RESEARCH ARTICLE

Ocular surface symptoms among individuals exposed to ambient levels of traffic derived air pollution – a cross-sectional study [version 1; referees: awaiting peer review]

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Abstract
Background: The ocular surface is separated by a thin layer of tear film from outdoor air pollutants making individuals exposed to outdoor air pollution prone to various ocular surface disorders. The aim of this study was to determine the magnitude of ocular surface disorders symptoms among traffic police officers of Kathmandu, Nepal.

Methods: Two hundred traffic police officers working at different traffic police office branches of Kathmandu, Nepal were invited to the police headquarters for eye and vision examination. Among them, 91 individuals (95% males) completed the ocular surface disease index (OSDI) questionnaire and underwent Schirmer’s I tear test.

Results: Symptoms of ocular surface disorders were reported by over 80% of the individuals. Approximately two fifths of the individuals (38%) reported severe symptoms. Only 17% of the individuals’ tear secretion was found to be below normal using the Schirmer’s tear test. There was no association between the OSDI score and Schirmer’s tear test scores ($r = 0.008$, $p = 0.94$). A weak but significant relationship was observed between the OSDI score and job duration ($r=0.21$, $p = 0.04$). Individual exposed to outdoor air pollution for more than 10 years had higher odds of reporting ocular surface complaints as compared to those who were exposed for less than 10 years (OR = 3.94, $p = 0.02$).

Conclusion: Ocular surface disorder symptoms are common among traffic police officers of Kathmandu, Nepal. The duration of exposure appears to significantly contribute to the increased symptoms in this vulnerable population.
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**Introduction**

Studies conducted so far on air pollution and the human ocular surface have demonstrated a link between air pollution and ocular discomfort, abnormal tear structure, and ocular surface inflammation. There are only a handful of studies demonstrating the association between the signs and symptoms of the ocular surface with air pollution. Studies are even more infrequent from cities in developing countries, where the concentration of air pollutants in the environment is on the rise. Kathmandu is considered as one of the most highly polluted cities in the world, and Nepal is listed as one of the most polluted countries according to the WHO urban air pollution database. Traffic police officers in Kathmandu spend most of their time outdoors, controlling the flow of vehicles because of the unavailability of modern electronic traffic management systems in the city.

The purpose of this study was to determine the magnitude of ocular surface disorders based on a subjective symptoms questionnaire and a commonly used tear secretion test (Schirmer’s I test), and then explore the association between these two tests in traffic police officers of Kathmandu, Nepal.

**Methods**

**Study population**

This study involved a cross-sectional, community-based assessment on 91 traffic police officers (86 male, 5 female) recruited among the officers of the Traffic Metropolitan head office, Baggikhana, Kathmandu, Nepal. The participants were invited by word of mouth by the head officer along with a formal written notice. Participants with any chronic illness, smoking habit, taking any systemic drugs, having any ocular diseases, previous ocular surgery and current contact lens wear were excluded from the study. All of the individuals had presenting visual acuity of better than 20/25 at both near and far. Only those participants who met our inclusion criteria and agreed to participate were included in the study. The study was conducted in the month of August 2017.

**Ethics and consent**

The study protocol was approved by the Ethics Committee of the Nepal Health Research Council (Reg.No.,218/2017). The study was part of a larger program that was aimed at determining ocular and visual disorders in police officers. All of the research participants provided their written informed consent for participation before being enrolled in the study. The Declaration of Helsinki was followed while assessing the participants.

**Ocular Surface Disease Index (OSDI) Questionnaire**

The Ocular Surface Disease Index Questionnaire is a validated tool to assess the subjective symptoms of individuals with potential ocular surface disorders. The Nepali translated OSDI questionnaire was administered to all of the participants before conducting the clinical assessment. An OSDI score of 0–12 was considered normal, 13–22 as mild, 23–32 as moderate, and 33–100 as a severe ocular surface disorder.

**Schirmer I test**

The Schirmer I tear test was conducted under topical anesthesia (0.5% Proparacaine). The test was conducted in an indoor setting at room temperature. After instilling one drop of proparacaine in each eye, the eye was dried with cotton for any residual drop. The Schirmer strip was then placed on the lateral 1/3rd aspect of the lower eye lid taking special care not to touch the cornea. The strip was removed from the lid after 5 minutes. The measurement of 5mm or less was considered as abnormal.

**Ophthalmological examination**

Routine ophthalmological examination including visual acuity, refraction, anterior segment assessment and posterior segment assessment was also conducted but were not analysed as a part of this study.

