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ORIGINAL RESEARCH

Impact of Mining on the Ocular Surface Health Among Residents of Mining Communities

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Purpose: Despite known associations between air pollution and ocular health, the specific impact of mining dust on ocular surface health remains largely unexplored. This study aims to address this gap by determining the ocular surface characteristics, the prevalence of dry eye disease (DED), tear film inflammatory markers, and their clinical correlation among people residing in mining communities.

Methods: This was a prospective one-year study at a primary eye care centre that included 376 participants. The participants were categorized into three sub-groups based on the duration of exposure to mining activities, namely high exposure (A: >8 h), moderate exposure (B: 2–8 h;), and minimal exposure (C: <2 h). The participants underwent thorough clinical examinations, ocular surface disease index (OSDI) scoring, Schirmer's test (without anaesthesia), ocular surface analyser and surface staining. The tear samples were analysed for selected inflammatory markers, such as interleukin-1Ra, interleukin-6, interleukin-8, tumour necrosis factor-alpha (TNF-α), and matrix metalloproteinase 9 using multiplex enzyme-linked immunosorbent assay. Bivariate and multivariate regression models with odds ratios were used for the statistical analyses.

Results: The prevalence of dry eyes was 15.4%. The OSDI and Schirmer's test scores were poor in group C and A as compared to group B. The risk of DED ($p<0.05$) increased with advancing age and elevated blood pressure and correlates with surface staining. No significant association could be established between the inflammatory markers and dry eyes using cytokine titres.

Conclusion: DED is prevalent in mining communities. Safety gear, periodic eye examinations, and appropriate treatment are recommended.

Keywords: dry eye disease, inflammatory markers, mining, ocular surface

Introduction

The latest Tear Film and Ocular Surface Society Dry Eye Workshop II (TFOS DEWS II) Definition and Classification Subcommittee, 2017, has redefined dry eye to be a multifactorial disorder of the ocular surface resulting from loss of tear film homeostasis leading to various ocular symptoms, caused by instability and hyperosmolarity of tear film, ocular surface inflammation and damage, and neuro-sensory abnormalities.[1]

The ocular surface has its own defence and cleaning mechanisms. The thin layer of tear film secreted by the lacrimal glands, meibomian glands and the conjunctiva aids in immune surveillance and precludes harmful substances from entering the eyes.[2]

Recently, tear film biomarkers have been employed in the diagnosis and management of dry eye disease (DED) because of their potential role in the pathogenesis of ocular surface damage and the feasibility of tear sampling.[3] The protective barrier of the tear film is compromised by acute and chronic external factors like environmental dust, smoke from vehicles, and chemicals from industries. Such breaches might cause redness, swelling, watering, burning, itchiness, and pain in the eyes. The degree and duration of exposure to such environmental factors play an important role in causing reversible or irreversible damage to the ocular surface. The effect of the environment can be assessed by enquiring about

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symptoms, clinical evaluation of signs, performing appropriate investigations, and correlating the extent of damage with inflammatory tear film biomarkers.

Human civilization is the major cause of air pollution these days because of industrialization and globalization. The upsurge in industrialization, especially mining activities, has increased the amount of mining associated pollution (dust) in the environment. Mining contributes to the dust directly through mining activities and indirectly through motorized vehicles engaged in the transportation of these minerals and metals, causing air pollution and poor air quality. Outdoor and indoor air pollution can affect the eye and manifest as ocular surface irritation, conjunctivitis, and dry eye disease. Fu et al showed that air pollutants specifically particulate matter (PM 2.5) significantly reduce the viability and proliferation of ocular surface epithelial cells.[4] They even concluded that interfering with epithelial cells' autophagy could be a potential treatment for air pollutant-induced ocular surface diseases. Previous studies have confirmed an association between air pollution and ocular surface disorders.[5] The pollutants might damage the tear film and disrupt the protective barrier, making the ocular surface vulnerable.

