

Role of Environmental Factors in Ocular Allergy: A Cross-Sectional Study in Eastern India

Saptarsi Ghosh¹, Dipanwita Ghosh², Dr. Koushik Tripathy³

¹B.Optom Graduate, Swami Vivekananda University, Barrackpore, India

²Assistant Professor, Department of Optometry, Swami Vivekananda University, Barrackpore, India

³Senior Ophthalmologist, ASG Eye Hospital, Agarpara, India

Abstract

Purpose:

Allergic conjunctivitis (AC) is a frequent but often underdiagnosed ocular disorder influenced by various environmental triggers. This study evaluates the relationship between environmental factors—including dust, air pollution, pollen, and air-conditioned environments—and the prevalence, severity, and frequency of ocular allergy.

Methods:

A cross-sectional study was conducted at ASG Eye Hospital, Agarpara (January–May 2024). Data were collected via structured questionnaires from patients presenting with allergic ocular symptoms. Information on demographics, environmental exposure, and allergy severity was analyzed using PQStat software (version 1.8.6). Fisher's exact test was applied, and $p < 0.05$ was considered statistically significant.

Results:

A total of 62 patients (mean age 22.03 ± 12.4 years) were evaluated; 56.45% were female, and 56.45% resided in urban areas. The 21–30-year age group showed the highest prevalence (32.25%). Dust (32.25%) and air pollution (30.65%) were the most common allergens. Itching (100%) and redness

(85.48%) were predominant symptoms. Exposure to air-conditioned environments for >1 hour daily was reported by 67.74% of participants. Dust was significantly associated with mild ($p = 0.001$) and moderate ($p = 0.0282$) allergies, while pollen correlated strongly with severe allergy ($p < 0.00001$). Air-conditioned exposure showed significant association with mild ($p = 0.0169$) and frequent ($p = 0.0265$) allergic episodes.

Conclusion:

Environmental factors such as dust, air pollution, and prolonged exposure to air-conditioned environments significantly influence ocular allergy prevalence and severity. Regular cleaning of air-conditioner filters, minimizing exposure to outdoor pollution, and using protective eyewear can mitigate allergic symptoms. Larger, multicentric studies integrating environmental indices (AQI, humidity, particulate matter) are warranted to develop targeted preventive strategies.

Keywords:

Allergic conjunctivitis, environmental allergens, air pollution, air conditioning, ocular allergy, dust mite, pollen allergy.

1. Introduction

Allergic conjunctivitis (AC) is a prevalent ocular allergic disease encountered frequently by ophthalmologists and anterior segment specialists, affecting up to 40% of the population. Though this condition is common, many individuals do not look for treatment, leading to underdiagnosis and undertreatment¹. The prevalence of AC has risen over the past decade, making it one of the most regularly observed conditions in clinical practice. AC results from various factors, including genetic causes, underlying inflammation, air pollution, atopic diseases, exposure to pollen, and pet dander. It is usually executed by allergen-induced cross-linking of immunoglobulin E attached to receptors on prime conjunctival mast cells, resulting in mast cell degranulation and histamine release, and also for the release of cytokines, lipid mediators and chemokines. The clinical result is conjunctival hyperemia, watering, severe itching, and chemosis^{1, 2}. Severe AC can

often lead to advanced keratoconjunctivitis causing corneal ulcers and can pose a threat to functional vision². While the condition rarely becomes a vision-threatening condition, the allergic symptoms can degrade the quality of life, especially for children and adolescents³.

AC is further categorized as seasonal and perennial, SAC is found to be more common. The difference between the two conditions is mostly the recurrence or chronicity of the symptoms, which is determined by type of the allergens patients are sensitized to⁴. Seasonal symptoms are mostly triggered by allergens like tree or grass pollens. Perennial symptoms are mainly caused by indoor allergens such as house dust mites, pet dander, spores from mould and mildews, rodents or pests like cockroaches. Among the types of allergic conjunctivitis, SAC and PAC are very frequently observed. Though estimations are variable in different countries, these types of allergies are thought to affect almost 15–20% of the population⁵. These two types have almost similar clinical presentation. The difference between them is the type of allergen and also the occurrence. SAC is usually caused by some airborne pollens. Signs and symptoms usually occur/worsen in the spring and summer, and remission is observed during the winter months. PAC can occur throughout the year with exposure to perennial allergens^{5,6}. Whereas VKC is a type of AC which can potentially affect the vision by giving rise to corneal pathologies. This type of AC is comparatively rare and usually occurs in young children especially males during spring or summer⁷. AKC is found among patients with existing atopic dermatitis and is the most severe form of chronic allergic conjunctivitis. It is usually a bilateral inflammatory chronic keratoconjunctivitis and can also involve the eyelids, thus being a blepharokeratoconjunctivitis³. It can also cause scarring with potential adverse ocular sequelae.

