Roles of pollution in the prevalence and exacerbations of allergic diseases in Asia

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The prevalence of asthma and allergic diseases has been found to be increasingly rapidly, especially in developing countries. Environmental factors have been found to be important contributors to the manifestations of allergic diseases. Air pollution has been extensively studied in different regions of the world. The levels of ambient air pollutants in many Asian countries are very high when compared with those in developed Western countries. However, the prevalence of asthma was relatively low across many Asian countries. Many studies have clearly documented that environmental air pollution is an important factor resulting in exacerbations of asthma. In particular, levels of traffic-related pollutants are increasing rapidly across many Asian countries in parallel with the level of urbanization and economic development. The loss of protective factors associated with a rural environment will further contribute to the adverse effect on patients with allergic diseases such as asthma. In this review the roles of air pollution were examined in relation to the inception and exacerbations of allergic diseases in Asia. (J Allergy Clin Immunol 2012;129: 42-7.)

Key words: *Air pollution, allergy, Asia, asthma, epidemiology*

Global epidemiologic data indicate that currently the increase in childhood asthma and allergies is most pronounced in developing countries.[1] This trend could be attributed to changes associated with environmental and lifestyle factors during the modernization process. Among others, the increasing level of ambient air pollution might affect children's asthma and allergies,[2] and indoor air pollution is another major health problem in developing countries. Many countries in Asia are densely populated; even a slight increase in asthma and allergy prevalence will translate into a large number of affected persons. Coal is still the major source of energy in many Asian countries, and consequently, there is an increase in coal smoke, with suspended particulate matter and sulfur dioxide (SO_2) as the predominant pollutants. The rapidly growing number of motor vehicles accelerates emissions of other ambient air pollutants, such as nitrogen dioxide (NO_2) and ozone (O_3).

Abbreviations used
CO: Carbon monoxide
NO_2: Nitrogen dioxide
NO_x: Nitrogen oxides
O_3: Ozone
OR: Odds ratio
$PM_{2.5}$: Particulate matter with an aerodynamic diameter ≤2.5 μm
PM_{10}: Particulate matter with an aerodynamic diameter ≤10 μm
RR: Relative risk
SO_2: Sulfur dioxide
TSP: Total suspended particle

Indoor air pollution is another important issue in Asia. Wood and coal burning are widely used for cooking or heating in dwellings in rural areas, which generates significant particle pollution. Such methods have been widely replaced by cleaner energy sources, such as gas and electricity, in homes in urban Asian cities. Nonetheless, new building materials and furniture emit chemicals, such as formaldehyde and volatile organ compounds, in urban areas. High indoor levels of these chemicals have been reported in China,[3] Korea,[4] and Hong Kong.[5]

Air pollution is consistently shown to be a potent trigger for asthma exacerbations both in children and adults, but there is limited and inconclusive evidence about its role in the initiation of allergic disorders. This review aimed to summarize the evidence of ambient air pollutant exposures as risk factors for the susceptibility of asthma and allergy in the Asian population (Table I)[6-17] and will only include articles that reported the measurements of individual air pollutants. Because many of these studies are based on proximity of the home to the nearest main road or pollution data obtained from monitoring stations, detailed personal exposures of different pollutants were not assessed, and one must interpret the results of these studies with caution.[6-11]

AIR POLLUTION AND PREVALENCE OF CHILDHOOD ASTHMA

Nitrogen oxides and nitrogen dioxide

Researchers from Taiwan published a number of epidemiologic studies for the association between asthma prevalence and ambient pollutant exposures. Hwang and Lee[6] analyzed the nationwide data of 5049 children in the Taiwan Children Health Study. The exposure parameters for SO_2, NO_2, O_3, carbon monoxide (CO), and particulate matter with an aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$) were calculated by using the between-community 3-year average concentration. The prevalence of bronchitic symptoms with asthma was positively associated with the 3-year average concentrations of NO_2 (adjusted odds ratio [OR], 1.81 per 8.79 ppb; 95% CI, 1.14-2.86),

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suggesting that long-term exposure to outdoor NO_2 was a risk factor for the prevalence of bronchitic symptoms among children. However, the same group reported in an earlier study that the risk of childhood asthma was not associated with levels of nitrogen oxides (NO_x; adjusted OR, 1.01; 95% CI, 0.95-1.12) among 32,672 Taiwanese schoolchildren.[10] On the other hand, Guo et al[17] found asthma prevalence to be associated with NO_x levels for both girls and boys. Furthermore, Ho et al[9] also failed to replicate the above findings. It should be emphasized that the levels of environmental pollutants, such as particulate matter with an aerodynamic diameter of 10 μm or less (PM_{10}) and NO_2, in China are 4 to 10 times higher than those in other Western countries,[12,13] yet the prevalence of asthma is much lower in China, suggesting that environmental pollution might have a minor role in the inception of asthma.