The relationship between air pollution, especially caused by mining activities, and its impact on ocular surface health have not been properly investigated to date. In this study, we attempt to assess the effect of mining activities on ocular surface health, especially the prevalence of dry eye disease in participants with varying levels of exposure to mining activity.

Materials and Methods

The study adhered to the Declaration of Helsinki. The study was approved by the Institutional Ethics Committee of L V Prasad Eye Institute, Bhubaneswar (IEC code: 2021–100-BHR-41). This was a prospective, non-randomized, cross-sectional study conducted at a primary-level vision centre near numerous iron-ore mines from July 2021 till June 2022. Anyone over 18 years who was willing to participate and provided consent for tear sample collection was included in the study.

The participants were divided into the following three groups based on the duration of exposure to mining particles: (A) Severely exposed: Miners who actively participate in mining activities (>8 h/day) and most vulnerable to mining particles present in the environment; (B) Moderately exposed: Residents with an occupation other than mining. They are moderately exposed passively to mining particles in the environment (2–8 h/day); (C) Minimally exposed: Residents who spent most of their time indoors, such as homemakers and the geriatric population, with the least amount of exposure to mining particles (<2 h/day). Those who refused to participate, the paediatric population, psychiatric patients, and those diagnosed with keratoconjunctivitis sicca and connective tissue disorders were excluded from the study to avoid confounding bias. A sample size calculation of 376 with near-equal representations from all three subgroups was considered for this study using the formula:

$$\text{Sample size n} = [\text{DEFF} * \text{Np}(1 - \text{p})]/[(\text{d}2/\text{Z}21 - \alpha/2 * (\text{N} - 1) + \text{p} * (1 - \text{p})]$$

where N = population size

p = hypothesized % frequency of outcome factor in the population (25%)

d = confidence limits as % of 100 (absolute ± %) (5%)

DEFF is the design effect (1.25) with 5% data loss

The purpose of the study was explained to all participants, and consent was obtained in their native language. They were asked about their symptoms using the Ocular Surface Disease Index (OSDI) questionnaire,[6] followed by documentation of systemic vitals (temperature, blood pressure) and a detailed history of their symptoms. The clinical findings were recorded via slit-lamp examination. This was followed by various tests, including Cochet Bonnet aesthesiometry (Luneau Technology, France), Schirmer test (without anaesthesia), recording of ocular surface parameters such as non-invasive tear film break-up time, tear meniscus height, lipid layer interferometry, eye blink quality, and infrared meibography (IDRA Ocular surface analyzer, S.B.M Sistemi, Italy). Tear samples were collected separately from each eye using microcapillary tubes (50–100 μL) for cytokine analysis such as interleukin-1Ra (ILR1a), interleukin-6 (IL-6), interleukin-8 (IL-8), tumour necrosis factor-alpha (TNF-α), and matrix metalloproteinase 9 (MMP-9). A third tear sample was used to detect the iron content when possible. Finally, the ocular surface (cornea and conjunctiva) was stained using sterile fluorescein strips, and the grading was documented using cobalt blue filtered photographs. The

National Eye Institute grading scale was used to score them.[7] The Schirmer strips were stored in phosphate-buffered saline (1xPBS) for further use after taking the reading. All tear fluid samples (microcapillary tubes and Schirmer strips) were immediately stored at −80 °C in microfuge tubes till further analysis. Ninety-seven tear fluid samples (IL-1Ra, IL-6, IL-8, TNF-α, and MMP9) were outsourced to MERCK labs, Bangalore, India, for cytokine analysis using a multiplex enzyme-linked immunosorbent assay (ELISA) analysis. The iron content in tear samples was also analysed using atomic absorption mass spectrophotometry at the Institute of Life Sciences, Bhubaneswar, India.

Diagnostic criteria: DED was diagnosed if non-invasive tear breakup time (NiTBUT) was <10 s and the OSDI score was ≥13 or unanesthesized Schirmer's I test was <10 mm in any eye.

