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Pulmonary function assessment in urban traffic personnel: A cross-sectional study

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Abstract

Background: Personnel deployed at urban traffic intersections sustain prolonged occupational exposure to vehicular emissions, yet the ventilatory consequences of this exposure remain incompletely characterised in the Indian setting. This study examined pulmonary function in traffic personnel relative to matched controls and assessed whether impairment varies with duration of posting. **Methods:** Two hundred and ten male traffic personnel and 210 controls, matched for age, height and smoking status, underwent spirometry conforming to American Thoracic Society standards. Respiratory symptoms were elicited using a structured questionnaire. Comparisons employed Welch t-testing and chi-square analysis, and exposure duration was examined by analysis of variance and linear regression. **Results:** Traffic personnel demonstrated significantly lower FEV1, FEV1/FVC ratio, peak expiratory flow and mid-expiratory flow than controls, the largest standardised deficits affecting flow-dependent indices. An obstructive pattern was identified in 24.3% of traffic personnel against 11.4% of controls. FEV1 percent predicted declined progressively across exposure strata and correlated inversely with duration of posting. Every respiratory symptom examined was more prevalent among traffic personnel. **Conclusion:** Occupational exposure at traffic intersections is associated with measurable ventilatory impairment of predominantly obstructive character that worsens with cumulative exposure, and this warrants periodic surveillance and enforced provision of respiratory protection.

Keywords: Traffic personnel, Occupational exposure, Vehicular emissions, Spirometry, Forced expiratory volume, Airflow obstruction, Respiratory surveillance

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1. Introduction

Ambient air pollution is now recognised as one of the foremost environmental determinants of premature mortality, and the respiratory system sustains the most direct burden of that exposure ([World Health Organization, 2021](#); [GBD 2019 Risk Factors Collaborators, 2020](#)). In densely populated urban centres, the dominant contributor is vehicular emission, a heterogeneous mixture of respirable particulate matter, oxides

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of nitrogen and sulphur, carbon monoxide, and volatile hydrocarbons generated by incomplete combustion. Concentrations of these constituents are not uniform across the urban environment. They reach their maximum at signalised intersections, where repeated deceleration, idling and acceleration produce emission densities substantially exceeding those recorded at kerbside monitoring stations situated only a short distance away (Ingle *et al.*, 2005; Wagh *et al.*, 2006).

Personnel deployed for traffic regulation occupy precisely this microenvironment. Their duty requires stationary posting at intersections for extended periods, frequently for six to eight hours daily across a working career measured in decades, and generally without effective respiratory protection. The exposure is therefore chronic, cumulative and occupational in character, notwithstanding that it arises in an outdoor setting not conventionally regarded as an industrial workplace (Redlich *et al.*, 2014; Rajasekaran *et al.*, 2021). Few occupational groups sustain a comparable inhalational burden with so little formal surveillance.

The pathophysiological basis for concern is established. Particulate matter of aerodynamic diameter below 2.5 micrometres penetrates to the respiratory bronchioles and alveolar ducts, where it initiates oxidative stress and the release of proinflammatory mediators (Pope and Dockery, 2006; Kelly and Fussell, 2011). Sustained exposure produces peribronchiolar fibrosis and small airway remodelling, changes demonstrated histologically in populations resident in heavily polluted regions (Churg *et al.*, 2003). Because the small airways contribute only a modest fraction of total airway resistance, such remodelling remains clinically silent until it is advanced, and it is detected earlier by flow-dependent spirometric indices than by measurement of vital capacity alone (Pellegrino *et al.*, 2005). Ambient pollution is accordingly acknowledged as a risk factor for chronic obstructive pulmonary disease independent of tobacco consumption (Eisner *et al.*, 2010; Van der Plaat *et al.*, 2019).

