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Review

A review on human health perspective of air pollution with respect to allergies and asthma

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ABSTRACT

The increase in cases of asthma and allergies has become an important health issue throughout the globe. Although these ailments were not common diseases a few short decades ago, they are now affecting a large part of the population in many regions. Exposure to environmental (both outdoor and indoor) pollutants may partially account for the prevalence of such diseases. In this review, we provide a multidisciplinary review based on the most up-to-date survey of literature regarding various types of airborne pollutants and their associations with asthma-allergies. The major pollutants in this respect include both chemical (nitrogen dioxide, ozone, sulfur dioxide, particulate matter, and volatile organic compounds) and biophysical parameters (dust mites, pet allergens, and mold). The analysis was extended further to describe the development of these afflictions in the human body and the subsequent impact on health. This publication is organized to offer an overview on the current state of research regarding the significance of air pollution and its linkage with allergy and asthma.

Contents

1. Introduction

The prevalence of allergic diseases has increased around the world in recent decades (Asher et al., 2006; Cakmak et al., 2010; Nicolaou et al., 2005; Solomon, 2011; Szyszkowicz et al., 2009). Since such an increase has taken place in a relatively short period of time, explanations based on genetic changes are insufficient to understand this unique phenomenon (Lobdell et al., 2011). Exposure to environmental pollutants or microorganisms especially in air (both indoors and outdoors) has in fact been identified as the main cause of many common ailments along with allergies (and chemical sensitivities) (Englert, 2004).

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To reduce heating and cooling costs, modern houses are built air-tight with poor ventilation, which can ultimately lead to deterioration in air quality. Under such circumstances, a variety of biophysical pollutants (dust, dirt, lint (from bed sheets), pollen, human skin, and animal dander) can be entrapped and accumulated indoors (Brauer et al., 2007; Solomon, 2011). Dust containing squalene was also reported to contribute to the scavenging removal of ozone in all settings occupied by humans (Charles et al., 2011). Likewise, there is a list of chemical pollutants that are abundant in the outdoor environment (such as volatile organic compounds (VOCs), nitrogen dioxide (NO_2), ozone, etc.), while simultaneously exerting significant influence on indoor air quality (Thurston and Wallace, 2007). If these facilities are not constantly managed against the potentially harmful pollutants, the symptoms of asthma and allergies can worsen (Ring et al., 2001).

This article reviews the common components of indoor pollution that can directly or indirectly induce allergy and asthma. Then, emphasis is put on up-to-date knowledge on the impact of air pollution on those diseases based on evidence collected by the professionals (e.g., hygienists or other environmental health (and safety) professionals) as well as members of the general public suffering from these afflictions. Information presented in this review can thus be used to take appropriate measures against these prevailing diseases.

2. Epidemiological aspects

The development and phenotypic expression of atopic diseases (i.e., allergic rhinitis (hay fever), allergic conjunctivitis, allergic asthma, etc.) depends on a complex interaction between genetic factors, environmental exposure to allergens, and non-specific adjuvant factors such as tobacco smoke, air pollution, and infections (Halken, 2004). The collaborative study known as the International Study on Asthma and Allergies in Childhood (ISAAC) was conducted repetitively using the same methodology with approximately 1.2 million children in 98 countries worldwide (e.g., Mallol et al., 2013). It was reported that the prevalence of symptoms associated with allergic rhinoconjunctivitis ranged from 2.2 to 14.6% among children aged 6–7 years and from 4.5 to 45.5% among adolescents aged 13–14 years during the 12 months prior to the application of the standard questionnaire (Mallol et al., 2013).