The data were checked for normality. The categorical variables were reported as frequencies and proportions, and the continuous variables as frequencies and measures of central tendency and dispersion. The comparison was done using parametric and non-parametric statistical tests wherever applicable. The findings were deemed to be statistically significant if p<0.05. Bivariate and multivariate analyses were done, with dry eye versus no dry eye as the dependent variables. For the multivariate logistic regression modelling, we chose variables pragmatically for adjustment into the model. Therefore, we adjusted for age (in years), gender, level of exposure, blood pressure, presence of refractive error, and serum cytokine (IL-1Ra, IL-6, IL-8, MMP-9, and TNF-α) titres as predictor variables. For the variables specific to the examined eye, such as lipid layer thickness (LLT), meibomian gland loss (MG loss) of lower lid, tear meniscus height (TMH) and eye blinking. If both eyes were dry, we considered measurements from the worst eye (based on Schirmer's test and NiTBUT) to fit the model. The data were managed in Microsoft Excel, and the analyses were done by a data analyst using STATA 13.

Results

General Distribution of Subjects (Table 1)

A total of 376 participants participated in this cross-sectional study. The mean age of the participants was 39.1±12.5 years (range 18–70 years). Among them, 49.6% (n=186) belonged to the age group of 18–39 years, followed by 44.8%

Table 1 Distribution of Study Participants According to Age and Exposure Status

Age (years)	**N (%)**
18–39	186 (49.6)
40–59	169 (45.1)
60+	21 (5.6)
Gender	**N (%)**
Male	234 (62.2)
Female	142 (37.8)
Category	**N (%)**
Highly exposed	129 (34.3)
Moderately exposed	123 (32.7)
Minimally exposed	124 (33.0)
Refractive Error	**N (%)**
Myopia (M)	44 (11.7)

(*Continued*)

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Table 1 (Continued).

Presbyopia (P)	148 (39.4)
Hypermetropia (H)	04 (01.1)
Emmetropia (E)	176 (46.8)
Total	376 (100.0)

(n=168) in the age group of 40–59 years and 5.6% (n=21) in the age group of 60 years and above. The male:female distribution was 1.64:1. The distributions based on the severity of exposure in group A, group B, and group C were 34.3% (n=129), 32.7% (n=123), and 33% (n=124), respectively. Most participants in group A belonged to the 18–39 years age group (n=77, 59.7%), followed by 40–59 years (n=52, 40.3%) and none were older than 60 years. In Group B, the age groups 18–39 years (n=60, 48.8%) and 40–59 years (n=59, 48%) were almost equally distributed, with only a few older than 60 years (n=3, 2.4%). In Group C, the age distribution was 40–59 years (n=57, 46%), 18–39 years (n=49, 39.5%), and >60 years (n=18, 14.5%). Group A comprised only males (n=129, 100%), while group C comprised more females (n=114, 91.9%).

In group A, the mean age of the participants with and without dry eyes was 39.8±12.0 and 37.3±8.9 years, respectively (p=0.38). In group B, the mean ages were 41.04±15.7 and 36.5±13.2 years, respectively (p=0.23). In group C, mean ages were 49.6±11.8 and 41±13.5 years, respectively (p=0.01).

The reasons for visiting the eye care centre were routine ophthalmology examination (n=188, 50%), defective vision (n=153, 40.7%), watering (n=25, 6.7%), redness (n=19, 5.1%), itching (n=19, 5.1%), pain (n=9, 2.4%), headache (n=3, 0.8%), burning sensation (n=2, 0.5%), swelling (n=1, 0.3%), and stickiness of eyelids (n=3, 0.8%). Many participants had multiple symptoms.

As part of the comprehensive eye examination, the refractive error status of the participants was checked. The examination revealed emmetropia, myopia, hypermetropia, and presbyopia in 46.8%, 11.7%, 1.1%, and 39.4% of participants, respectively. Approximately 40.7% of participants were using glasses before the evaluation.