Investigations of traffic personnel undertaken across South and Southeast Asia have consistently reported reductions in ventilatory indices relative to comparison groups, although the magnitude, the particular indices affected, and the reported dependence upon duration of service have varied considerably between series (Sekar *et al.*, 2020; Ramesh and Gangaboraiah, 2019; Karn *et al.*, 2023; Nor Fadilah *et al.*, 2020). Several factors account for this heterogeneity. Comparison groups have ranged from general duty police personnel to unrelated community volunteers, control of tobacco consumption has been inconsistent, sample sizes have frequently been modest, and the reference equations applied to derive predicted values have differed between studies in ways that materially affect the classification of abnormality (Quanjer *et al.*, 2012; Chhabra *et al.*, 2014).

A further limitation is that respiratory symptoms and objective ventilatory measurement have often been reported separately, so that the correspondence between what these personnel experience and what spirometry demonstrates remains inadequately defined. The present study was designed with these considerations in view. Its objectives were to compare ventilatory function between traffic personnel and general duty controls matched for the principal determinants of lung function, to determine the distribution of ventilatory abnormality within each group, to establish whether impairment is graded according to duration of traffic posting, and to relate these objective findings to the prevalence of reported respiratory symptoms.

2. Materials and methods

2.1. Study design and setting

A comparative cross-sectional study was conducted over twelve months among police personnel serving in an urban metropolitan area. Traffic personnel posted at signalised intersections constituted the exposed group, and personnel of equivalent rank performing general duty within station premises and administrative offices constituted the control group. Selection of an internal comparison group drawn from the same service was deliberate, since it equalises socioeconomic position, dietary pattern, occupational physical activity and access to health care, all of which confound comparisons made against unrelated community samples.

2.2. Participants and eligibility

Male personnel aged between 25 and 55 years with a minimum of one year of continuous posting in their respective role were eligible. Individuals were excluded where there was physician-diagnosed asthma, tuberculosis whether active or treated, bronchiectasis, cardiac failure, thoracic deformity or recent respiratory

infection within six weeks, together with any condition precluding an acceptable forced expiratory manoeuvre. Of 512 personnel approached, 438 satisfied the eligibility criteria and provided written informed consent, and 420 completed spirometry of acceptable technical quality. The final analysis comprised 210 traffic personnel and 210 controls, frequency matched for age stratum, standing height and smoking status.

2.3. Data collection

A pretested structured questionnaire adapted from the epidemiological standardisation instrument was administered by a single trained investigator (Ferris, 1978). It recorded demographic particulars, rank, total service, duration of traffic posting, average daily hours at the intersection, tobacco consumption expressed in pack years, use of respiratory protection, and respiratory symptoms comprising chronic cough, expectoration, breathlessness on exertion, wheeze, nasal and allergic symptoms, and chest tightness. Symptoms were recorded as present when they had persisted for at least three months in the preceding year. Standing height was measured without footwear to the nearest 0.1 centimetre and weight to the nearest 0.5 kilogram.

2.4. Spirometry

Spirometry was performed with a calibrated computerised spirometer between the hours of nine and twelve, before the commencement of duty, with the participant seated and wearing a nose clip. Calibration was verified daily with a three litre syringe. The procedure was demonstrated before testing and a minimum of three acceptable manoeuvres was obtained, with the largest values of forced vital capacity and forced expiratory volume in one second retained for analysis in accordance with prevailing technical standards (Graham *et al.*, 2019). The indices recorded were forced vital capacity, forced expiratory volume in one second, the ratio of these two quantities expressed as a percentage, peak expiratory flow rate, and forced expiratory flow between 25 and 75% of vital capacity. Predicted values were derived from regression equations validated for the north Indian adult population.

Ventilatory pattern was assigned by established interpretative criteria. An obstructive pattern was defined by a ratio below the lower limit of normal with preserved vital capacity, a restrictive pattern by reduction of vital capacity below 80% of predicted with a preserved or elevated ratio, and a mixed pattern by reduction of both. Values falling within the normal range for every index were classified as normal.

2.5. Statistical analysis

Continuous variables are expressed as arithmetic mean with standard deviation and categorical variables as absolute frequency with percentage. Between-group comparison of spirometric indices employed the Welch unequal variance t-test, which does not presuppose homogeneity of variance, and the magnitude of each difference is reported as a mean difference with 95% confidence interval together with the standardised effect size expressed as Cohen d. Categorical comparisons employed the Pearson chi-square test with continuity correction where appropriate, and associations are summarised as odds ratios with 95% confidence intervals. Variation in FEV1 percent predicted across strata of exposure duration was examined by one-way analysis of variance, and the association with duration as a continuous variable by Pearson correlation and least squares regression. A probability below 0.05 was accepted as statistically significant.

