suburban landscape and ongoing development, will provide valuable insights into the specific risk factors relevant to this population.

METHODOLOGY

Study population

This cross-sectional study included 547 fourteen-year-old adolescents from 8 secondary schools located in the Hulu Langat district, Selangor, Malaysia. This district was selected due to its diverse urban and suburban regions and ongoing industrial and property development projects. Several areas within Hulu Langat (Kajang, Ampang Jaya, and Batu 9 Cheras) are classified as urban, with a total population of approximately 882,000 in 2010. These areas were designated as urban based on population size (over 80,000 individual within a 5-10 km radius area), central location, functional services, health and educational service levels, and economic growth potential. Suburban areas were defined as townships located on the outskirts of Kuala Lumpur, Kajang, Ampang Jaya (Ulu Langat), and Batu 9 Cheras, characterized by residential areas and fewer commercial activities than urban areas [13,14]. Data collection was conducted between August and November 2018. The study protocol was approved by the Universiti Putra Malaysia Ethics Committee for Research Involving Human Subjects (JKEUPM) (JKEUPM-2018-189), and written consent was obtained from guardians prior to the study's commencement.

Assessment of demographic and health data

A self-administered questionnaire, adapted from the International Study of Asthma and Allergies in Childhood (ISAAC), was used to gather data on allergic conditions, home environmental factors and demographic characteristics. For this study, a participant was considered to have allergic rhinitis (AR) if they answered "yes" to experiencing sneezing, a runny nose, or a blocked nose when not affected by a cold or flu over the past 12 months. Atopic dermatitis (AD) was defined by a positive response regarding a history of diagnosis and symptoms of an itchy rash lasting at least six months. Based on the provided addresses, adolescents' home locations were categorized as either urban or suburban. The completed questionnaires were cross-checked, verify responses, and clarify any uncertainties during in-person interviews conducted by the researchers.

Allergy skin test

Skin prick tests were administered to all participating adolescents after obtaining consent and assent. Five common aeroallergens, namely cat (Felis domesticus), house dust mite (Dermatophagoides pteronyssinus and Dermatophagoides farina), and fungi (Cladosporium herbarium and Alternaria alternate) (ALK-Abelly, Madrid, Spain) were tested on the anterior forearm. For quality control, histamine (10 mg/mL) acted as the positive control, whereas glycerol-saline functioned as the negative control. The allergic reaction was measured after 15 minutes by quantifying the mean diameter of the wheal using ruler. This procedure was conducted by trained medical assistants following the Australasian Society of Clinical Immunology and Allergy guidelines. Individuals were classified as atopic if they exhibited a positive skin prick reaction to one or more allergens tested [15].

Statistical analysis

Descriptive test analyses were performed by using the Statistical Package for the Social Sciences (SPSS) version 25.0 to examine the characteristics of study population characterised by urban and suburban areas. A comparative analysis of prevalence between urban and suburban areas for demographic characteristics, reported symptoms, and smoking status was performed using the chi-square test. The associations between home environmental factors and allergic conditions (AR and AD) were assessed using logistic regression, controlling for demographic (gender and ethnicity), smoking status, clinical variables (diagnosed asthma, atopic and parental allergy/asthma). The regression models were analysed using Stata/MP version 15.1 in which a two-sided alternative hypothesis at 5% significance level was used.

RESULTS

The personal characteristics of adolescents

Table I shows the comparison of personal characteristics between adolescents stay in urban and suburban areas. The majority of participants were Malay (87.9% overall), but the distribution differed significantly between urban and suburban locations. Suburban areas had a higher proportion of Malay participants (40.8%) compared to urban areas (59.2%). High proportion of doctor-diagnosed asthma were reported by urban adolescents (65.0%) than from suburban (35.0%), nevertheless, the

observed difference did not reach statistical significance (p > 0.05). Likewise, no statistically significant were observed in positive allergy prick test responses (atopy), parental allergy/asthma, smoking, or parental/sibling smoking between adolescents living in urban and suburban settings (p > 0.05). Allergic rhinitis (AR) was reported by 55.1% (301) of the overall study population, with similar rates observed in suburban (55.7%) and urban (54.8%) areas (p > 0.05). Meanwhile atopic dermatitis (AD) was reported by 14.8% (81) of the total study population, with 14.4% in suburban and 15.1% in urban areas (p > 0.05).

