

ORIGINAL ARTICLE

Association between Ambient Air Pollution Exposure and Ocular Surface Disorders Among Adults in Urban Lahore. A Cross-Sectional Clinical Study

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**ABSTRACT**

Background: Urban air pollution has turned out to be a leading issue of public health in Lahore with frequent air smog cases, contributing to a high level of ocular morbidity. Pollutants of the air particularly affect the eyes because the eyes constantly encounter the environment.

Objectives: It is aimed to determine the correlation between the exposure to air pollution in the ambient setting and ocular surface diseases among adults living in Lahore.

Methods: It was a cross-sectional clinical study in 100 adults who were recruited at ophthalmology outpatient clinics. The structured questionnaires and clinical examinations, which were used to get the data included tear break-up time (TBUT), Schirmer test, eyelid margin test, conjunctival hyperemia, allergic conjunctivitis, and meibomian gland dysfunction. The level of exposure was determined with the help of outdoor time per day, living in close relation to traffic and industrial facilities, and environmental AQI.

Results: Eye redness (72%), dryness (68%), burning sensation (61%), tearing (54%) and foreign-body sensation (49%) were found to be the most common. Clinically diagnosed dry eye (TBUT <10 seconds) was found in 58% of the subjects, low tear production in 40% and meibomian gland dysfunction in 32%. The percentage of allergic conjunctivitis was detected as 27. The exposure to greater pollution levels was associated with greater ocular symptoms and lower tear stability.

Conclusion: There are several ocular surface disorders that have a close correlation with ambient air pollution among the adult population in Lahore. There is an urgent need to implement preventive methods such as the development of public awareness, protection-based eyewear, and prompt ophthalmic examination during smog-prone instances to decrease the morbidity of the eye in a highly polluted environment.

Keywords: Air pollution, ocular disorders, dry eye, smog.

INTRODUCTION

Air pollution has become one of the primary health concerns in fast urbanizing areas (mainly South Asian cities like Lahore): industrial effluents, motor emissions, construction dust-clouds, and occurrences of seasonal smog are among the factors which contribute to the consistently high polluting levels¹. Fine particulate matter (PM_{2.5} and PM₁₀), sulfur dioxide (SO₂), nitrogen oxides

(NO_x), carbon monoxide (CO) and ozone (O₃) all have been developed to be known to negatively impact on the various organ systems with the eyes being first directly exposed to irritators of the environment with no substantial defense mechanisms either biologically or through filtering².

Ocular surface, which includes the cornea, conjunctiva, tear film, and adnexal structures are very sensitive to chemical and tiny pollutants³. High loads of

pollutants have been associated with ocular surface diseases that include conjunctival hyperemia, dry eye disease, heightened tear film instability, allergic conjunctivitis and symptoms of irritation like burning, tearing and weight of foreign body⁴. A number of population-based studies and experimental studies have also proved that urban air pollution has the potential of causing oxidative effects, epithelial incorporation, breakage of the tear film, and dysfunction of the meibomian glands that can eventually damage ocular comfort and visual capacity⁵.

The Lahore city is subjected to frequent episodes of intense smog, particularly in the months of October-February when the value on buildings like air quality index (AQI) often surpasses the risks⁶. In spite of extensive respiratory and cardiovascular studies on the effects of exposure to smog, there are minimal local studies on the effects of smog on ocular morbidity⁷. As the challenge of eye irritation, dryness, and ocular allergies among adults increasingly emerges in the contaminated environments, it is essential to conduct clinical studies on the links⁸.

The research paper will seek to establish the correlation between exposure to air pollution and ocular surface disorders in adults in the context of Lahore⁹. The recognition of the relevant ocular symptoms and signs of pollutants will aid in the formulation of prevention methods, reinforcement of the population health policy, and establishing awareness on eye protection responses in the periods of high-polluted situations¹⁰.

MATERIAL AND METHOD

This was a cross-sectional clinical study done from October 2024 till March 2025 on adult subjects that reside in Lahore to determine the relationship between ambient air pollution exposure and ocular surface disorders. The sample size of 100 respondents was attained by recruiting the subjects in the outpatient units of ophthalmology and primary care unit at the Shaikh Zayed Medical Complex and other community clinics. The use of consecutive sampling was in order to enhance the inclusion of people, who appeared with eye discomfort between the period of study.

Population of the Study and eligibility:

The possible participants were persons between the ages of 18 years and above and were required to have resided in Lahore at least 1 year since they needed to have such a good exposure of the environmental conditions in the city. Everyone who had an active ocular infection that could not be explained by environmental factors (e.g., bacterial keratitis), an ocular infection that occurred recently (within the last six months), a history of ocular surgery within the

past six months, autoimmune ocular diseases, ocular abnormalities acquired in infancy, or taking topical eye medications (i.e., steroids) were excluded to reduce confounding factors.

Data Collection Procedure:

A structured and pre-tested questionnaire was used to gather data: it captured demographic factors (age, gender, occupation, residence), the duration of daily exposure to the outside world, and its proximity to a high-traffic or industrial area, the use of protective eyewear or face mask, and the presence of ocular symptoms like dryness, redness, tearing, itchy, burning, and the presence of a foreign body.

Each subject was given a clinical ocular evaluation consisting of an eye test, which entailed a conjunctival congestion check, corneal surface integrity assessment, tear break-up time (TBUT), a tear production test, and an assessment of meibomian gland condition. The intensity of the dry eye was categorized according to the standard diagnostic criteria.