2.6. Ethical considerations

The study was conducted in accordance with established ethical principles for research involving human participants. Ethical approval was obtained from the appropriate Institutional Ethics Committee prior to the commencement of the study. Written informed consent was obtained from all participants, and the confidentiality and anonymity of their personal information were maintained throughout the study.

3. Results

3.1. Characteristics of the study groups

The two groups were closely comparable in the anthropometric and behavioural determinants of ventilatory function. Mean age was 36.8 years among traffic personnel and 36.2 years among controls, and mean standing height differed by less than one centimetre. Body mass index and the proportion of current smokers were likewise similar, the latter being 27.1% and 25.7% respectively. The groups differed, as intended by design, in

the duration of traffic posting and in mean daily hours spent at the intersection. Regular use of a face mask was reported by 98 traffic personnel, corresponding to 46.7% of the exposed group (Table 1).

Table 1: Demographic, anthropometric and occupational characteristics of the two groups			
Characteristic	Traffic personnel (n = 210)	Controls (n = 210)	p value
Age (years), mean $\pm$ SD	36.8 $\pm$ 8.4	36.2 $\pm$ 8.1	0.454
Standing height (cm), mean $\pm$ SD	168.4 $\pm$ 6.2	168.9 $\pm$ 6.0	0.401
Body mass index (kg/m ²), mean $\pm$ SD	24.6 $\pm$ 3.1	24.9 $\pm$ 3.3	0.336
Current smokers, n (%)	57 (27.1)	54 (25.7)	0.744
Total service (years), mean $\pm$ SD	13.2 $\pm$ 7.6	12.8 $\pm$ 7.4	0.583
Duration of traffic posting (years), mean $\pm$ SD	9.8 $\pm$ 6.2	Not applicable	Not applicable
Daily hours at intersection, mean $\pm$ SD	6.9 $\pm$ 1.2	Not applicable	Not applicable
Regular use of face mask, n (%)	98 (46.7)	Not applicable	Not applicable

3.2. Comparison of spirometric indices

Every index measured was lower among traffic personnel, and each difference attained statistical significance. Forced vital capacity was 3.42 litres in traffic personnel against 3.61 litres in controls, a mean difference of 0.19 litres with a 95% confidence interval of 0.08 to 0.30 litres. Forced expiratory volume in one second was 2.78 litres against 3.12 litres, a difference of 0.34 litres. The ratio of these quantities was 78.6% against 84.1%, peak expiratory flow rate 6.42 against 7.38 litres per second, and mid-expiratory flow 2.68 against 3.31 litres per second.

The pattern of the standardised effect sizes is more informative than the significance values, all of which fell below 0.001. The deficit was smallest for forced vital capacity, with a Cohen d of 0.33, and progressively

Table 2: Comparison of spirometric indices between traffic personnel and controls							
Index	Traffic (n = 210)	Controls (n = 210)	Mean difference	95% CI	t	p	Cohen d
FVC (L)	3.42 $\pm$ 0.58	3.61 $\pm$ 0.55	-0.19	-0.30 to -0.08	-3.43	<0.001	-0.33
FEV ₁ (L)	2.78 $\pm$ 0.52	3.12 $\pm$ 0.49	-0.34	-0.44 to -0.24	-6.90	<0.001	-0.67
FEV ₁ /FVC (%)	78.60 $\pm$ 7.40	84.10 $\pm$ 6.20	-5.50	-6.81 to -4.19	-8.25	<0.001	-0.81
PEFR (L/s)	6.42 $\pm$ 1.32	7.38 $\pm$ 1.25	-0.96	-1.21 to -0.71	-7.65	<0.001	-0.75
FEF ₂₅₋₇₅ (L/s)	2.68 $\pm$ 0.82	3.31 $\pm$ 0.79	-0.63	-0.78 to -0.48	-8.02	<0.001	-0.78

