SJ IMPACT FACTOR: 2.912 CRDEEP Journals
Global Journal of Current Research Mitiku & Tiwari Vol. 4 No. 4 ISSN: 2320-2920
Global Journal of Current Research Vol. 4 No. 4. 2017. Pp. 52-57

Review Paper

Aeroallergens, Associated Allergic Diseases and Climate Change: A Preliminary Review

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Article history
Received: 23-04-2017
Revised: 01-05-2017
Accepted: 10-05-2017

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Abstract:
This paper is an effort to highlight the potential impacts of climate change on aeroallergens and the allergic diseases associated with them. Recent researches have indicated that there are many effects of climate change on aeroallergens and thus allergic diseases in humans. Increased atmospheric carbon dioxide as well as increased temperature increases pollen production and the allergen content of pollen grains. There is no definitive data however, on how climate change might impact aeroallergens and, subsequently, the severity or prevalence of allergic diseases. Allergies which commonly originate due to exposure of aeroallergen are: Allergic rhinitis (hay fever), Asthma, and Atopic dermatitis (eczema - either alone or collectively impose both substantial health effects and large economic burdens.

Key words: Climate Change, Health Impact, Indoor aeroallergen, Mold, Tree pollen.

Introduction

Aeroallergen can be defined as *"any of various airborne substances such as pollen or spores that can cause an allergic response"* (Stedman's Medical Dictionary, 2002). It include the pollens of specific seasonal plants commonly known as *"hay fever"*, because it is most prevalent during haying season, from late May to the end of June in the Northern Hemisphere; but it is possible to suffer from hay fever throughout the year.

These are classified into three groups: Pollens (tree, weed, and grass), Molds, and Indoor allergens. There is evidence to support a causal relationship between each aeroallergen within these groups and one or more allergic diseases, including allergic rhinitis (hay fever), asthma, and atopic dermatitis (eczema). Global climate change could alter the concentrations, distributions, of aeroallergens in the environment in ways that could further increase the prevalence of allergic diseases.

Climate change, caused in part by increased atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases, is likely to result in increases in temperature and humidity, changes in the amount, distribution, and intensity of precipitation events, and increases in the intensity and frequency of certain extreme weather events (Solomon et al., 2007). Air pollutants can independently, and in conjunction with aeroallergens, cause and exacerbate allergic diseases. (Reid and Gamble, 2009)

The potential impacts of climatic changes on aeroallergens and allergic diseases are still unclear. Present review is an attempt to squeeze available literature on examining how elements of climate change (e.g., increased CO_2 levels, changing temperatures, and increased and decreased regional precipitation) can alter the production, distribution, and allergen content of aeroallergens.

Aeroallergens and Allergic Diseases

Aeroallergens are classified into three primary categories: pollen, mold, and indoor allergens.

Pollens: are fine powdery substances, typically yellow in color, consisting of microscopic grains discharged from the male part of a flower or from a male cone. These are divided into three subcategories: tree pollen, grass pollen, and weed pollen. The pollen size for all of the subcategories varies from 5 μm to greater than 200 μm (Wood, 1986). The pollen of each species has a distinct distribution, season of pollination, and level of dispersal, as discussed in detail by Kosisky and Carpenter (1997). Dvorin *et al.* (2001) found that tree pollen accounts for the largest percent (approximately 75%) of the total annual pollen produced. Although there are clear differences in the amounts of different types of pollen produced, other factors, including prevailing winds and the pattern of land use, may also affect the level of airborne allergens in an area (Wood, 1986). (Table 1).

Tree Pollen

Tree pollen accounts for the largest percent of pollen produced during the pollen season approximately 75 to 90% (Dvorin *et al.*,., 2001; Kosisky and Carpenter, 1997).

