

# Air Pollution Awareness, Personal Protective Practices, and Levels of CRP and Fibrinogen in Traffic Police of Peshawar: A Cross-Sectional Study

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## ABSTRACT

**Background:** Traffic police officers face prolonged exposure to vehicle emissions, potentially increasing systemic inflammation and highlighting the importance of awareness and protective practices.

**Objectives:** To evaluate air pollution awareness and preventive measures of traffic police officers, as well as their relationship with serum C-reactive protein and plasma fibrinogen levels.

**Methods:** We conducted a cross-sectional study among 100 traffic police officers in Peshawar from January 2025 to December 2025. We used consecutive sampling to recruit participants. A structured questionnaire recorded demographic characteristics, occupational exposure, smoking status, awareness of air pollution, and personal preventive measures. We used standard laboratory procedures to measure plasma fibrinogen and serum C-reactive protein (CRP) levels. We excluded officers with acute infections or known inflammatory disorders. We analyzed the collected data using SPSS version 27.0. We reported continuous variables as mean  $\pm$  SD and categorical variables as frequencies and percentages. We used independent-samples t-tests and chi-square tests for comparisons, with  $p < 0.05$  considered statistically significant.

**Results:** Among 100 traffic police officers, mean age was  $37.6 \pm 8.4$  years. Adequate awareness was observed in 58%, while 46% regularly used protective masks. Inadequate protective practices were associated with higher CRP levels ( $6.7 \pm 2.8$  vs.  $4.8 \pm 2.2$  mg/L;  $p = 0.001$ ) and plasma fibrinogen levels ( $407.5 \pm 76.8$  vs.  $353.9 \pm 65.2$  mg/dL;  $p < 0.001$ ). Longer occupational exposure was also associated with higher CRP ( $p = 0.018$ ) and fibrinogen levels ( $p = 0.011$ ).

**Conclusion:** Inadequate protective practices and prolonged roadside exposure were associated with elevated CRP and fibrinogen levels, highlighting occupational air-pollution risks and the need for effective protective measures.

**Keywords:** Air Pollution; Traffic Police; C-Reactive Protein; Fibrinogen

## INTRODUCTION

Air pollution is a major environmental and occupational health problem, especially in developing cities experiencing rapid urbanization, where the rising number of vehicles is a major contributor. Combustion-related pollutants emitted from motor vehicles include a complex mixture of particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), volatile organic compounds (VOCs), and other pollutants. Fine particulate matter (PM<sub>2.5</sub>) can be inhaled and enter systemic circulation, causing oxidative stress, endothelial dysfunction, and inflammation. Exposure to traffic-related air pollution has thus been linked with respiratory disease, cardiovascular morbidity, lung function impairment, and mortality.<sup>1,2</sup> Traffic police officers, who work close to busy roadways and direct traffic for several hours daily, may be at special risk of occupational exposure. Traffic police may come into contact with vehicle exhaust and

resuspended road dust more often and for longer periods than the general population. Exposure levels can vary based on traffic volume, time spent on the roadside, weather, roadside location, and vehicle emissions. Cumulative effects of repeated occupational exposure can occur, especially when protective measures are not consistently used. In big cities like Peshawar, traffic police workers may therefore be highly vulnerable to the negative health impacts of air pollution.<sup>3</sup> Air pollution may cause systemic inflammation and affect the respiratory system. C-reactive protein (CRP) is an accepted acute-phase inflammatory biomarker, which is secreted mainly in the liver in response to inflammatory stimuli. Particulate air pollution exposure has been linked to increased CRP levels, a key indicator of systemic inflammatory activity. Like fibrinogen, other acute-phase proteins are linked to inflammation, thrombosis, and cardiovascular risk, and play a role in the coagulation pathway. The inflammatory and prothrombotic effects of air pollution may