Office blood pressure evaluation indicated uncontrolled blood pressure in 81 participants (21.5%) (as per American Heart Association guidelines).[8] The distribution of participants with elevated blood pressure across the groups was as follows: group A (18.6%, n=24), group B (24.4%, n=30), and group C (21.8%, n=27) respectively.

Specific Dry Eye Tests

The Ocular Surface Disease Index (OSDI) score was positive (≥13) in 88 participants (23.4%) distributed across three groups, with group A having 23 participants (17.8%), group B having 32 (26%), and group C having 33 (26.6%), which were not significant (p=0.225). Overall, a low Schirmer's value (<10 mm) was seen in 15 (4.2%) participants, and corneal sensation was diminished in seven participants (1.9%).

Prevalence of Dry Eye Disease (DED)

DED was diagnosed if the OSDI score was ≥13 and either NiTBUT <10 s or Schirmer's test <10 mm in any eye. Based on the above criteria, the overall prevalence of DED among participants was 15.4% (n=58.95% CI: 11.9–19.5). The distribution of dry eye disease (DED) among the three categories of participants was as follows: group A: 22.4% (n=13), group B: 39.7% (n=23), and group C: 37.9% (n=22). Table 2 compares the prevalence of DED according to age, gender, blood pressure, corneal sensation, and eye blinking. Among all the parameters', advanced age has a positive correlation with the presence of DED (p=0.001). The elderly population (>60 years) was associated with DED (p=0.001), and 24.7% of patients with DED had high blood pressure (p=0.014). Table 3 compares the distribution of OSDI score in the various groups (A, B and C). The OSDI score was noted to be positive (≥13) in 88 subjects (23.4%) distributed among the three groups as group A (n=23,17.8%), group B (n=32,26%) and group C (n=33,26.6%) which was not statistically significant (p=0.225). Table 4 compares the prevalence of dry eye across the Groups A, B, and C.

Table 2 Overall Prevalence of Dry Eye According to Age, Gender, Blood Pressure, Aesthesiometry Test, and Eye Blink

	n/N (%)	95% Confidence Interval		p-value
		Lower Limit	Upper Limit	
Age (years)				
18–39 (N=186)	18 (09.7)	05.8	14.9	0.001
40–59 (N=168)	32 (19.1)	13.4	25.8	
60+ (N=21)	08 (38.1)	18.1	61.6	
Gender				
Male (N=232)	34 (14.7)	10.4	19.9	0.558
Female (N=141)	24 (17.0)	11.2	24.3	
Blood Pressure				
Normal BP (N=295)	38 (12.9)	09.3	17.2	0.014
High BP (N=81)	20 (24.7)	15.8	35.5	
Aesthesiometry Test				
Positive (N=07)	01 (14.3)	0.4	57.9	1.000
Negative (N=369)	57 (15.5)	11.9	19.5	
Eyeblink				
Less than 80 (N=44)	08 (18.2)	08.2	32.7	0.415
80–100 (N=281)	42 (15.0)	10.9	19.7	

Table 3 Distribution of Ocular Surface Disease Index (OSDI) Score as per Exposure

OSDI	Highly Exposed N (%)	Moderately Exposed N (%)	Minimally Exposed N (%)	Total N (%)
Normal	106 (82.17)	91(73.98)	91(73.39)	288(76.6)
Mild	19((14.73)	15(12.2)	16(12.9)	50(13.3)
Moderate	4(3.1)	13(10.57)	5(4.03)	22(5.85)
Severe	0	4(3.25)	12(9.68)	16(4.26)
Total	129	123	124	376

Table 4 Prevalence of Dry Eye Across the Groups A, B, and C

Diagnosis	Group A	Group B	Group C	Total
Normal	116 (89.92%)	100 (81.3%)	102 (82.26%)	318 (84.57%)
Dry eye	13 (10.08%)	23 (18.7%)	22 (17.74%)	58 (15.43%)
Total	129 (100%)	123 (100%)	124 (100%)	376 (100%)