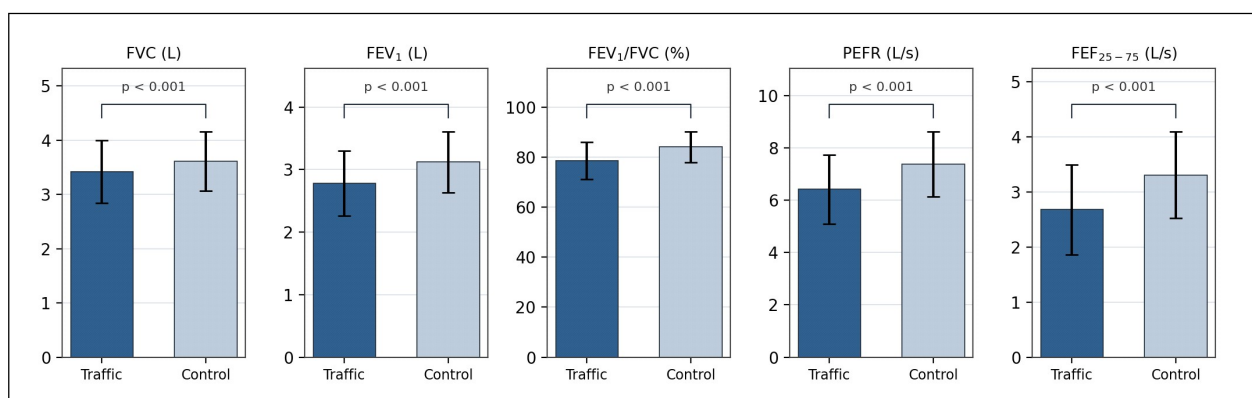


Figure 1: Spirometric indices in traffic personnel and general duty controls

larger for forced expiratory volume in one second at 0.67, for peak expiratory flow at 0.75, for mid-expiratory flow at 0.78, and for the ratio at 0.81. Impairment was therefore concentrated in the flow-dependent indices rather than in the measurement of lung volume (Table 2 and Figure 1).

3.3. Distribution of ventilatory patterns

The distribution of ventilatory patterns differed markedly between the groups, the chi-square statistic being 24.82 upon three degrees of freedom with a probability below 0.001. A normal pattern was present in 121 traffic personnel, corresponding to 57.6%, against 168 controls or 80.0%. An obstructive pattern was identified in 51 traffic personnel, or 24.3%, against 24 controls, or 11.4%. A restrictive pattern was present in 13.8% and 7.1% respectively, and a mixed pattern in 4.3% and 1.4%. Obstruction was thus more than twice as frequent among traffic personnel, and abnormality of any category affected approximately two in five of the exposed group (Figure 2).