Exposure Assessment:

- Based on, the exposure of the participants to ambient air pollution was estimated according to:
- Length of outdoor daily activities.
- Self-reported exposure to smog episode.
- Location of residence to major roads and industrial locations.
- The data concerning AQI in Lahore Environment Protection Department on the days of the study.

Ethical Considerations:

Institutional ethical requirements were followed in the study and informed consent was given to all the subjects. The data confidentiality was also strong, ethical approval certificate was obtained Ref (SZH/ERC/2024/122A).

RESULTS

In the study, 100 adult subjects were used. The average age of the participants was 34.86 years and 56% (n=56) participants were males and 44% (n=44) were female. Most participants (62 percent) stated that they spent more than 2 hours outdoors on a daily basis, and 67 percent lived within 1km of high-traffic thoroughfares. Ocular surface symptoms and clinically diagnosed disorders were found to be prevalent among people who were more exposed to pollution.

Table 1 indicated that eye redness (72%) was the commonest reported ocular discrimination among the participants just after eye dryness (68) and burning sensation (61). The subgroup exposed to a daily outdoor activity of more than two hours had serious symptoms in

comparison to the other subgroups. Moreover, clinically confirmed dry eye, as determined by a tear break-up time of less than 10 seconds, was noted in 58 percent of the subjects, which showed a great deal of tear film instability in a very big sample.

Poor production of tears on Schirmer testing (below 10 mm) was reported in 40 percent of the people indicating that long-term exposure to urban pollution could be one of the causes of the evaporative dry eye as well as the aqueous-deficient version of dry eye in a significant

proportion. Dysfunction of the meibomian glands was also found (32%), which proved the relationship between the exposure to particles and the blockage of the meibomian glands. Clinical diagnosis of allergic conjunctivitis was performed in 27 percent of the subjects and majority of them had an aggravation of symptoms during the high-AQI smog. In general, the evidence shows that ambient air pollution exposure has a great connection with both subjective symptoms and objective results of ocular surface disorders.

Table 1. Distribution of Ocular Symptoms and Disorders Among Participants (N = 100)

Ocular Symptom / Disorder	Number of Participants (n)	Percentage (%)
Eye redness / conjunctival hyperemia	72	72%
Eye dryness (self-reported)	68	68%
Burning sensation	61	61%
Tearing / watering	54	54%
Foreign-body sensation	49	49%
Itching	45	45%
Clinically diagnosed dry eye (TBUT <10 seconds)	58	58%
Low tear production (Schirmer's test <10 mm)	40	40%
Meibomian gland dysfunction (MGD)	32	32%
Allergic conjunctivitis	27	27%

DISCUSSION

The results of this paper present a strong association between exposure to air pollution and the development of ocular surface abnormalities in the group of adult residents of Lahore. The prevalence of the symptoms of redness, dryness, burning, tearing, and foreign-body cost in the polluted environments, is quite significant to suggest that the ocular surface is seriously irritated in the polluted environments¹¹. The same tendencies have been described in literature on other countries, and particulate matter (PM_{2.5}, PM₁₀), nitrogen oxides, and the ozone have been characterized by a strong association with ocular discomfort, oxidative stress, epithelial damages, and tears film instability¹².

This equals to a prevalence rate of clinically diagnosed cases of dry eye in 58 percent of the test people, which is significantly higher than those of regions with purer air reported globally, indicating that the smog problems consistently experienced in Lahore are escalating the tear film disturbance¹³. The damaged TBUT and the values of Schirmer indicate that both evaporative and aqueous-deficient processes are the causes of dry eye in the population that is exposed to pollution¹⁴. A dysfunction of the Meibomian glands which was seen in 32 percent of the study participants also helps in reaffirming the role of particulate deposition and chronic inflammation as one which would hamper the glandular duct termed lipid secretion¹⁵.

The diagnosis of allergic conjunctivitis was made in 27% of the participants, which represents augmented quality of sensitization to air pollutants, allergens, and chemical irritants¹⁶. Research in other high polluted areas has also demonstrated high allergic ocular symptoms at times of high smog levels and this indicates that pollutants are causative factors that enhance the immune mediated response¹⁸.

The dose response relationship between the exposure to pollutants and ocular morbidity was also supported by higher symptom burden among people living close to roadways with high traffic or with longer exposure to pollutants on a daily basis¹⁹. The AQI data recorded at the time of the study is also always considered to be above the safe levels and this is in keeping with the national reports that the environmental pollution in Lahore had escalated²⁰.

On the whole, the results confirm the necessity of the inclusion of ocular health into air quality policies. Education to the community on the use of protective eyewear and minimized outdoor activities during periods of smog can play a major role in lowering the cost of ocular complications. Early ophthalmic examination can also prove to be helpful.

CONCLUSION

The effects of ambient air pollution on the ocular health in adults in Lahore are immense. The large number of cases

with the problem of the dry eye disease, the instability of the tear film and allergic conjunctivitis, as well as the meibomian glands dysfunction reveal the susceptibility of the ocular surface to the pollutants of the air. Those who reside close to the busy roads and those who are continuously exposed to the outdoor pollution are especially vulnerable. Enhancement of the population through spreading awareness campaigns, advancing protective measures, and advancing environmental laws are important procedures to reduce the harmful impact of air pollution on the eye health.

DECLARATION

Conflict of Interest

The authors declare no conflict of interest.

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Author's Contribution

All authors contributed equally in the complication of current study.

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Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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