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Indoor air pollutant exposure and eosinophil cationic protein as an upper airway inflammatory biomarker among preschool children

Andrew Dana Wesley[a] and Juliana Jalaludin[a]*

[a]*Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia*

Abstract

The upper and lower airways of the respiratory tract are functionally linked, with inflammation in the former playing a vital role in the pathogenesis of asthma and allergy. Studying the association between indoor air pollutants with upper airway inflammation in children will help improve childhood asthma and allergy management related to poor indoor air quality. A cross-sectional study was conducted among preschool children in industrial (Kelana Jaya and Shah Alam) and suburban (Semenyih and Hulu Langat) areas in Selangor, Malaysia. A questionnaire adapted from the American Thoracic Society and International Study on Asthma and Allergy in Children was distributed to obtain the respondents' background information, school, and home environment. Eosinophil cationic protein (ECP) concentrations in nasal swab samples were collected and analyzed to determine the prevalence of upper airway inflammation. An indoor air quality (IAQ) assessment was also conducted in seven preschools in both industrial and suburban areas, including parameters such as particulate matter up to 10 μm in size (PM_{10}), volatile organic compounds (VOCs), total mold, total bacteria, relative humidity, and air temperature. Statistical analysis shows significant differences in PM_{10}, total mold, total bacteria and relative humidity between the study areas ($p < 0.05$). The ECP levels among respondents vary significantly between study areas ($t = 8.473$, $p < 0.001$). The VOC concentration and ECP level are significantly correlated(prevalence ratio 6.41; 95% CI, 1.268 to 32.394) after controlling all confounders. This study concludes that exposure to indoor air pollutants increases the risk of respiratory problems and may have an impact on the inflammatory and secretory response of the nasal mucosa.

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* Corresponding author. Tel.: +603-89472401; fax: +603-89472305
E-mail address: juliana@upm.edu.my

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1. Introduction

Indoor air quality (IAQ) is a measure of the cleanliness of the air that we breathe indoors, which may have negative implications to human health. High quality indoor air is important because humans spend 80–95% of our lives indoors [1]. Furthermore, the correlation between IAQ and human health has currently become a major concern, with more studies emerging to understand their relationship. However, studies are lacking on the effects of IAQ on preschool-aged children because data on epidemiological studies on pediatric asthma are often based on extrapolation from older children (i.e., 7 years old and above) [2]. Preschool-aged children are more vulnerable to compromised IAQ than adults and older children because of their immature immune systems, greater food intake, inhaled breath per unit mass, and rapid growth [3]. A study of association also found numerous health implications, particularly asthma, from the exposure of this group of children to indoor pollutants. Asthma severity in children can be related to the level of exposure to common indoor allergens, such as dust mites and cat allergens [4].

In some studies, 95% of asthma cases are associated with nasal disease, whereas other studies maintain that the ideal management of asthma cannot be effective without including the control of upper airway disease [5, 6]. Upper airway inflammation is characterized by rhinitis, sinusitis, and rhinosinusitis, which are related to postnasal drip [5]. Previous studies have measured the outcome of upper airway inflammation on the basis of reported symptoms. In the current study, a biomarker was used to determine the prevalence of upper airway inflammation. Eosinophil cationic protein (ECP) is a biomarker that has been well characterized as an inflammation marker [7]. ECP secretion is commonly associated with allergic rhinitis but can also be used as a marker for acute exposure effects in non-allergic rhinitis triggered by irritants or pollutants [8]. Therefore, diagnosed asthmatic and allergic children are excluded from the sample population to study the relation of exposure with the prevalence of upper airway inflammation. The objective of this study is to identify various indoor air pollutants and associate upper airway inflammation among preschool children influenced by different socioeconomic activities in industrial and suburban areas in Selangor, Malaysia.

2. Methodology

A cross-sectional study was conducted among 98 preschool children aged 5 years old to 6 years old who attended preschools in an industrial area (Shah Alam and Kelana Jaya) and a suburban area(Semenyih and Hulu Langat) in Selangor, Malaysia. The sample size was calculated on the basis of a formula using combined standard deviation from a group comparison study, as described in Lemeshow et al. [9]. The preschools were selected within a 5 km radius of the predetermined industrial and suburban settings. Surveys and inspections were conducted to determine the characteristics of the preschools that could influence exposure to indoor air pollutants, such as their distance from the main road, their proximity to factories, and other potential sources of pollutant emission. Parents or guardians were asked to fill out a questionnaire adapted from the American Thoracic Society and International Study on Asthma and Allergy in Children. Those with known medical evidence of asthma, allergy, and other respiratory illnesses were excluded. Out of the 98 study respondents, a subset of 70 children was drawn for nasal sampling prior to the parents' consent to the method.

The sampling devices were placed at an area approximately 0.6 m to 0.9 m; this area represented the average breathing zones of the children while seated in the classroom during lesson periods; sampling devices were also placed in the middle of the classroom to obtain representative conditions [10].The real-time readings of particulate matter up to 10 μm in size (PM_{10}) and volatile organic compounds (VOCs) were recorded continuously for 4 hours during normal class activities by using Dust Trak™ DRX Aerosol Monitor 8534 and ppbRAE VOC Monitor Model PGM-7240, respectively. Temperature and relative humidity were measured periodically in various sampling points throughout the preschools by using TSI Q-Trak™ IAQ Monitor 7575 before obtaining the mean reading. These parameters were also measured in the outdoor air by using the same methods as indoor air monitoring.The microbiological pollutants were measured on the basis of the volume of air sampled (500 L) by using a PBI Duos SAS Super 360™ directed on the surface of a contact plate with agar. The bacterial samples were incubated at 37 °C