Though the condition can be easily treated in most cases recurrence occurs, especially after discontinuation of drugs. This causes major dissatisfaction among the patients. Prolonged usage of anti-histamines and immunosuppression can have major effects and ocular health⁸.

This situation addresses a need to investigate the environmental factors that are associated with the patient's daily life. The current upsurge of AC makes understanding the associated environmental factors a matter of concern. Because the allergic manifestations are rooted in the immune system reactivity of an individual, the environmental factors are the most significant factors for the manifestation of the condition. There are indoor factors as well as outdoor factors which can cause the condition. An approach to non-pharmacological treatment should be made first and topical medications can be administered alongside⁹. Complete avoidance from potential allergens is the best strategy although it is frequently hard to carry out, and is especially important in PAC and SAC and also in VKC or AKC when there is a documented allergy³. The study aims to identify the potent environmental allergens which can contribute to the condition to enhance and extend the clinical management of AC by providing personalized treatment plans for individuals providing evidence-based insights to enlighten practitioners and patients alike.

This study aims to identify environmental allergens contributing to AC, analyze their correlation with disease frequency and severity, and assess the influence of air-conditioned environments in a clinical population in Eastern India.

2. Materials and Methods

2.1 Study Design and Setting

A prospective, cross-sectional prevalence study was conducted at ASG Eye Hospital, Agarpara, West Bengal, between January and May 2024.

2.2 Participants

Patients presenting with clinical symptoms of ocular allergy (itching, redness, tearing, swelling) were included. Exclusion criteria were: presence of skin allergies, contact lens wear, or absence of symptoms for over one month.

2.3 Data Collection

Participants completed a structured questionnaire assessing demographic profile, environmental exposures (dust, pollen,

pet dander, air pollution, air-conditioning), and frequency/severity of symptoms. Severity was graded as mild, moderate, or severe based on symptom impact. All patients underwent slit-lamp evaluation.

2.4 Sample Size

The calculated sample size ($n = 62$) was based on the formula $Z^2 p \cdot (1-p) / d^2$, with $Z = 1.96$, $p = 0.2$, and $d = 0.1$.

2.5 Statistical Analysis

Data were analyzed using PQStat (version 1.8.6). Fisher's exact test assessed associations between environmental factors and allergic severity/frequency. Odds ratios (OR) were calculated; $p < 0.05$ was statistically significant.

3. Results

The average age was 22.03 ± 12.4 (mean $\pm$ SD) in this study. Females were found to be more affected (56.45%) than males (43.55%) in this study [Table 1]. In this study most patients were from urban areas (56.45%), followed by suburban (38.70%) & rural (4.84%) [Table 2]

[Table 1]

Demographic data of the patients

Gender	No. Of patients n=62	Percentage(%)
Male	27	43.54
Female	35	56.45

[Table 2]

Locality

Locality	No. Of patients n=62	Percentage(%)
Urban	35	56.45
Suburban	24	38.70
Rural	3	4.84

In the study, ages between 21 to 30 were the age group with the maximum number of patients with ocular allergy (32.25%), [Table 3] shows the prevalence of age groups.

[Table 3]

Age group

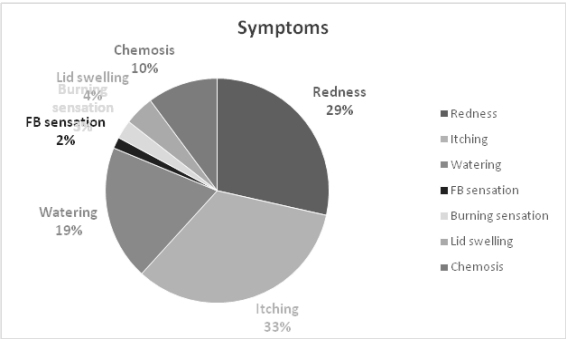
Age group	No. Of patients n=62	Percentage(%)
1-10	16	25.81
11-20	11	17.74
21-30	20	32.25
31-40	8	12.90
41-50	7	11.29

Among known allergic factors dust was the most common (32.25%), followed by air pollution (30.65%), pollen (9.68%) & pet dander (4.84%). For 22.58% of individuals, it was unknown [Table 4 & Figure 1].