therefore contribute to cardiovascular and other systemic effects. Therefore, measuring CRP and fibrinogen might serve as valuable objective markers of biological responses to chronic exposure to traffic pollutants.<sup>4,5</sup> Biological exposure effects as well as awareness and personal protective practices can also affect the extent of occupational risk. Air pollution emergency responders, such as traffic police officers, may have different levels of awareness of the major sources and health impacts of air pollution, as well as vulnerable populations and preventive measures. Respiratory masks and other protective measures can reduce inhalation exposure, but only when used appropriately, worn consistently, and replaced as needed. Breaks away from areas of heavy vehicle traffic, distance from vehicle tailpipes, and workplace health and safety guidelines can also affect exposure. Understanding the relationship between awareness and actual protective behavior is important for developing targeted occupational health interventions.<sup>6</sup> Peshawar is a major urban area with high traffic volumes and congestion. City traffic police officers regularly work in settings where they are directly exposed to vehicle emissions. Although this occupation is at risk, local research has been limited in concurrently addressing air-pollution awareness, personal protective behavior, and objective inflammatory markers. Most occupational air-pollution exposure assessment studies rely on ambient exposure or self-reported symptoms, but combining behavioral data with laboratory indicators can provide a more holistic view of potential health impacts.<sup>7,8</sup> Thus, this study was planned to evaluate awareness of air pollution and personal protection measures among traffic police in Peshawar and their correlation with serum CRP and plasma fibrinogen levels. This study will provide evidence on occupational characteristics and behavioral and biochemical parameters to support education, interventions, and policies that can mitigate the occupational health risks of traffic-related air pollution for traffic police workers.<sup>9</sup>

## METHODOLOGY

To evaluate awareness of air pollution personal protective practices and inflammatory biomarkers, we conducted a cross-sectional analytical study among traffic police officers in Peshawar. We conducted the study over six months at selected traffic police stations and duty points in Peshawar. We recruited 100 traffic police officers using consecutive sampling, enrolling all eligible officers who consented to participate during the study period until the required sample size was achieved. Participants were male and female traffic police officers aged 20 to 60 years who had worked on the road for at least one year. We excluded officers who refused to participate, had an acute febrile illness or active infection at the time of sampling, had a history of chronic inflammatory or autoimmune disorders, or were taking medications that might significantly affect inflammatory markers. All participants provided written informed consent before inclusion. We collected information on age, sex, education level, BMI, smoking habits, years in occupational service, average hours of roadside duty, work site, and perceived exposure to traffic-related air pollution using a structured questionnaire. We measured awareness with questions about the main sources of air pollution, polluting chemicals, the respiratory and cardiovascular health effects of air pollution, and actions to prevent air pollution. We divided participants into adequate and inadequate awareness groups based on their questionnaire responses. We assessed personal protective practices using an instrument that recorded whether participants wore masks, how often they wore them during duty, what type of mask they used, how often they replaced them, and other practices designed to reduce exposure. A predetermined score defined the practices as adequate or inadequate. We aseptically drew about 5 mL of venous blood from

each participant. Serum CRP was quantified by an automated laboratory method that had been standardized, and plasma fibrinogen was assessed by a standard coagulation method. Where possible, laboratory staff were blinded to questionnaire responses. Data were entered and analyzed using SPSS version 27.0. Continuous variables were summarized as mean  $\pm$  standard deviation (SD), and categorical variables as frequencies and percentages. Independent-samples t-tests were used to compare continuous variables between groups, while chi-square tests were used to assess associations between categorical variables. Statistical significance was set at  $p < 0.05$ . Potential confounding by age, smoking status, body mass index (BMI), and duration of occupational exposure should be assessed using an appropriate multivariable regression model, with adjusted effect estimates and 95% confidence intervals reported where applicable.

## RESULTS

The study included 100 traffic police officers. Participants' mean age was  $37.6 \pm 8.4$  years, with a mean occupational exposure duration of  $11.2 \pm 6.7$  years.