Table 1. List of selected relevant Aeroallergens

Latin name	Common name
Tree pollen	
Acer negundo	Box-elder
Acer rubra	Red maple
Alnus rubra	Alder
Betula papyrifera	Paper birch
Carya illinoensis	Pecan
Olea europaea	Olive
Quercus alba	White oak
Quercus rubra	Red oak
Ulmus Americana	American elm
Ulmus parvifolia	Chinese elm
Ulmus pumila	Siberian elm
Grass pollen	
Cynodon dactylon	Bermuda
Festuca elatior	Meadow fescue
Lolium perenne	Rye
Paspalum notatum	Bahia
Phleum pretense	Timothy
Weed pollen	
Amaranthus retroflexus	Red root pigweed
Ambrosia artemisiifolia	Short ragweed
Artemisia vulgaris	Mugwort
Kochia scoparia	Burning bush
Plantago lanceolata	English plantain
Rumex acetosella	Sheep sorrel
Mold	
Alternaria alternata	N/A
Aspergillus fumigatus	N/A
Drechslera or *Bipolaris* type	N/A
(e.g., *Helminthosporium solani*)	N/A
Epicoccum nigrum	N/A
Penicillium (*P. chrysogenum*;*P. expansum*)	N/A
	N/A
Indoor allergens	
Felis domesticus	Cat (epithelium)
Canis familiaris	Dog (epithelium)
Dermatophagoides farinae; *Dermatophagoides pteronyssinus*	House dust mites
Blattella germanica	German cockroach

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008 and Joint Task Force on Practice Parameters (2003).

Pollen Season

The pollen seasons of the clinically relevant tree species are shown in Table 2. The period from late April to early May is of particular importance because this is the period with the highest pollen prevalence due to considerable overlap of the pollen seasons of multiple tree species (Dvorin *et al.*,., 2001). April, in particular, has been found to have the highest weekly average pollen concentrations (Kosisky and Carpenter, 1997).

Table 2. Pollen season of some relevant species

Latin name	*Common name*	*Pollen season*	*Reference*
Acer rubra	Red maple	Mid-April to Mid-May	Dvorin *et al.*, 2001
Alnus rubra	Alder	February to April	Weber, 2003a, b
Betula papyrifera	Paper birch	Late April to Late May	Dvorin *et al.*, 2001

Carya illinoensis	Pecan	April to June	Phadia, 2002
Fraxinus americana	White ash	April to May	Phadia, 2002
Juglans nigra	Black walnut	Late spring (May) to Early summer	Levetin, 2006; Phadia2002
Juniperus ashei	Mountain cedar	December to January	Levetin and Van de Water, 2003
Morus alba	Mulberry Spring	April to May	Levetin, 2006; Phadia, 2002
Populus deltoids	Eastern cottonwood	March to April	Levetin, 2006
Quercus alba	White oak	March to May	Dvorin *et al.,* 2001;
Quercus rubra	Red oak	March to April	Levetin, 2006
Ulmus Americana	American elm	February to March	Levetin, 2006
Ulmus parvifolia	Chinese elm		Fall Tidwell, 2006
Ulmus pumila	Siberian elm	February to March	Tidwell, 2006
Acer negundo	Box-elder	Early spring	Phadia, 2002

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008.)

Grass Pollen

Grass pollen accounts for the smallest percent of pollen produced during the pollen season—approximately 3 to 10% (Dvorin *et al.,*., 2001; Kosisky and Carpenter, 1997). Grass pollen is usually deposited within 50 miles of its release, and although the exact distance can vary, it will mostly be confined to the relative vicinity in which it grows (Wood, 1986) (Table 3).

Table 3. Major relevant grass pollen

Latin name	Common name
Cynodon dactylon	Bermuda
Festuca elatior	Meadow fescue
Holcus halepensis	Johnson
Lolium perenne	Rye
Paspalum notatum	Bahia
Phleum pretense	Timothy

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008.)

Pollen Season

Dvorin *et al.* (2001) found that for the majority of grasses, the pollen season tends to last from late April to mid-June, with a secondary peak in early September. Table 4 shows the pollen season for each of the clinically relevant grass pollens.