Table I: Personal characteristics of adolescents in urban and suburban areas

Characteristics	Overall (n = 546)	Suburban (n = 201)	Urban (n = 345)	*p*-value
Gender				
Male	217 (39.7)	66 (30.4)	151 (69.6)	0.012*
Female	329 (60.3)	135 (41.0)	194 (59.0)	
Ethnicity				
Malay	480 (87.9)	196 (40.8)	284 (59.2)	< 0.001**
Non-Malay	66 (12.1)	5 (7.6)	61 (92.4)	
Doctor-diagnosed asthma (Yes)	60 (11.0)	21 (35.0)	39 (65.0)	0.933
Atopic (Yes)	313 (57.3)	110 (35.1)	203 (64.9)	0.349
Allergic rhinitis (AR) (Yes)	301 (55.1)	112 (55.7)	189 (54.8)	0.832
Atopic dermatitis (AD) (Yes)	81 (14.8)	29 (14.4)	52 (15.1)	0.838
Parental allergy/asthma (Yes)	179 (32.8)	74 (41.3)	105 (58.7)	0.126
Smoking (Yes)	31 (5.7)	9 (29.0)	22 (71.0)	0.355
Parental/sibling smoking (Yes)	314 (57.5)	125 (39.8)	189 (60.2)	0.477

*$p < 0.05$; **$p < 0.001$

Association analysis

Table II presents the findings of logistic regression analyses conducted separately for adolescents residing in urban and suburban areas. After controlling for key demographic, smoking status, clinical variables, we found floor renovation, water leakage and other odor last 12 months were significantly associated with AR in adolescents from suburban areas with the odd values of 1.91 (95% CI = 1.01-4.04), 1.81 (95% CI = 1.03-3.19) and 2.37 (95% CI = 1.32-4.25), respectively. In the model analysis for adolescents from urban, home environmental factor of painting, floor renovation, water leakage, mold odor last 12 months were also significantly associated with AR with the odd values of 1.26 (95% CI = 1.01-1.61), 1.70 (95% CI = 1.25-2.32), 1.22 (95% CI = 1.19-1.26), and 1.51 (95% CI = 1.06-2.15), respectively. Notably, the same model also shows that EST exposure on every day (OR = 2.32, 95% CI = 1.40-3.86) and 1-4 times/week day (OR = 1.12, 95% CI = 1.02-1.24) were significantly associated with an increased likelihood of AR. Furthermore, adolescents from urban who keeping fury pet at home were more likely to reported AR (OR = 1.20, 95% CI = 1.17-1.24).

Table II: Association (OR) of AR and home environmental factors in adolescent from urban and suburban area

Home Environmental Factor	Suburban		Urban	
	OR	95% CI	OR	95% CI
ETS at home	1.08	0.60-1.96	1.20	0.77-1.86
Frequency ETS exposure				
Never	1	-	1	-
1-3 times/month	1.09	0.15-8.21	0.53	0.11-2.46
1-4 times/week	1.28	0.52-3.12	1.12	1.02-1.24
Everyday	1.09	0.32-3.64	2.32	1.40-3.86
Furry pet	0.88	0.54-1.43	1.20	1.17-1.24
Indoor painting last 12 months	1.33	0.48-3.66	1.26	1.01-1.61
Floor renovation last 12 months	1.91	1.01-4.04	1.70	1.25-2.32
Water leakage last 12 months	1.81	1.03-3.19	1.22	1.19-1.26
Mold odor last 12 months	2.69	0.14-5.12	1.51	1.06-2.15
Other odor last 12 months	2.37	1.32-4.25	1.14	0.42-2.78

OR = Odd ratio; 95% CI = 95% Confidence interval; R^2 = Coefficient of determination

The associations between home environmental factors and AD were used similar statistical analysis, logistic regression stratified by house areas. Surprisingly, all the home environmental factors tested in the models analysis were not statistically associated with the AD reported by adolescents from both areas (p > 0.05) (Table III).