[Table 4]

Symptoms reported

Symptoms	No. Of patients n=62	Percentage (%)
Redness	53	85.48
Itching	62	100
Watering	36	58.06
FB sensation	3	4.84
Burning sensation	5	8.06
Lid swelling	8	12.90
Chemosis	19	30.65



[Figure 1]

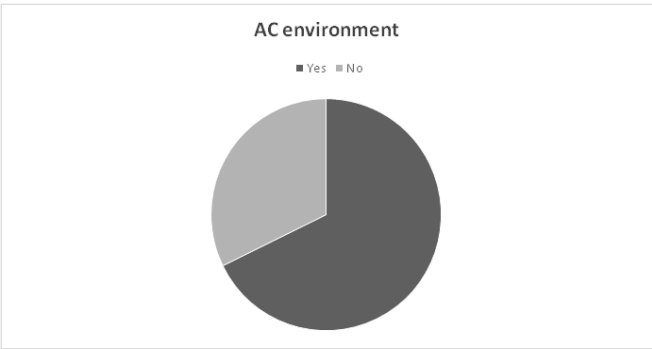
Prevalence of symptoms

Among the 62 patients, 42 were found to stay in an air-conditioned environment for more than 1 hour (67.74%) [Table 5 & Figure 2].

[Table 5]

Air-conditioned environment

Air-conditioned environment	No. Patients n=62
Yes	42
No	20



[Figure 2]

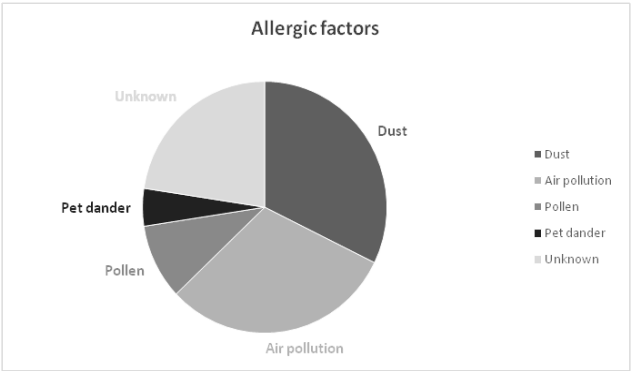
Air-conditioned environment

Itching was found among all the affected patients, redness was the 2nd most presenting symptom (85.48%) followed by watering (58.06%) [Table 6 & Figure 3].

[Table 6]

Known allergic factors

Allergic factors	No. Of patients n=62
Air pollution	19
Dust	20
Pollen	6
Pet dander	3
Unknown	14



[Figure 3]

Known allergic factors

A significant association of mild ($P=0.001$, 95% CI OR 2.15-22.5) and moderate ($P=0.0282$) AC was found with dust [Table 7]. Extremely high significance was observed between pollen and severe allergy ($P<0.00001$, 95% CI OR 6.83-459.74). air-conditioned environment was significant for mild allergy ($P=0.0169$).

[Table 7]
Co-relation between allergic factors and severity

Allergic factors		Severe	Not severe	p-value	Moderate	Not moderate	p-value	Mild	Not mild	p-value
Dust	Yes	1	19	0.6532	7	13	0.0282	12	8	0.001
	No	5	35		28	14		7	35	
Air pollution	Yes	2	17	1	11	8	1	6	13	1
	No	6	37		24	19		13	30	
Pollen	Yes	5	1	<0.00001	1	5	0.0772	0	6	0.1632
	No	3	53		34	22		19	34	
Pet dander	Yes	0	3	1	3	0	0.2473	0	3	0.5435
	No	6	52		32	28		19	34	
AC environment	Yes	7	32	0.2447	24	15	0.1682	8	31	0.0169
	No	1	19		8	12		11	9	

Dust was found to be significant for occasional ocular allergy [Table 8]. For frequent allergy also the p-value was very significant (p=0.0008, 95% CI OR 2.16-22). Air-conditioned environment was also proven significant for occasional(p=0.005) and frequent ocular allergy (P= 0.0265, 95% CI OR 1.14-12.96). Air pollution was found to be significant for occasional ocular allergy(p=0.0494, 95% CI OR 1.1-10.5).

[Table 8]
Co-relation between allergic factors and frequency

Allergic factors		Occasionally	Not occasionally	p-value	Frequently	Not frequently	p-value	Very frequently	Not very frequently	p-value
Dust	Yes	5	15	0.0134	14	6	0.0008	1	19	0.0788
	No	26	16		10	32		10	29	
Air pollution	Yes	13	6	0.0494	5	14	0.1606	1	18	0.4196
	No	15	25		19	21		6	34	

Pollen	Yes	1	5	0.1979	3	3	0.6793	2	4	0.1444
	No	27	26		21	32		5	48	
Pet dander	Yes	3	0	0.2377	0	3	0.2766	0	3	1
	No	28	31		24	35		7	52	
a i r conditioned environment	Yes	13	26	0.0052	20	19	0.0265	6	33	0.4045
	No	15	5		4	16		1	19	

4. Discussion

From the study, it is observed that the age group of 21-30 is the most affected group and females are more affected than males. This finding correlates with a previous study¹⁰. The relationship between female steroid sex hormones and allergies is highlighted in some previous research. Reasons for this might be that estrogen receptors are found in a large number of immunological cells¹¹. It has been suggested that estrogen can influence to modulate the immunological pathway to direct the immunological response towards the allergen directly and can favour an allergic response by promoting Th2 polarization which can lead to class switching of B cells to produce IgE. However, those findings need further study^{12, 13}. Another finding is that the younger age group (21-30) was more affected. Several factors influence in occurrence of allergic diseases like genetics, various medications, internal diseases and Immunosenescence. Immunosenescence is the change in immune function with ageing. Immunosenescence involves the modification and remodelling of tissue structure. Many functions sometimes decline with ageing, while other functions can become more active. A senescent immune system can show impaired interactions between the innate and adaptive immune responses¹⁴. Also the elderly mostly take many kinds of medications, which may also hinder any allergic response.