Table 4. Pollen season for each of the clinically relevant grass pollens

Latin name	Common name	Pollen season
Cynodon dactylon	Bermuda	Late April to mid-June, early September
Festuca elatior	Meadow fescue	Late April to mid-June, early September
Holcus halepensis	Johnson	Late April to mid-June, early September
Lolium perenne	Rye Late	April to mid-June, early September
Paspalum notatum	Bahia	Late April to mid-June, early September
Phleum pretense	Timothy	Late April to mid-June, early September

Sources: Weber (2003a, b), White and Bernstein (2003).

Weed Pollen

Second greatest percentage of pollen produced during the pollen season—approximately 6 to 17%. However, the amount produced is significantly less than the total amount of tree pollen produced in a single year (Dvorin *et al.,* 2001; Kosisky and Carpenter, 1997). (Table 5)

Table 5. Major clinically relevant weed pollen

Latin name	Common name
Amaranthus retroflexus	Red root pigweed
Ambrosia artemisiifolia	Short ragweed
Artemisia vulgaris	Mugwort
Plantago lanceolata	English plantain
Rumex acetosella	Sheep sorrel

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008.)

Mold: Its spores are substantially small than pollen grains, (ranging in size from 2 to 10 µm, and are more abundant (Burge, 2002). Mold counts are often 1,000-fold greater than pollen counts (Bush and Prochnau, 2004). Some clinically relevant mold includes: *Alternaria alternate, Aspergillus fumigatus, Helminthosporium solani*, *Epicoccum nigrum and Penicillium* (*P. chrysogenum*; *P. expansum*)

It is usually located at outdoors (*Alternaria* and *Cladosporium* are universally dominant outdoor fungal species that are detected indoors), but unlike pollen, can colonize indoor materials (Burge, 2002)., while *Penicillium* and *Aspergillus* are universally dominant indoors (Hamilton, 2005). Other fungal species that can cause allergenicity include mushrooms, and yeasts; however, few of the fungal allergens have been well-characterized, possibly due to the complexity and large number of fungal spores (Horner *et al.,* 1995).

Indoor Allergens: The concentrations of all indoor allergens do not vary with season as is observed for pollen and some mold, but are instead found perennially. Major clinically relevant indoor allergens include cat epithelium, dog epithelium, domestic mites, and German cockroaches (Table 6).

Table 6. Major clinically relevant indoor allergens

Latin name	Common name
Felis domesticus	Cat (epithelium)
Canis familiaris	Dog (epithelium)
Dermatophagoides farinae; ***Dermatophagoides pteronyssinus***	House dust mites
Blattella germanica	German cockroach
Penicillium	Penicillium mold

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008.)

Associated Allergic Diseases

Development of allergic disease is a two-stage process. First stage, results in the production of antibodies whereas, second stage involves a disease response due to the presence of antibodies and the associated cellular response (Nielsen *et al.,* 2002). Currently, three main allergic diseases have been associated with exposure to aeroallergens viz., Allergic rhinitis (hay fever), Asthma, and Atopic dermatitis (eczema).

Apart from many other factors, Genetic factors (Hereditary) have been found to development of allergic diseases during the course of an individual's life. The hereditary association between aeroallergen exposure and allergic illness development has been identified as a primary risk factor for the development of allergic rhinitis in children, especially if both parents are affected by the illness (Phipatanakul, 2005). Although there is a major hereditary contribution to the development of these allergic diseases, environmental factors, specifically exposure to aeroallergens, play a significant role in their manifestation (Nielsen *et al.,* 2002).