**Table 1. Demographic and occupational characteristics of traffic police officers (n=100)**

| Variable                                         | Frequency (%) / Mean $\pm$ SD |
|--------------------------------------------------|-------------------------------|
| <b>Age (years)</b>                               | 37.6 $\pm$ 8.4                |
| <b>Age 20–30 years</b>                           | 22 (22.0)                     |
| <b>Age 31–40 years</b>                           | 38 (38.0)                     |
| <b>Age 41–50 years</b>                           | 29 (29.0)                     |
| <b>Age &gt;50 years</b>                          | 11 (11.0)                     |
| <b>Sex</b>                                       |                               |
| <b>Male</b>                                      | 92 (92.0)                     |
| <b>Female</b>                                    | 8 (8.0)                       |
| <b>Educational status</b>                        |                               |
| <b>Secondary education</b>                       | 24 (24.0)                     |
| <b>Intermediate</b>                              | 39 (39.0)                     |
| <b>Graduate or above</b>                         | 37 (37.0)                     |
| <b>BMI (kg/m<sup>2</sup>)</b>                    | 25.8 $\pm$ 3.6                |
| <b>Normal BMI</b>                                | 48 (48.0)                     |
| <b>Overweight</b>                                | 38 (38.0)                     |
| <b>Obese</b>                                     | 14 (14.0)                     |
| <b>Duration of occupational exposure (years)</b> | 11.2 $\pm$ 6.7                |
| <b><math>\leq 10</math> years</b>                | 47 (47.0)                     |
| <b>&gt;10 years</b>                              | 53 (53.0)                     |
| <b>Daily roadside duty (hours)</b>               | 7.1 $\pm$ 1.3                 |
| <b><math>\leq 7</math> hours/day</b>             | 44 (44.0)                     |
| <b>&gt;7 hours/day</b>                           | 56 (56.0)                     |
| <b>Current smokers</b>                           | 31 (31.0)                     |
| <b>Non-smokers</b>                               | 69 (69.0)                     |

Data are presented as frequency (percentage) for categorical variables and mean  $\pm$  standard deviation (SD) for continuous variables. BMI = body mass index.

The mean daily roadside duty duration was  $7.1 \pm 1.3$  hours. Overall, 58 (58.0%) officers demonstrated adequate awareness regarding air pollution and its potential health effects, whereas 42 (42.0%) had inadequate awareness. 46 (46.0%) participants reported regular mask use, while 54 (54.0%) reported inconsistent or no mask use. The overall mean serum CRP concentration was  $5.8 \pm 2.7$  mg/L, while the mean plasma fibrinogen concentration was  $382.6 \pm 74.5$  mg/dL. Participants with inadequate protective practices had significantly higher CRP levels than those with adequate practices ( $6.7 \pm 2.8$  vs.  $4.8 \pm 2.2$

mg/L;  $p=0.001$ ). Similarly, fibrinogen levels were significantly higher among officers with inadequate protective practices ( $407.5 \pm 76.8$  vs.  $353.9 \pm 65.2$  mg/dL;  $p<0.001$ ). Longer occupational exposure was significantly associated with elevated CRP ( $p=0.018$ ) and fibrinogen ( $p=0.011$ ). Adequate awareness was significantly associated with better protective practices ( $p=0.003$ ). Smokers also demonstrated higher CRP levels than non-smokers ( $p=0.027$ ).