Several studies from China addressed the deleterious effects of ambient air pollution on allergy and asthma susceptibility. Pan et al[7] from Liaoning, a major industrial province of northeastern China, studied 11,860 preschool and school-aged children. They found large variation for NO_2 levels (29-94 $\mu g/m^3$) across the 18 districts of 6 cities in this province. Such exposure increased the subjects' risks for persistent cough, persistent phlegm, and current asthma. Rates of respiratory symptoms were significantly higher for younger children and those with atopy, early-onset respiratory disease, family history of asthma or chronic bronchitis, and tobacco smoke exposure. Zhao et al[8] investigated children's respiratory heath and air pollution in schools in urban Taiyuan, a coal-burning city in north China. They assessed the effects of both indoor and outdoor air pollution in schools, as well as selected home exposures. Among these 1993 children, 1.8% had cumulative asthma, 8.4% had wheezing, and 29.8% had daytime attacks of breathlessness. They found that either wheeze or daytime or nocturnal attacks of breathlessness were positively associated with NO_2 exposure. It is interesting to note that the prevalence of respiratory symptoms is much higher than that of asthma in polluted cities. This finding is similar to those data comparing the former East and West Germany, where ambient pollution is higher in the East.[14]

Shima and Adachi[15] investigated concurrently the effects of outdoor and indoor NO_2 levels on the prevalence and incidence of respiratory symptoms among 842 Japanese schoolchildren. Indoor NO_2 levels over 24 hours were measured in both winter and summer, and a 3-year average of outdoor NO_2 levels was calculated. They observed a significant increase in the prevalence rates of bronchitis, wheeze, and asthma with increasing indoor NO_2 levels among girls but not boys. Interestingly, girls might be more susceptible to indoor air pollution than boys. In addition, a 10 ppb increase in outdoor NO_2 levels was associated with an increased incidence rate of wheeze (OR, 1.76; 95% CI, 1.04-3.23) and asthma (OR, 2.10; 95% CI, 1.10-4.75). Such associations were not detected with indoor NO_2 concentrations. These investigators subsequently evaluated the effects of air pollution on asthmatic symptoms in a prospective cohort study of 3049 Japanese schoolchildren.[16] The incidence rates of asthma were associated with ambient NO_2 concentrations during follow-up.

SO_2

Several groups of Taiwanese researchers could not detect any association between the prevalence of asthma or bronchitic symptoms and ambient SO_2 exposure.[6,9,10,13] On the other hand, large variation was detected for SO_2 levels (14-140 $\mu g/m^3$) across the 18 districts of 6 cities in the heavily industrialized Liaoning.[7] Pan et al[7] reported such exposure to be associated with the risks for persistent cough, persistent phlegm, and current asthma. Rates of respiratory symptoms were significantly higher for younger children and those with atopy, early-onset respiratory disease, family history of asthma or chronic bronchitis, and tobacco smoke exposure. In Taiyuan, another industrial city in northern China, Zhao et al[8] reported higher outdoor than indoor levels of SO_2, and either wheeze or daytime or nocturnal attacks of breathlessness were positively associated with SO_2 exposures. These findings suggested that pollutants of mainly outdoor origin were risk factors for respiratory symptoms in children at school.

CO

Among 5049 children in the Taiwan Children Health Study, Hwang and Lee[6] detected a positive association between the prevalence of bronchitic symptoms with asthma and 3-year average concentrations of CO (OR, 1.31 per 105 ppb; 95% CI, 1.04-1.64). Such a result supported long-term outdoor CO exposure as an important risk factor for bronchitic symptoms. They similarly identified childhood asthma prevalence to be positively associated with CO exposure (adjusted OR, 1.05; 95% CI, 1.02-1.07) from routine air pollution monitoring.[10] Guo et al[17] compared asthma prevalence with climate and air pollution data in 331,686 Taiwanese children. The prevalence rates of asthmatic symptoms adjusted for age, history of atopic eczema, and parental education were found to be associated with nonsummer (June-August) temperature, winter (January-March) humidity, and traffic-related air pollution for CO for both girls and boys. These associations suggested that pollution does play an important role in the exacerbations of allergic diseases, such as asthma. In a 6-month mass screening survey of junior high school students in Taiwan, Ho et al[9] found significant associations between asthma prevalence and CO exposures in male (OR, 1.98; 95% CI, 1.54-2.56) and female (OR, 1.78; 95% CI, 1.38-2.30) subjects. Despite these preliminary findings, the influence of ambient CO exposure on asthma prevalence was not examined in studies from China.[7,8]

O_3

Several studies from Taiwan assessed the effects of ambient O_3 exposure on asthma prevalence. In the 2-stage hierarchic model adjusting for confounding, the prevalence of phlegm with no asthma was related to 3-year averaged O_3 concentrations (OR, 1.32 per 8.77 ppb; 95% CI, 1.06-1.63) in the Taiwan Children Health Study.[6] Hwang et al[10] analyzed routine air pollution monitoring data for O_3 and found the prevalence of childhood asthma to be positively associated with O_3 concentrations (adjusted OR, 1.14; 95% CI, 1.00-1.29) among 32,672 schoolchildren. Another 6-month mass screening study performed between October 1995 and March 1996 assessed asthma status in Taiwanese adolescents by using the International Study of Asthma and Allergies in Childhood questionnaire and the New England Core Questionnaire.[9] They reported ambient O_3 levels to be positively associated with asthma prevalence in male subjects (OR, 1.02; 95% CI, 1.00-1.03). Nonetheless, a