Table 5 Logistic Regression for Identifying Association of Dry Eye Disease with Selected Set of Variables Selected Pragmatically

Variable	Bivariate Regression		Multi-Variate Regression	
	Unadjusted Odds Ratio (95% CI)	P value	Adjusted Odds Ratio (95% CI)	P value
Group (Ref. Maximally exposed)				
Moderately exposed	2.05 (0.99–4.26)	0.054	1.71 (0.46–6.39)	0.425
Minimally exposed	1.92 (0.92–4.02)	0.081	0.94 (0.13–7.05)	
Age Category (Ref. 18–39 years)				
40–59 years	2.20 (1.18–4.08)	0.013	3.79 (1.31–11.0)	0.014
60 years and above	5.74 (2.10–15.71)	0.001	11.6 (1.62–82.3)	0.015
Gender (Ref. Male)				
Female	1.19 (0.68–2.11)	0.541	2.17 (0.40–11.64)	0.368
Blood Pressure (Ref. Controlled)				
Uncontrolled	2.22 (1.21–4.08)	0.010	2.31 (0.79–6.79)	0.127
IL1RA	1.00 (1.00–1.00)	0.419	1.00 (1.00–1.00)	0.898
IL6	1.00 (0.99–1.00)	0.158	1.00 (1.00–1.00)	0.427
IL8	0.99 (0.98–1.00)	0.019	0.99 (0.98–1.01)	0.217
TNF alpha	0.99 (0.98–1.00)	0.027	0.99 (0.98–1.00)	0.085
MMP9	1.00 (0.99–1.00)	0.489	1.00 (1.00–1.00)	0.749

Note: $p<0.05$ is statistically significant.

Cytokine analysis done in 97 samples (group A: 34, group B:24 and group C:39) done by multiplex ELISA method showed raised levels of all cytokines in all tear fluid samples except in 3 samples (one from group A and 2 from group C) for MMP-9 and one sample (group A) for IL-6. We could not achieve an unequivocal finding for the association of cytokine titres with DED.

On bivariate logistic regression (Table 5), higher age categories (as compared to the 18–39-year category) and uncontrolled blood pressure showed statistically significant odds with prevalence of dry eye. Although IL-8 and TNF-α also showed statistically significant p-value, the upper limit of the unadjusted odds ratio touched the value "1" indicating possible chance finding. On multivariate logistic regression (Supplementary Table (S1)), only advanced age category showed statistically significant association with dry eye; with reference to the 18–39-year-old category, those aged 40–59 years had 3.79 times odds (p=0.014) and those aged 60 years and above had 11.6 times odds (p=0.015) of having dry eye. Level of exposure did not show statistically significant association with dry eye (possibly, due to "healthy worker effect" since those with maximal exposure were current miners)

Discussion

Constant exposure to mining dust can lead to chronic inflammation, oxidative stress, and toxicity, resulting in cataract formation, glaucoma, uveitis, retinal layer thinning, macular degeneration, and diabetic retinopathy.[9] Previous studies have shown significant correlations between various intensities of air pollution and tear cytokine concentrations. Air pollution might lead to a cytokine imbalance at the ocular surface, with signs and symptoms of ocular discomfort.[10] The eye when exposed to pollutants can lead to ocular surface damage which can trigger a range of symptoms, such as itching, discharge, congestion, photophobia, blurred vision, and irritation. However, the damage can be clinically assessed in several ways, like measurement of tear production, slit-lamp examination, corneal staining, and conjunctival staining. At the cellular level, these environmental toxins in the form of particulate matter, liquids, aerosols, or vapours can cause oxidative damage, apoptosis of corneal and conjunctival cells, cell ageing, and impaired motility, which may or may not be reversible.[11]