**Table 2. Air pollution awareness, protective practices, and inflammatory biomarkers among traffic police officers (n=100)**

| Variable                             | Frequency (%) / Mean $\pm$ SD | p-value |
|--------------------------------------|-------------------------------|---------|
| Air pollution awareness              |                               |         |
| Adequate awareness                   | 58 (58.0)                     |         |
| Inadequate awareness                 | 42 (42.0)                     |         |
| Personal protective practices        |                               |         |
| Adequate practices                   | 46 (46.0)                     |         |
| Inadequate practices                 | 54 (54.0)                     |         |
| Serum CRP (mg/L)                     | $5.8 \pm 2.7$                 |         |
| Adequate protective practices        | $4.8 \pm 2.2$                 | 0.001   |
| Inadequate protective practices      | $6.7 \pm 2.8$                 | 0.001   |
| Plasma fibrinogen (mg/dL)            | $382.6 \pm 74.5$              |         |
| Adequate protective practices        | $353.9 \pm 65.2$              | <0.001  |
| Inadequate protective practices      | $407.5 \pm 76.8$              |         |
| Occupational exposure and CRP        |                               | 0.018   |
| $\leq 10$ years                      | $5.1 \pm 2.4$ mg/L            |         |
| $>10$ years                          | $6.4 \pm 2.8$ mg/L            |         |
| Occupational exposure and fibrinogen |                               | 0.011   |
| $\leq 10$ years                      | $361.8 \pm 68.4$ mg/dL        |         |
| $>10$ years                          | $401.1 \pm 76.1$ mg/dL        |         |
| Awareness vs. protective practices   |                               | 0.003   |

Data are presented as frequency (percentage) or mean  $\pm$  standard deviation (SD). CRP = C-reactive protein. We used an independent-samples t-test to compare continuous variables and a chi-square test for categorical variables. A p-value  $<0.05$  was considered statistically significant.

DISCUSSION

This study found that traffic police officers in Peshawar had high exposure to traffic-related air pollution, creating a significant occupational burden. The average age was  $37.6 \pm 8.4$  years, average occupational exposure was  $11.2 \pm 6.7$  years, and average roadside duty was  $7.1 \pm 1.3$  hours per day among 100 participants.<sup>10</sup> Notably, personal protective practices were associated with significantly higher CRP and fibrinogen levels. The results align with the hypothesis that chronic exposure to traffic-related pollutants could lead to systemic inflammatory and prothrombotic effects.<sup>11</sup> Our study aligns with recent evidence showing the biological effects of chronic exposure to urban air pollution.<sup>12</sup> According to a systematic review of 82 studies conducted in 2024, outdoor workers (such as police officers,

drivers and street vendors) had higher levels of inflammatory and oxidative-stress markers in the air they breathed in urban environments.<sup>13</sup> The review highlighted that outdoor pollutant exposure can exceed ambient air-quality guidelines even when exposure levels are below traditional work exposure standards. This evidence is especially important for traffic police officers, who must stand for long periods near vehicle exhaust emissions as part of their work.<sup>14</sup> The relationship between protective practices and CRP observed aligns with recent population-based research. In the 2023 Multiethnic Cohort Study, Sangaramoorthy et al. found that several traffic-related pollutants, such as PM10, coarse particulate matter, NOx, and benzene, were correlated with increased circulating CRP concentrations, especially with longer-term exposure.<sup>15</sup> The KORA study released in 2024 showed that long-term exposure to fine and ultrafine particles was linked to inflammatory responses, with positive associations for long-term exposure to ultrafine particles and high-sensitivity CRP and fibrinogen. The results are biologically plausible for the increased CRP found in officers who perceived poor protection in our study.<sup>16</sup> Recent evidence also supports our fibrinogen findings. Each  $10 \mu\text{g}/\text{m}^3$  rise in PM2.5 was associated with a significant increase in circulating fibrinogen, suggesting that particulate exposure may affect coagulation in addition to inflammation, as reported in a systematic review and meta-analysis. Another 2022 meta-analysis also linked systemic inflammatory activation to air pollutants, showing associations between short-term exposure to gaseous pollutants and increased CRP, especially for ozone, NO2, and SO2.<sup>17</sup> This current research is especially applicable to Pakistan. In Peshawar, a 2021 pilot study found high concentrations of air pollutants at outdoor monitoring sites, including PM2.5, PM10, SO2, and NO2. Recently, research in Pakistan has also shown high health risks associated with traffic exposure.<sup>18</sup> A 2024 study found health risks for traffic wardens working on busy roads, with high levels of roadside pollutants in Lahore. This study indicated that occupational traffic exposure is a significant yet potentially controllable public-health issue in Pakistan's urban areas.<sup>19</sup> The significant relationship between awareness and protective practices in our study is also noteworthy. 58% of officers had a sufficient level of awareness, but 46% reported sufficient protective practices.<sup>20</sup> This disparity suggests that knowledge does not necessarily translate into consistent occupational protection. Actual behavior may be affected by availability, comfort, perceived risk, duty requirements, environmental conditions, and workplace enforcement. Occupational interventions should therefore go beyond education and include providing suitable respiratory protection, training in its appropriate use, replacement procedures, periodic health screening, and reduced roadside exposure.<sup>21</sup> We also found that smoking was independently correlated with higher levels of CRP in our study. This result is biologically plausible, as the effects of tobacco smoke on the immune system are largely independent of air pollution and may confound the relationship between air pollution and inflammatory markers. Future studies should thus carefully account for smoking, BMI, age, duration of work, etc. as potential confounders.<sup>22</sup> The study has several weaknesses. Because of its cross-sectional design, it is not possible to infer causality between air pollution exposure and inflammatory biomarkers. The study did not collect individual exposure measurements, and it based the exposure assessment primarily on occupational parameters.<sup>23</sup> The sample size was comparatively small and restricted to traffic police officers in Peshawar and hence may not be generalizable. However, the use of questionnaires for occupational information, together with the objective measurements of CRP and fibrinogen, enhances the study. Overall, the results support better protection for traffic police and further studies over time, including personal