Table III: Association (OR) of AD and home environmental factors in adolescent from urban and suburban area

Home Environmental Factor	Suburban		Urban	
	OR	95% CI	OR	95% CI
ETS at home	1.10	0.42-2.85	1.62	0.40-1.95
Frequency ETS exposure				
Never	1	-	1	-
1-3 times/month	0.65	0.06-7.15	0.82	0.30-2.26
1-4 times/week	0.67	0.21-2.10	1.06	0.18-2.06
Everyday	1.08	0.35-2.46	1.16	0.68-2.51
Furry pet	1.53	0.77-3.06	1.28	0.95-1.72
Indoor painting last 12 months	1.43	0.50-4.06	0.85	0.43-1.64
Floor renovation last 12 months	2.99	0.61-4.05	2.41	0.53-10.95
Water leakage last 12 months	0.76	0.32-1.77	1.01	0.53-1.91
Mold odor last 12 months	0.46	0.04-6.01	1.02	0.58-2.03
Other odor last 12 months	0.51	0.09-3.01	1.22	0.13-1.11

DISCUSSION

This study employed a cross-sectional study design to investigate the association of home environmental factors and allergic rhinitis and atopic dermatitis among adolescents from urban and suburban areas. Briefly, logistic regression analysis revealed that some of the home environmental factors including indoor painting, floor renovation, and water leakage last 12 months were significantly associated with AR and AD in adolescents from both urban and suburban areas. EST frequency exposure and keeping furry pets at home were also more likely associated with AR among adolescents from urban areas. These findings help clarify the prevalence and allergic reactions among adolescents, especially those living in urban and suburban settings. This information can assist in developing and increase awareness to the major publics on the environmental factors that potentially trigger and exacerbate the allergic sensitization among adolescents in urban and suburban areas.

In the present study, a higher prevalence of doctor-diagnosed asthma among adolescents living in urban areas (65%) compared to those in suburban areas (35%). Compared to other studies conducted in Northwestern Iran and China, the proportion of adolescents diagnosed with asthma were also higher among adolescents from urban than suburban areas [16,17]. Similarly, a recent study conducted in Australia strongly identified that the risk of asthma increase from inner city to the outer suburban and this trend is attributed by areal socioeconomic and distance from healthcare facilities [18]. Furthermore, a review concluded that the development of asthma in children and adolescents is influenced by several urban factors, including indoor environmental allergens and pollutants exposure, obesity, chronic stress and social determinants like poverty and housing quality [19].

Furthermore, adolescents from urban and suburban areas exhibited similar prevalence rates of AR and AD over the past 12 months and six months, respectively. This suggests that AR and AD are common conditions among adolescents across both study areas. This finding was similar to those reported by Pisithkul et al. [20] and Saeki et al. [21] among adolescents aged 12-25 years in Northern Thailand and Japan, respectively. Surprisingly, a recent systemic review reported that the prevalence of AD among adolescents in different continents ranged between 6.8% and 57.6%, which directly and indirectly impacts quality of live, behaviour, mental, family, school life and social group [22].

Findings from the logistic regression analysis in this study indicated a positive association between exposure to ETS and AR among adolescents in urban areas. This finding aligns with previous research conducted among adolescents in Korea [23]. Furthermore, recent research suggests that tobacco smoke exposure induces significant neutrophil migration in response to inflammation, increases myeloperoxidase enzyme (MPO) activity, and leads to tissue damage through the production of hypochlorous acid (HOCl) [24]. Previous studies and review show mixed results on the relationship between exposure to furry pets and the development of allergic responses [25,26]. Many studies observed risk factors of furry pet exposure for allergic reactions, whereas other studies have shown protective effects and no associations [6,27,28].