The mean age of participants in our cross-sectional study was 39.1±12.5 years (mean ± SD, range 18–70 years), with the male: female distribution being 1.64:1. Group A comprised the younger age group, group B had almost equal distribution in age groups, and group C skewed towards the middle and older age groups. The primary purpose of the visit was routine check-ups (50%), followed by defective visual acuity (40.7%). This survey helped to detect the prevalence of DED in the cohort and facilitated a comprehensive eye screening. Approximately 12.5% of participants were unaware of their refractive status. They were prescribed glasses for the first time during our survey. Similarly, 21.5% of participants had elevated blood pressure. While some were already on medications, others were diagnosed for the first time during the screening. There were more participants in group B and group C that were on medication than group A. This could be because of the "healthy worker effect" and annual health check-ups provided by the mining company, facilitating good health among miners (group A). The remaining participants were asked to visit the nearby dispensary to manage their conditions.

Even though the questionnaire was explained in their respective native language, we assume that many inquiries were not relevant to the study population, such as the use of computer screens, air-conditioners, and symptoms in humid conditions. The OSDI subjective questionnaire has been used as one of the diagnostic criteria to report the prevalence of DED in various papers.[12,13]

The overall prevalence of dry eye among the participants (n=58) was 15.4% (95% CI: 11.9–19.5) based on the above criteria. The prevalence of DED in India is higher as compared worldwide ranging from 18.4% to 54.3%.[12,14,15] The diversity in geographic location, different methods of evaluation, and different diagnostic criteria in detection might be responsible for such variations in the prevalence of DED. In our study, we tried to incorporate a combination of symptoms (OSDI questionnaire), signs (clinical evaluation), diagnostic findings (IDRA), and confirmatory evidence (Cytokine analysis) as a stringent criterion for better correlation. Titiyal et al conducted a similar study in Northern India and used an OSDI questionnaire to evaluate the prevalence and risk factors of DED. Schirmer's test and tear break-up time were performed only in the subset who consented for these tests. The tests found a prevalence of 32%, which is high.[12] However, we tried to follow strict criteria, including ocular symptoms (OSDI) and either one of the DED tests (NiTBUT or Schirmer's test). This might be the reason for a low prevalence rate in this study, despite our participants being predisposed to harsh working and ecological conditions compared to the rural or urban cohorts.

The results of this study show that group B and group C had an almost equal prevalence of DED and more compared to group A participants (Table 3). Of the 58 participants with dry eyes, 34 (58.6%) were male. Titiyal et al also observed a similar prevalence in males (65.28%).[12]

Various parameters, such as age, gender, blood pressure, corneal sensation, and completeness of eye blink, were correlated with the prevalence of dry eyes. Among them, advanced age had a positive correlation with the presence of DED (p=0.001). The elderly population (>60 years) was associated with DED (p=0.001), and 24.7% of patients with DED had high blood pressure (p=0.014) (Table 2). Tandon et al conducted a cross-sectional population-based study, where dry eye assessment was performed by objective (TBUT, Schirmer-I, and corneal staining) and subjective (OSDI) tests. It also included a questionnaire-based assessment of exposure to sunlight and smoke. They observed that DED is common in a population ≥40 years and is affected by extrinsic (geographic location, exposure to sunlight, smoke) and intrinsic factors (age, gender, blood pressure, diabetes, and body mass index).[13]

A study by Berra et al has shown that the tear break-up time (TBUT), a measure of tear film stability, significantly decreases during acute episodes affected by air pollutants in the study group compared to the control group.[16] Such sudden exposure to excessive levels of air pollution can result in tear film instability without causing re-modulation of the ocular surface. In our study, the participants were subjected to chronic exposure to environmental pollutants (ie, iron ore particles). We observed NiTBUT less than 10s in 321 participants (85.4%). Since a low value was noted in most of the participants, we considered the value <10 s as a part of the diagnostic criteria and not as the exclusive diagnostic criteria.