PM2.5 monitoring and repeated biomonitoring of traffic police.<sup>24</sup>

## CONCLUSION

Peshawar traffic police have high occupational exposure to air pollution. Lower levels of protective practices were linked to significantly higher fibrinogen and CRP levels. To minimize inflammation and other occupational health risks, raise awareness, ensure consistent use of appropriate respiratory protection, and reduce prolonged roadside exposure.

## Ethical Approval

Ethical approval for this study was obtained from the Institutional Review/Ethics Committee of Khyber Medical College, Peshawar, before commencement of the research. The study was conducted in accordance with institutional ethical guidelines and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment.

## Data Availability

The data generated and analyzed during this study are available from the corresponding author upon reasonable request. The data are not publicly available to protect the privacy and confidentiality of the study participants.

## Author Contributions

Natasha Junaid: Conceptualization, study design, data acquisition, interpretation of results, manuscript drafting, critical revision, final approval, and accountability for the work.

Zahid Sarfraz Khan: Study conception and design, supervision, interpretation of findings, critical revision of the manuscript, final approval, and accountability for the work.

Bibi Hajira Ishaq: Laboratory investigations, data acquisition, biochemical analysis, interpretation of results, critical revision, final approval, and accountability for the work.

Muhammad Umar Faraz: Methodology, data acquisition, interpretation of findings, critical revision of the manuscript, final approval, and accountability for the work.

Kashif ur Rehman Khalid: Data analysis, interpretation of results, manuscript review, critical revision, final approval, and accountability for the work.

Hamza Shahzad: Data collection, literature review, manuscript drafting, critical revision, final approval, and accountability for the work.

All authors contributed substantially to the study, reviewed the manuscript critically, approved the final version, and agreed to be accountable for all aspects of the work.

## Informed Consent

We obtained written informed consent from all participants before enrollment in the study. Participants were informed about the study objectives, procedures, potential risks and benefits, and their right to refuse participation or withdraw at any time without affecting their employment or access to services. The study maintained the confidentiality and anonymity of all collected information throughout.

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## Conflict of Interest

The authors declare no conflict of interest associated with this study.

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## Declaration of AI-Assisted Language Editing

Grammarly AI was used for language and grammar correction.

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