**Other variables**

Other variables such as age, gender, and duration of working as a traffic officer were also recorded.

**Statistical analysis**

The OSDI score was calculated using the following formula:

\[
\text{OSDI Score} = \left(\frac{\text{Sum of scores for all questions answered}}{\text{total number of questions answered}}\right) \times 25
\]

Data are presented as means±SD unless mentioned otherwise. Independent sample t-test was employed for comparing mean between two groups whereas one way ANOVA, along with appropriate posthoc tests, was employed for comparing means between three or more groups. Pearson correlation was employed to determine the association between variables. Binary logistic regression analysis was also employed to determine association between dependent and independent variables. Statistical analysis was conducted using SPSS V22, IBM, California.

**Results**

The mean age of the participants was 32±6 years. The OSDI questionnaire was completed by all subjects. The mean OSDI score was 30.11±19.70 (range 2 to 97.90). Based on the OSDI score, 81% of the participants reported symptoms of ocular surface disorder; over one third (38%) of the participants reported symptoms of severe ocular surface disorder (Figure 1).

Schirmer’s test of both eyes was conducted in 91% of the participants. The mean ± SD Schirmer’s test value (mm) for right eye (RE) and left eye (LE) was 16.12±10.42 and 17.42±10.84, respectively. There was a high correlation (r= 0.80, p<0.001) but a non-significant difference (p=0.08) in the Schirmer’s test score between the two eyes. Hence the results of the right eye only were used for analysis. Only 17% of the subjects’ Schirmer’s score showed abnormal results.
No association was observed between the OSDI score and the Schirmer’s test results \((r=0.008, p=0.94)\). No significant correlation was also observed between the OSDI scores and age \((r=0.15, p=0.14)\). A weak, but statistically significant, positive correlation was observed between OSDI score and duration of work \((r=0.21, p=0.04)\). The mean duration of work was 11±6 years. Individuals who had held the job for more than 5 years had severe symptoms, as compared to those who had held the job for less than five years \((p=0.001)\). A one way ANOVA test demonstrated a significant difference in the OSDI score between different age groups \(<30, 30–40 and >40 years\) \((F_{2,88} = 3.86, p=0.025)\). The symptoms score was statistically significantly different between individuals who had worked for up to 5 years, six to ten years \((mean\ difference, 13.65 \pm 6.44, 95\% CI, 0.85 to 26.46)\) and more than 10 years \((mean\ difference, 16.48 \pm 5.93, 95\% CI, 4.70 to 28.27)\). However, no statistically significant difference was observed between individuals who had held the job for 6–10 years and >10 years \((mean\ difference, 2.82 \pm 4.54, 95\% CI, -6.20 to 11.50)\) (Figure 2). Furthermore, individuals who held the job for 10 years or more had significantly higher odds of having ocular surface symptoms as compared to those who had the job for less than ten years \((OR: 3.94, 95\% CI, 1.25-12.8, p = 0.02)\). There was a slight increase in the odds of having ocular surface symptoms after adjusting for age and gender, but it was borderline significant \((OR: 4.28, 95\% CI, 0.93-19.58, p = 0.05)\)

Of the 74 subjects identified as having symptoms of ocular surface disorders according to the OSDI score, only 16 were identified as abnormal by the Schirmer’s test.

![Figure 1. Frequency of ocular surface disorder symptoms according to the OSDI score.](image1)

![Figure 2. Variation of the OSDI score according to the duration of the job. (** = statistically significant, * = non-significant). Error bars denote standard deviation.](image2)
Discussion

This study explored the symptoms of ocular surface disorders among individuals exposed to traffic-derived air pollution in Kathmandu, Nepal. A remarkable number of individuals reported symptoms with over one third reporting symptoms of severe ocular surface disorder. Ocular surface disorder vary with age, whereby the prevalence is 11% among individuals between 40 to 59, and 18% in individuals above 80\(^6\). In this study, individuals were between 18 to 48 years, and 80% had symptoms of OSD, which is alarmingly high as compared to the general population\(^7\).

Previous reports exploring symptoms in individuals exposed to traffic-derived air pollution have found mixed results. The Torricelli et al.\(^7\) study in a group of 71 taxi drivers and traffic controllers reported that most of their subjects reported few symptoms, and fell within the normal category according to the OSDI scoring. However, they demonstrated that objective tests such as tear osmolarity and break up time were significantly reduced. In contrast, Saxena et al. reported that most of the subjects who were exposed to air pollution had more symptoms (irritation, itching, lacrimation, and redness) as compared those who were not exposed\(^8\).