We also noted a significant association between DED, advancing age, uncontrolled blood pressure, LLT, and ocular surface staining (especially left eye). Tear fluid cytokine levels are considered probable markers of inflammation in DED. The raised levels of cytokines in all tear fluid samples except in 3 samples for MMP-9 and one sample for IL-6 also highlights that overall the mining environment harbours potential irritants which are sufficient enough to cause ocular surface inflammation in all groups irrespective of direct or indirect exposure to mining activities. However, we did not get an unequivocal finding for the association of cytokine titres with DED. The upper limit of the 95% CI of the adjusted odds ratio (AOR) for each cytokine measured (IL1-Ra, IL-6, IL-8, TNF-α, and MMP9) touched the null value of 1, irrespective of whether the p-value was statistically significant. Literature suggests that the adjusted odds ratio (AOR) should be interpreted by considering the 95% limits of AOR and the p-value. In a study of 46 eyes with moderate evaporative-type DED, five inflammatory molecules were elevated in the tear samples. The IL-1Ra, IL-6, IL-8, and EGF levels were correlated with pain and clinical parameters measuring the tear stability, production, or ocular surface integrity. The authors concluded that inflammation plays a role in severe and moderate evaporative-type DED.[17] These cytokines and chemokines were increased in evaporative-type MDG-dependent DED and showed mild-to-moderate clinical signs with moderate-to-severe symptoms. There were correlations between the inflammatory mediators and the signs and symptoms. Previous works on tear film biomarkers have concluded that among the 33 detectable markers, IL-1Ra and IL-8 were associated with clinical signs and disease severity.[18]

When we looked at the clinical signs of inflammation, the presence of congestion and occurrence of pinguecula was seen more in the severely exposed group A (Right eye: p=0.145, Left eye: p=0.234). These signs can be considered as clinical indicators of ocular surface irritation and inflammation resulting from prolong exposure to mining dust and hot working environment. Berra et al showed a significant increase in bulbar conjunctival hyperaemia (exposed vs control group, p=0.0061) during acute episodes of exposure.[17] Our participants were permanent residents who were prone to various levels of exposure to environmental pollutants.

A combination of symptom questionnaires and clinical tests is recommended to diagnose DED.[19] These clinical assessments assess tear clearance (production and elimination), tear stability, and ocular surface integrity. However, a few specific tests, such as tear osmolarity,[20] conjunctival cytology,[21] visual function,[22] and confocal microscopy,[23] can be incorporated into clinical practice for better understanding.

The limitations of our study were that individuals in each group inhabiting the same ecosystem, thereby subjecting them to the mining particles to a certain extent, and the categorization may not be very discrete. In addition, the data specific to particulate size could not be obtained in our study and limited tear sample volume in certain subjects made it difficult for cytokine analysis. The quantitative detection of iron content from the tear fluid was not feasible by using atomic absorption spectroscopy. An alternate simple questionnaire would have been more effective in picking up signs and symptoms in the participants. To the best of our knowledge, this is the first to study to report the prevalence of DED in a mining community. There is a need for larger, prospective, epidemiological study in similarly vulnerable ecological areas to establish the effect of mining activities on the ocular surface. It would also be worthwhile to study the impact of such activities on the ocular surface prior to and after prolonged period of exposure.

Conclusion

Living in harsh environments such as mining areas can lead to inflammatory dry eye disease (DED). Understanding the prevalence and severity of DED in these areas will aid in formulating preventive guidelines and measures to improve health. The way forward in terms of advocacy would be creating awareness among the community and encouraging compulsory use of personal protective equipments such as moist chamber glasses at the workplace as well as within the community to limit the direct exposure to these harmful particulates. Regular ophthalmologic screening to rule out dry eye diseases may be considered as part of annual health checkup in such susceptible communities.

Data Sharing Statement

Data are available upon reasonable request.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The author(s) report no conflicts of interest in this work.

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