Table 7. Allergic diseases correlated with the major clinically relevant aeroallergens

Latin name	Common name	Allergic illness	Reference
		Tree pollen	
Acer negundo	Box-elder	Asthma, Allergic rhinitis	Phadia, 2002; White *et al.,* 2005
Acer rubra	Red maple	Allergic rhinitis	White *et al.,* 2005
Alnus rubra	Alder	Allergic rhinitisa	Nielsen *et al.,* 2002
Betula papyrifera	Paper birch	Asthma, Allergic rhinitis	White *et al.*, 2005; White and Bernstein, 2003;
Carya illinoensis	Pecan	Allergic rhinitisa, d	White *et al.,* 2005
Fraxinus americana	White ash	Asthma, Allergic rhinitis	Phadia, 2002; White *et al.,* 2005
Juniperus ashei	Mountain cedar	Asthma, Allergic rhinitis	Phadia, 2002
Morus alba	Mulberry	Asthma, Allergic rhinitis	Phadia, 2002
Populus deltoids	Eastern cottonwood	Asthma, Allergic rhinitis	Phadia, 2002; White *et al.,*2005
Quercus alba	White oak	Allergic rhinitis	White *et al.,* 2005; White and Bernstein, 2003
Quercus rubra	Red oak	Allergic rhinitis	White *et al.,* 2005; White and Bernstein, 2003
Ulmus pumila	Siberian elm	Allergic rhinitisa	Nielsen *et al.,*2002

		Grass pollen	
Cynodon dactylon	Bermuda Asthma,	Allergic rhinitis	Nielsen *et al.*,2002
Festuca elatior	Meadow fescue	Asthma, Allergic rhinitis	Nielsen *et al.*, 2002
Holcus halepensis	Johnson	Asthma, Allergic rhinitis	Nielsen *et al.*,2002
Lolium perenne	Rye	Asthma, Allergic rhinitis	Nielsen *et al.*, 2002
Paspalum notatum	Bahia	Asthma, Allergic rhinitis	Nielsen *et al.*, 2002
Phleum pretense	Timothy	Asthma, Allergic rhinitis	Nielsen *et al.*, 2002
		Mold	
Alternaria alternata	N/A	Asthma, Allergicc	Halonen *et al.*, 1997; Corden and Millington, 2001; Andersson *et al.*, 2003
Aspergillus fumigatus	N/A	Asthma	Nielsen *et al.*, 2002
***Cladosporium* (*C. cladosporioides*; *C. herbarum*)**	N/A	Asthma	Nielsen *et al.*, 2002
***Penicillium* (*P. chrysogenum*; *P. expansum*)**	N/A	Asthma	Nielsen *et al.*,2002

(Source: A Review of the Impacts of Climate Variability and Change on Aeroallergens and Their Associated Effects, 2008.)

Impact of Climate change on Aeroallergen and Allergic diseases

Climate change in part of increased atmospheric CO_2 and other greenhouse gas concentrations may result in increases in temperature, precipitation, humidity, and extreme weather events. These factors in association can impact the production, distribution, dispersion, and allergen content of aeroallergens and the growth and distribution of organisms that produce them (i.e., weeds, grasses, trees, and fungus). Shifts in aeroallergen production and subsequently human exposures may result in changes in the prevalence and severity of symptoms in individuals with allergic diseases. If changes in aeroallergen production occur as a result of climate change, then the patterns of seasonal allergic disorders, such as allergic rhinitis (hay fever), asthma, and possibly atopic dermatitis could be affected as well.

Linkages among Air Pollution, Aeroallergens, and Allergic Diseases

Some recent studies have shown that the links between air pollution, aeroallergens, and allergic diseases. Although, considered complex but still many researches indicate a possible link in between air pollution and some allergic diseases. D'Amato *et al.* (2002) hypothesize that the reason for the increase in urban allergic disease could be due to the role that air pollutants play in mediating the health effects of aeroallergens.

Conclusion

This review paper is an attempt to find a link in between climate change-aeroallergens and allergic diseases but still there is no definite linkage on how climate change might impact aeroallergens and subsequently the severity and prevalence of allergic diseases. It is understood that apart from climate variability there are numerous other factors responsible for aeroallergen production and subsequent allergic diseases.

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