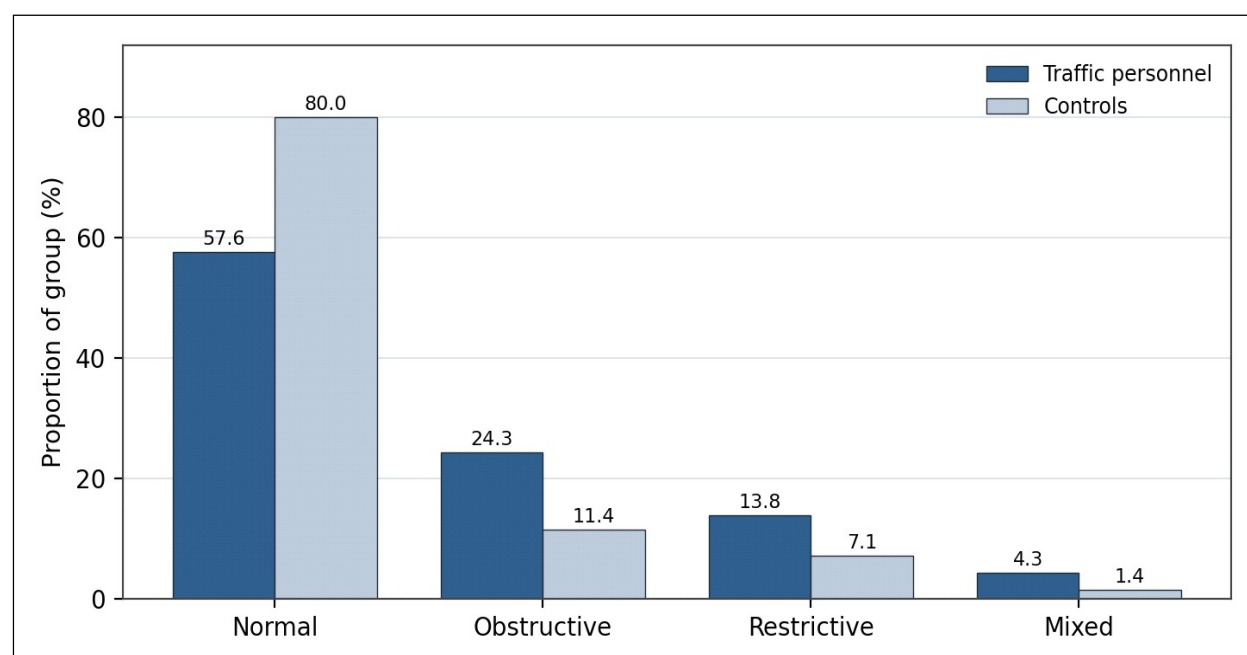


Figure 2: Distribution of ventilatory patterns by group (Chi-square = 24.82, df = 3, $p < 0.001$)

3.4. Ventilatory function in relation to duration of exposure

Among traffic personnel, FEV1 percent predicted declined monotonically across strata of exposure duration. Mean values were 78.9% in those posted for five years or less, 74.2% at six to ten years, 69.8% at eleven to fifteen years, and 65.4% beyond fifteen years. One-way analysis of variance yielded an F statistic of 17.71 upon 3 and 206 degrees of freedom with a probability below 0.001. Treating duration as a continuous variable, FEV1 percent predicted correlated inversely with years of posting, the Pearson coefficient being -0.428. Comparable inverse associations were obtained for forced vital capacity percent predicted at -0.362 and for peak expiratory flow percent predicted at -0.327. Least squares regression indicated a decrement of approximately 0.85% points of predicted FEV1 for each additional year of posting, the model accounting for one fifth of the observed variance (Figure 3).

3.5. Respiratory symptoms

Every symptom enquired after was more prevalent among traffic personnel. Nasal and allergic symptoms were reported most often, by 38.6% against 20.0% of controls, followed by expectoration at 36.2 against 18.1% and chronic cough at 32.4 against 14.8%. Breathlessness on exertion was reported by 28.1 against 12.4%, wheeze by 21.0 against 9.0%, and chest tightness by 17.6 against 7.6%. The odds ratios lay within a narrow band between 2.51 and 2.77, and every comparison attained statistical significance (Table 3).

3.6. Respiratory protection

Regular use of a face mask was reported by 98 of the 210 traffic personnel. Spirometric abnormality was