We also observed that the reported risk of AR among adolescents from both urban and suburban areas was attributed to indoor painting, floor renovation and water leakage in the last 12 months. Additionally, we found that the presence of mold odor inside the house within the last 12 months, as reported by adolescents residing in urban areas, was associated with AR. Numerous studies have shown that visible mold and damp conditions in the home increase the risk of AR among children, adolescents, and adults [29,30]. Possible explanations for this association include water leakage creating dampness and promoting mold growth. Exposure to mold can then lead to allergic reactions and stimulate immune system activation [31,32]. Exposure to mold has the potential to cause allergic responses and initiate immune system activity.

Our finding that indoor painting is a risk factor for AR aligns with previous studies [33,34]. Indoor painting emissions such as volatile organic compounds (VOCs), heavy metals and solvents generally lead to short-term chemical exposure. It is suggested that exposure to VOCs like propylene glycol which are emitted from acrylic paints, may contribute to the development or exacerbation of AR. This occurs through the activation of the immune system, specifically by promoting a Th2-dominant immune response over Th1 function [35].

Moreover, the observed association between floor renovation and AR in adolescents from both urban and suburban areas aligns with findings reported by Ren et al. [36] in Wuhan, China. The same authors also mentioned that the chemical emission from home renovation materials including formaldehyde, phthalate esters, VOCs, and artificial synthetic materials could be the risk factors for AR, eczema and asthma. In this study, we also found that exposure to 'other odor' was a contributing risk factor for AR among adolescents in suburban areas. The results align with those reported in earlier studies from Japan and Northern Thailand [37,38]. Indoor odors, which may originate from chemicals found in cleaning products, cooking fumes, pet dander, air fresheners, and furniture, are often indicative of inadequate ventilation [39].

Nevertheless, in the present study, no home environmental factors were found to be significantly associated with

AD among adolescents in either the urban or suburban groups. In contrast to earlier studies reported that several home environmental factors including dampness, own furry pets, house renovation were positively associated with AD in children and adolescents [40]. A possible explanation for this discrepancy is that early-life indoor and outdoor environmental exposures, along with lifestyle factors from childhood to adolescence, particularly in urban environments may shape the development of innate and adaptive immune responses. This is supported by recent research demonstrating that early-life exposures, including animals, time spent outdoors, house locations and home environment factors, influence the upregulation of immune cell transcriptomes [41]. Furthermore, the clinical manifestation of allergic reactions may emerge towards the end of adolescence and typically peaks between the second and fourth decades of life [42].

This study had several limitations. First, clinical diagnoses of AR and AD were not performed. Second, recall bias may have influenced the observed associations. However, standardized questionnaires were used to collect information on AR and AD, and trained enumerators validated the responses after questionnaire completion. Finally, the use of a cross-sectional study design restricts interpretation of causal relationships.

CONCLUSION

In conclusion, our regression model demonstrated that floor renovation, water leakage and other odor within the past 12 months are significant risk factors for allergic rhinitis (AR) among adolescents residing in both urban and suburban areas. These insights are valuable for shaping targeted health interventions and treatment plans for these adolescents. Specifically, preventive measures such as avoidance of ETS exposure, implementation of adequate ventilation systems to ensure continuous air circulation and prioritizing the use of construction materials and furnishings with low emissions of organic compounds are crucial for effectively reducing pollutant exposure and enhancing indoor air quality for residents. Reducing pollutant exposure can be effectively achieved through the strategic implementation of robust ventilation systems and the careful selection of low-emitting building materials and furnishings.

ACKNOWLEDGEMENT

We gratefully acknowledge the contributions of the adolescents involved in this research and the teachers for their ongoing support and gracious hospitality. The authors wish to acknowledge Dr. Mohammed Abdulrazzaq Jabbar for his skillful technical assistance during the allergy skin prick test.

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