The number of people with asthma has grown continuously. In 2011, 235–300 million people worldwide were affected by asthma and allergic rhinitis (World Health Organization(WHO), 2013). One in 12 people (about 25 million or 8% of the U.S. population) had asthma in 2009, compared with 1 in 14 (about 20 million or 7%) in 2001 (CDCP, Centers for Disease Control, Prevention, 2011). In general, such symptoms are reported more frequently in developed than in developing countries (Abdulrahman et al., 2012; Bateman et al., 2008; Wu et al., 2011). Moreover, it is seen more commonly from those who are economically disadvantaged in developed countries, while it is more pronounced in the affluent group in developing countries (Sembajwe et al., 2010). The reason for these differences is not well known. Although asthma is twice as common in boys as girls, severe asthma tends to be found on equal ratio from both sexes (Asher et al., 2006). In contrast, adult women have a higher rate of asthma than men, while the young generation seems to suffer more than the old one (Loerbroks et al., 2012). However, previous studies documented a wide variability in the prevalence and severity of asthma and rhinoconjunctivitis, as observed not between regions and countries but between centers in the same country and centers in the same city. As such, the large variability of these diseases suggests a possibly crucial role of local environment in determining the differences in their prevalence patterns between one place and another.

3. The potent role of chemical pollutants

It is reported that exposure to outdoor airborne pollutants such as ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulates have adverse effects on immune competent cells and airway responsiveness (Delfino et al., 2009; Duki et al., 2003; Jerrett et al., 2005). These outdoor airborne pollutants are known to be released from both mobile (road and off-road vehicles, ships, and aircraft) and stationary sources (power plants, manufacturing industries, waste deposits, agriculture, volcanoes, forest fires, etc.). Many of these chemicals can also be produced indoors, although their concentrations can vary greatly depending on the type of source activities. Moreover, aeroallergens are also carried and delivered by fungal spores or by particles of various origins. In Table 1, the sources of outdoor allergens and their health effects are summarized.

3.1. Ozone (O_3)

As the chief component of urban smog, O_3 is formed by the photochemical reaction in ambient air through interactions with nitrogen oxides and hydrocarbons emitted from traffic and/or industrial sources (U.S. Environmental Protection Agency, U.S. EPA, 2006). Because of the potential to sensitize airway inflammation or damage lung tissues, ozone can cause many types of breathing problems including coughing, wheezing, and chest pain (Szyszkowicz et al., 2012; Trasande and Thurston, 2005; Xu et al., 2011). It can also increase the immune response to allergens in some individuals (Auten and Foster, 2011). Approximately 40–60% of inhaled O_3 is absorbed in the nasal airways, while the remainder can reach the lower airways (Bosson et al., 2008). Bayram et al. (2001) demonstrated that O_3 and NO_2 modulate airway inflammation, while stimulating the release of inflammatory mediators from bronchial epithelial cells. Moreover, O_3 can also prompt a dose-dependent increase in

Table 1
Chemical pollutants and their impact on allergy and asthma.

Order	Pollutants	Source	Health effect	Reference
1	Nitrogen dioxide	Vehicle exhaust, power plants, gas cooking stoves, kerosene space heaters, and other sources that burn fossil fuels	Chronic and acute changes in lung function, bronchial neutrophilic infiltration, proinflammatory cytokine production, and response to inhaled allergens in subjects with asthma	Koenig, 1999; Barck et al., 2005; Everard, 2006
2	Ozone	Photochemical reaction involving ultraviolet radiation acting upon atmospheric mixture of nitrogen oxides and hydrocarbons emitted from vehicles and/or industrial sources	Inhalation of ozone at high concentration increase risk of asthma development, airway inflammation, and responsiveness	Bell et al., 2004; Auten and Foster, 2011
3	Sulphur dioxide	Industrial activities following the combustion of coal and oil	Sulphur dioxide can induce acute constriction of the bronchi to asthmatic patients. It can induce the development of asthma	Winterton et al., 2001; Brown et al., 2003
4	Particulate matter	Natural sources such as dust storms, vegetation, and/or anthropogenic sources like industry and vehicle emissions	Increases the number and severity of asthma attacks, bronchitis and other lung diseases may aggravate due to the penetration of particulate matter	Trasande and Thurston, 2005; Porter et al., 2007
5	Volatile organic compounds	Vegetation, automobile emissions, gasoline marketing and storage tanks, petroleum and chemical industries, dry cleaning, natural gas combustion, etc.	Respiratory, allergic, or immune effects in infants or children, nocturnal breathlessness, increased bronchial responsiveness, and decreased lung function	Delfino et al., 2003; Rumchev et al., 2004