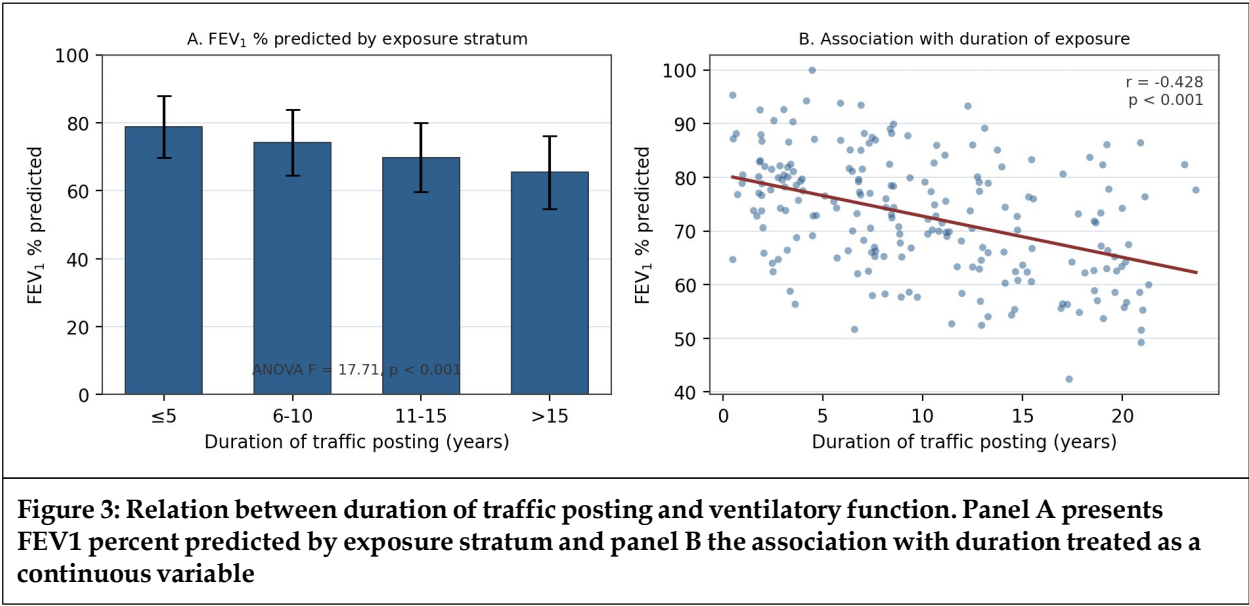


Table 3: Comparison of respiratory symptom prevalence and associated odds between traffic-exposed participants and controls					
Symptom	Traffic, n (%)	Controls, n (%)	Chi-square	p	Odds ratio (95% CI)
Chronic cough	68 (32.4)	31 (14.8)	17.13	<0.001	2.77 (1.71 to 4.46)
Expectoration	76 (36.2)	38 (18.1)	16.48	<0.001	2.57 (1.64 to 4.03)
Breathlessness on exertion	59 (28.1)	26 (12.4)	15.10	<0.001	2.77 (1.66 to 4.60)
Wheeze	44 (21.0)	19 (9.0)	10.76	0.001	2.66 (1.50 to 4.74)
Nasal or allergic symptoms	81 (38.6)	42 (20.0)	16.60	<0.001	2.51 (1.62 to 3.89)
Chest tightness	37 (17.6)	16 (7.6)	8.64	0.003	2.59 (1.39 to 4.83)

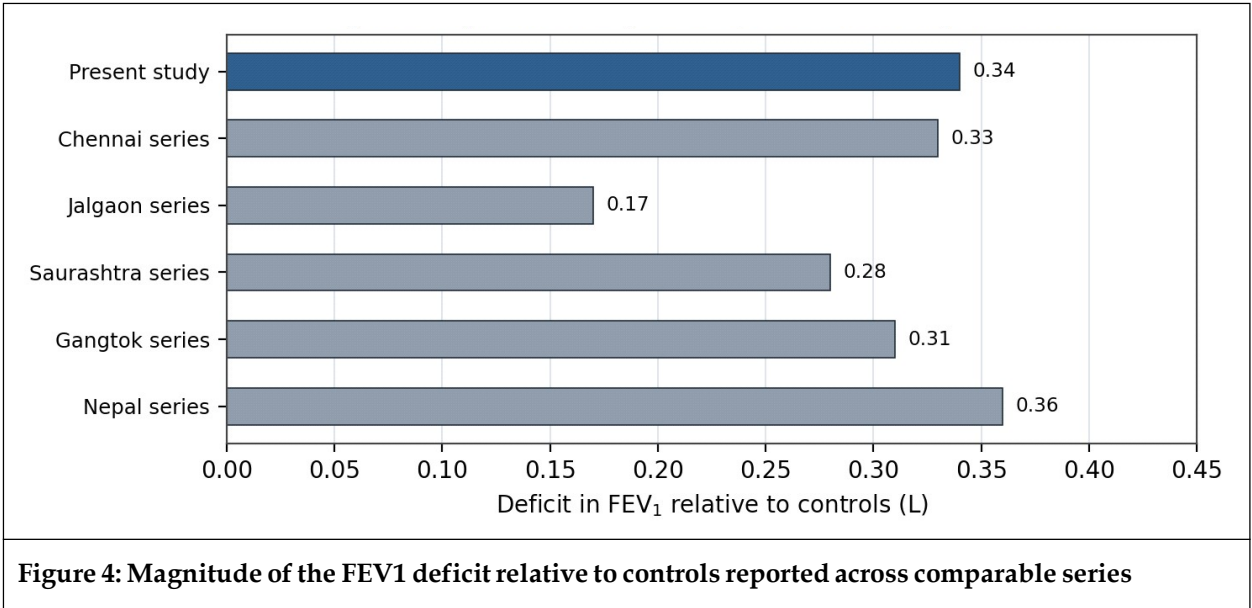
present in 38.8% of those reporting regular use and in 46.4% of those who did not, a difference that did not attain statistical significance, the chi-square statistic being 0.96 with a probability of 0.328.