House dust was found to be the most prevalent allergen in this study (32.25%). Dust mite allergy is an IgE-mediated Type 1 hypersensitivity reaction to dust mite allergens,

commonly found in household dust, so it is also known as house dust allergy. It is sensitization and an allergic reaction to the droppings of the dust mites. The droppings are an indoor aeroallergen, which on inhalation triggers the allergic reaction¹⁵. Dust mite causes PAC which persists throughout the year. In this study, dust was significant for mild to moderate ocular allergies and occasional frequency. Air pollution was found to be the 2nd most prevalent factor, To date, the underlying pathophysiological mechanism of conjunctivitis caused by air pollutants is still unclear. As a human's eyes are directly exposed to air pollution, some studies have speculated that PM_{2.5}^{16, 17} PM₁₀¹⁸ particles may easily cause the inadaptability of intraocular epidermal cells, leading to cell death and the inflammation of tissue cells. Second, NO₂ and O₃ have strong oxidative stress effects¹⁹, which may stimulate conjunctival cell inflammation. Finally, NO₂ is an acidic gas. When it enters the eyes, it easily changes the acidic and alkaline environment of the inner epidermis cells of the eyes^{20, 21}, breaking the function of the eye cells and causing inflammation. Air pollution mostly accounted significant for occasional allergy, indicating the patients faced the symptoms of ocular allergy after going outside. 9.68% of patients were found with pollen allergy, which mostly manifested as seasonal VKC causing severe allergic conjunctivitis, mainly observed among children.

Among the patients, a significant number of patients (67.74%) stayed in an air-conditioned environment for more than 1 hour. Most patients with mild allergic severity were found to stay in an air-conditioned environment and the frequency was found to be significant for mild to moderate symptoms. This may indicate that the individuals get the allergy symptoms at the times when they stay in the air-conditioned environment. The cause behind the air-conditioned environment producing ocular allergy is mainly the filters and humidity. Uncleaned filters without maintenance become a shelter for mould and mildew, the spores released from which can cause allergic conjunctivitis. Dust and pollen can also get stuck in the filters and get distributed when the air conditioner is turned on. In the study, 14 patients were unknown of any possible allergen, but 12 of them were found to stay in an air-conditioned

environment for a long time, which supports the previous statements.

Limitations

Though the study gives meaningful insights into the environmental risk factors of allergic conjunctivitis, there were a few limitations to the study. The sample was relatively small compared to the context of the research. Further studies can work with a bigger sample size to provide a deeper insight. The study was a survey-based study and dependent on the data which were provided by the patients themselves. So there is a chance of error and bias which could not be avoided.

The environmental factors of the patients were not evaluated, such as air quality index, the concentration of various elements in the air, the environment of the patient's residence and working place, the type of air-conditioner used and details about its maintenance; which could provide more details to this study.

Conclusion

From this study, dust and air pollution were found to be the most reported known allergens and responsible for mild to moderate with severity seen occasionally to frequently. This is practical because low AQI can be observed in polluted areas and house dust is ubiquitous. The patients mostly seem to be aware of those allergens but they are yet to give enough significance. On the other hand, an air-conditioned environment was observed mostly among the patients with frequent and occasional symptoms and from the data it can be assumed air-conditioned environment can also be a significant factor in giving rise to ocular allergy as well as prolonging/worsening the symptoms.

Awareness needs to be spread among patients to avoid possible allergens. Tidiness should be maintained in every house to prevent allergy from dust mites, nose, mouth and eyes should be covered during cleaning the house. Individuals living in areas with low AQI should wear masks and eyeglasses/sunglasses while going out. Air conditioners need to be well

maintained by checking and cleaning/replacing the filters regularly. Humidifiers can be used alongside air conditioners to maintain good humidity.

Despite the meaningful insights, there were many limitations faced in the study, future studies with a bigger sample size and detailed analysis of environmental and behavioural factors can provide a deeper and more significant understanding of the relationship between environmental allergens and ocular allergy. By expanding the understanding of these relationships, both clinical practice and public health strategies can be well informed, ultimately reducing the burden of AC on affected individuals and strengthening non-pharmacological management.

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