Rev. salud pública. 15 (6): 889-902, 2013

Occupational exposure to air pollutants: particulate matter and respiratory symptoms affecting traffic-police in Bogotá

Exposición ocupacional a contaminantes atmosféricos: material particulado y síntomas respiratorios en policías de tránsito de Bogotá.

Jesús A. Estévez-García[1], Néstor Y. Rojas-Roa[2] y Alba I. Rodríguez-Pulido[3]

1 InstitutoNacional de Salud, Bogotá, Colombia. jestevez@ins.gov.co
2 Department, Engineering Faculty. Universidad Nacional de Colombia. nyrojasr@unal.edu.co
3 Toxicology Department, Medicine Faculty. Universidad Nacional de Colombia, Bogotá. airodriguezp@unal.edu.co

Received 19th February 2013/Sent for Modification 20th March 2013/Accepted 22th April 2013

ABSTRACT

Objectives Quantifying personal exposure to particles less than 10 micrometres in diameter (PM_{10}) and determining the prevalence of respiratory symptoms in traffic-police officers working in Bogotá's metropolitan area.

Methods This was a cross-sectional study of 574 traffic-police officers divided into two groups (477 traffic-police and 97 police working in an office). They were given a questionnaire inquiring about respiratory symptoms, toxicological medical evaluation, lung function tests and personal PM_{10} monitoring. The differences between groups were found using stratified analysis (i.e. comparing odds ratios). Multivariate analysis of factors related to symptoms and diagnosis of respiratory alteration was also performed.

Results Respiratory symptoms concerned a higher prevalence of cough, expectoration and rhinosinusitis in the traffic-police group. Medical examination revealed that the traffic-police group had higher nasal irritation prevalence; lung function tests showed no difference. Mean PM_{10} levels were higher for the traffic-police group (139.4 µg/m^3), compared to the office work group (86.03 µg/m^3).

Discussion PM_{10} values in both groups did not exceed allowable limits for respirable particles in the workplace according to ACGIH standards. Traffic-police exposed to air pollution had an increased risk of developing respiratory symptoms and signs, thereby agreeing with the results of this and other studies. Personal monitoring is a valuable tool when quantifying the concentration of PM_{10} to which an individual has been exposed during a normal workday. This study contributes towards further research in to the effects of PM_{10} in populations at risk.

Key Words: Air pollution, signs and symptoms, respiratory tract disease, particulate matter, traffic-police officer, occupational exposure (*source: MeSH, NLM*).

RESUMEN

Objetivos Cuantificar la exposición personal a partículas menores de 10 micras (PM_{10}) y determinar la prevalencia de síntomas respiratorios en policías de tránsito que trabajan en el área metropolitana de Bogotá.

Métodos Estudio transversal de 574 policías divididos en dos grupos (477 policías de tránsito y 97 policías de oficina). Se les aplicó cuestionario sobre síntomas respiratorios, evaluación médica toxicológica, pruebas de función pulmonar y monitoreo personal a PM_{10}. Las diferencias entre los grupos se hallaron mediante análisis estratificado y calculo Odds Ratio. Se realizó análisis multivariado de factores relacionados con los síntomas y diagnósticos de alteración respiratoria.

Resultados Síntomas respiratorios como tos, expectoración y rinosinusitis tuvieron mayor prevalencia en los policías de tránsito. El examen médico mostró mayor prevalencia de signos de irritación nasal en los policías de tránsito. Pruebas de función pulmonar no mostraron diferencias. Los niveles promedio de PM_{10} fueron mayores en el grupo de tránsito (139,4 g/m^3) comparados con el de oficina (86,03 g/m^3).

Discusión Los valores de PM_{10} en ambos grupos no exceden los límites permisibles de partículas respirables en el lugar de trabajo por la ACGIH. Los policías de tránsito expuestos a la contaminación del aire tienen mayor riesgo de desarrollar síntomas y signos respiratorios, como lo muestran este y otros estudios. El monitoreo personal es una herramienta valiosa para cuantificar la concentración de PM_{10} a la cual un individuo está expuesto durante la jornada laboral. Este estudio contribuye a una mayor investigación sobre los efectos de PM_{10} en las poblaciones en riesgo.