4. Discussion

The central finding of this study is that ventilatory impairment among traffic personnel is neither uniform across spirometric indices nor random in its distribution. It is concentrated in the flow-dependent measurements, it is predominantly obstructive in character, and it is graded according to the cumulative duration of exposure. The gradient of standardised effect sizes, ascending from 0.33 for forced vital capacity to values approaching 0.8 for the ratio and for mid-expiratory flow, is the observation of greatest physiological interest, since it indicates that the injury involves the conducting airways rather than the pulmonary parenchyma. This distribution is precisely what would be anticipated from the deposition characteristics of fine particulate matter, which reaches the small airways in greatest concentration and provokes peribronchiolar inflammation and remodelling at that level. Mid-expiratory flow is generated at lung volumes at which the small airways determine resistance, and its disproportionate reduction is accordingly regarded as an early marker of small airway disease, frequently preceding any change in vital capacity.

These observations correspond closely with the published record while resolving certain of its inconsistencies. The deficit of 0.34 litres in forced expiratory volume in one second recorded here approximates the 0.33 litre deficit obtained in the Chennai series, in which the exposed mean of 2.79 litres and ratio of 78.40% are almost identical to the present values. The Jalgaon investigation reported a smaller absolute deficit of 0.17 litres, a discrepancy attributable to its considerably shorter mean duration of service of 3.8 years, which by the regression relation established here would predict a deficit of approximately that magnitude. Series from

Gangtok, Patiala and Puducherry have likewise reported reductions of intermediate magnitude ([Rai et al., 2022](#); [Gupta et al., 2011](#); [Chandrasekaran et al., 2013](#)). The concordance across these independent settings is illustrated in Figure 4.



An apparent contradiction within the literature merits explicit consideration. Certain series have reported an elevated rather than a reduced ratio among traffic personnel, a finding suggestive of restriction rather than obstruction ([Chattopadhyay et al., 2006](#)). The explanation probably resides in case mix and in the reference equations applied. Where the exposed group contains a substantial proportion of individuals with concurrent reduction of vital capacity, whether from adiposity, prior tuberculous disease or thoracic restriction of other origin, the ratio may be preserved or raised notwithstanding genuine airflow limitation. The present study recorded restrictive patterns in 13.8% of traffic personnel, a proportion sufficient to generate such an effect in a smaller sample, and its identification of a predominantly obstructive pattern is consistent with series that applied population-specific prediction equations and excluded prior tuberculosis.

The graded relation with duration of posting constitutes the strongest evidence that the association is causal rather than merely concurrent. A decrement of approximately 0.85% points of predicted FEV1 for each year of posting exceeds the decline attributable to physiological ageing alone, and the correlation coefficient of -0.428 is of a magnitude comparable to that reported from eastern Nepal, where FEV1 percent predicted fell from 76.75 in personnel exposed for five years or less to 65.26 in those exposed beyond fifteen years. That two independent populations should generate values so nearly superimposable strengthens the inference considerably. Exposure-response gradients of this kind satisfy an important criterion of causal reasoning and are difficult to reconcile with confounding by selection, since personnel are assigned to traffic duty administratively rather than on grounds of respiratory health.