A majority of the individuals' Schirmer's results were within normal range in the present study. Similar normal findings of Schirmer’s test have been found by previous researchers\(^8\). This finding is not surprising as the poor diagnostic ability of the Schirmer's test for detecting ocular surface dysfunction has been well recorded in the literature\(^9\). The Schirmer’s test has shown normal results in many previous studies conducted among established dry eye population\(^10\).

The lack of correlation between the OSDI scores and the Schirmer’s results is also not surprising, as this finding is consistent with most of the previous studies where the signs and symptoms of ocular surface disorders, particularly that of the dry eyes, are not correlated with one another\(^11\). It is postulated that dry eye is a multifactorial disorder, and different mechanisms and factors act in compliment or may act independently to elicit the symptomatology of this condition\(^11\).

The weak but statistically significant positive correlation between the OSDI score and duration of holding the current job (years) implies that the longer the exposure, the more severe the symptoms. However, the finding that the mean symptom score is not significantly different between individuals who have held the job for 6–10 years and in those over 10 years signifies that exposure to ambient air pollution over 5 years poses a significant impact on the ocular surface. Furthermore, the higher odds of having ocular symptoms in individuals with over 10 years of holding the job implies that the effect of air pollution on the ocular surface may have a cumulative effect over the years until symptoms start to appear.

Nepal was ranked as the 177th country just above China, Bangladesh, and India among the 180 countries with air quality issues according to the Environmental Performance Index (EPI) of 2016\(^1\). A report in 2007 on the air pollution concentration, specifically of the PM\(_{1.5}\) of the Kathmandu valley, was found to be 17-18 fold higher than the recommended 25ug/m\(^3\) threshold provided by the WHO. A 2016 air pollution report of Nepal provided by the WHO has shown a considerable increase in PM\(_{2.5}\) concentration over a decade\(^1\). Our study was conducted in the month of August 2017. The mean 24-hour average PM\(_{2.5}\) concentration during that month was 113.5 ug/m\(^3\)(approximately 5 fold higher than that recommended by the WHO) and the PM\(_{10}\) concentration was 633ug/m\(^3\)(approximately 13 fold higher than the WHO recommendation) (see Kathmandu Air Pollution: Real-time Air Quality Index and Department of Environment, Air Quality Monitoring). In light of the high levels of air pollution of Kathmandu, the higher number of individuals reporting severe symptoms of ocular surface disease in our study can be explained.

While this study provided novel ocular health issues in this vulnerable population, some limitations must be acknowledged. Firstly, only two tests were used – the OSDI questionnaire and the Schirmer’s I test to determine ocular surface disorder. Use of more sensitive tests such as corneal and conjunctival staining, tear film break up time and tear osmolarity would have detected more individuals with ocular surface disorders, and may also have demonstrated structural/physiological anomalies of the ocular surface. However, as this was a community-based study, tests were chosen based on the non-requirement of sophisticated clinical instruments and investigations. Secondly, the actual duration and concentration of air pollution exposures in our subjects were not assessed. Measurement of the PM\(_{2.5}\) and NO\(_x\) concentration, along with a range of ocular surface disorder diagnostic tests like that of a few previous studies, would have provided us a better understanding of the association between air pollution and ocular surface disorders. Thirdly, a comparison with a control group of individuals who were not exposed to a different level of air pollution would have confirmed that the ocular symptoms were primarily due to air pollution. Nevertheless, this study was a first step toward generating awareness, and exploring symptoms related to ocular surface disorder in the vulnerable population. Future large-scale studies need to be conducted in city areas to explore ocular surface anomalies in this vulnerable population and necessary precautions are taken in order to protect the ocular health of people exposed to outdoor air pollution.

Conclusion

Traffic police officers of Kathmandu valley have a high prevalence of ocular surface complaints, which do not correlate well with the subjective tear secretion test. The duration of job appears to somewhat contribute to the increasing symptoms. In the meantime, the use of protective sunglasses and regular eye consultations for people who are exposed to outdoor air pollution is
recommended. More importantly, the government must implement new rules to reduce the levels of outdoor air pollution.

Data availability

Dataset 1: Data on the ocular surface symptoms among individuals exposed to ambient levels of air pollution. DOI: 10.5256/f1000research.13483.d18859

Competing interests

No competing interests were disclosed.

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References

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