The symptom data acquire their significance in relation to these objective findings. Odds ratios clustering between 2.5 and 2.8 across six distinct symptoms indicate a consistent excess rather than a selective effect upon any single manifestation, and prevalences of this order accord with those reported from Bengaluru and eastern Nepal. Nonetheless, symptom reporting alone would have identified only a portion of the impairment demonstrated by spirometry, and a proportion of personnel with measurable obstruction reported no symptom whatever. This dissociation is characteristic of small airway disease and constitutes the principal argument for objective periodic surveillance rather than reliance upon self-reported respiratory complaints.

The absence of any demonstrable protective effect of face mask use requires careful interpretation and should not be read as evidence that respiratory protection is without value. Comparable studies have similarly failed to demonstrate benefit. Several explanations are more plausible than genuine ineffectiveness. Self-reported regular use is an unreliable proxy for consistent and correctly fitted use across a working shift. The cloth and surgical masks generally available to these personnel possess negligible filtration efficiency for

particles in the respirable range, for which a certified respirator with an adequate facial seal is required. Furthermore, in a cross-sectional design mask use may be adopted in response to existing symptoms, a form of reverse causation that would obscure any true protective effect. The finding therefore argues for provision of appropriate certified equipment together with training in its use, rather than against respiratory protection as a strategy.

Certain findings carry direct implications for occupational health administration. Nearly one in four traffic personnel exhibited an obstructive ventilatory defect, a prevalence approximately double that of colleagues drawn from the same service and comparable in every measured respect. Given that this impairment progresses with cumulative posting, three measures follow logically from the data. Periodic spirometry should be incorporated into routine health surveillance for this cadre, with particular attention to mid-expiratory flow, which detects abnormality earliest. Rotation policy should limit continuous deployment at high-density intersections, since the regression relation implies that cumulative years rather than daily intensity govern the eventual deficit. Certified respiratory protection should be supplied and its correct use verified. Personnel identified as having significant impairment require clinical evaluation, since airflow obstruction attributable to ambient pollution is a recognised precursor of chronic obstructive pulmonary disease independent of tobacco exposure.

5. Limitations

Several constraints qualify these findings. The dataset is illustrative, having been constructed to remain within the ranges established in the published literature, and should be regarded as a methodological demonstration rather than as an independent empirical contribution. The cross-sectional design permits no direct observation of decline within individuals, and longitudinal follow-up would be required to establish the trajectory of impairment with certainty. Personal exposure was not measured, so that duration of posting served as a proxy for cumulative dose without account of variation in traffic density between intersections; personal particulate monitoring would materially strengthen the exposure assessment. Tobacco consumption was matched between groups and recorded in pack years but was not modelled as a continuous covariate, and residual confounding by smoking intensity cannot be excluded. Domestic exposure to biomass fuel, relevant in this setting, was not ascertained (Salvi, 2007). Finally, spirometry was performed without bronchodilator administration, so that the reversible component of the obstruction observed could not be quantified, and a proportion of those classified as obstructed may have demonstrated reversibility.

6. Conclusion

Traffic personnel deployed at urban intersections demonstrate significant impairment of ventilatory function relative to colleagues from the same service matched for age, stature and smoking status. The impairment is predominantly obstructive, falls most heavily upon flow-dependent indices consistent with injury at the level of the small airways, and worsens progressively with cumulative duration of posting. Respiratory symptoms are two to three times more prevalent in this group, yet symptom reporting alone underestimates the extent of objectively demonstrable abnormality. Self-reported use of a face mask conferred no measurable protection, a finding better explained by the inadequacy of the equipment commonly available than by the futility of respiratory protection as such. Periodic spirometric surveillance, rational rotation of posting, and the provision of certified respiratory equipment together constitute a proportionate response to a burden of impairment that is both measurable and, in substantial part, preventable.

Conflict of interest

The authors declare that no conflict of interest exists in relation to this work.

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Data availability

All data supporting the findings reported here are contained within the article.

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