Palabras Clave: Contaminación del aire, material particulado, policía, exposición profesional (*fuente: DeCS, BIREME*).

Air pollution is a form of environmental degradation which has become widespread regarding economic and population growth. Such environmental degradation leads to public health consequences, thereby causing diseases impairing community welfare (1,2). A relationship between PM10 exposure and negative effects on health leading to respiratory and cardiovascular morbidity and mortality has already been established (3,4). Larsen found that the average annual cost of air pollution regarding health in Colombia was nearly 1 % of national GDP, 65 % being associated with mortality and 35 % with morbidity (5). More than 1.2 million vehicles circulate in Bogotá, representing the main source of atmospheric emission (70 %); this leads to more than 2,200 tons of PM10 and other pollutants being produced annually (6). Exposure has only been quantified at fixed monitoring stations in many countries and this does not provide a reliable correlation between individual exposure and outcomes (7, 8). Long-term studies have shown that every 10 μg/m^3 increase in PM10 concentration is associated with an increase of around 5 % regarding the risk of cardiopulmonary mortality and 8 % lung cancer (9). There is a lack of research in Colombia regarding environmental pollution's toxic effects on occupationally-exposed groups; the present study shows how quantifying individual exposure to PM10 through personal sampling was correlated to respiratory tract symptoms and abnormal clinical findings in lung function tests in a population having great exposure to this pollutant (i.e. traffic-police officers).

METHODS

Study population and design

This was a cross-sectional study which lasted one year on a sample of 574 police officers working in the metropolitan area of Bogota. Traffic-police were defined as being the exposed group, regarding their operational duties (477 police officers), and police having administrative functions (97 office police) formed the less exposed or control group. The sample was based on the prevalence for respiratory symptoms (cough) for individuals who were occupationally exposed to PM, according to previous studies (10). These police agents were working in twelve operational areas and formed five special groups: environmental control, bus and airport terminal control, road construction group, mass transit system control and police officers working at the tolls on the city's limits. Inclusion criteria required the officers to be volunteers and that they had signed the informed consent form. The study complied with international and national ethical health research standards and was granted approval by the Universidad Nacional de Colombia's the School of Medicine's ethics committee and the Colombian Police Health Department's equivalent body.

Sampling PM_{10} levels

Personal PM_{10} measurement and sampling strategy involved using the methodology recommended by the US National Institute for Occupational Safety and Health (NIOSH) (11). Calibrated and certified battery-operated pumps were used for personal sampling (MSA Escort ELF and Apex Pro Casella). The devices were carried during working hours and flow-rate sampling was checked with a flow-meter at the beginning and end of each shift. PM_{10} concentrations, obtained from the city's network of air quality monitoring stations, were calculated by applying correction factors for environmental variables (humidity and barometric pressure)for the day and area where the respective sampling was made. The measurements were compared with PM_{10} occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIH).

Questionnaire

An amended version of the American Thoracic Society's Division of Lung Disease (ATS-DLD-78) health status questionnaire was used; this requests data concerning demographic variables, the presence of respiratory symptoms, family medical history, occupational exposure to substances causing respiratory disorders, smoking index, exposure to indoor sources of pollution, the use of respiratory protection devices and current employment history.

Toxicological medical evaluation

The participants' clinical status was individually assessed regarding vital signs, anthropometric measurement, otorhinolaryngology and a review of the officers' rib cages, emphasizing cardiovascular and respiratory systems. Clinical signs of ocular and nasal irritation were also evaluated.

Lung function test

A portable spirometer (Jaeger) was used by qualified personnel at the end of the workday, following ATS spirometry criteria and standardization procedures; vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and the CVF/VEF1 ratio were evaluated. These volumes were evaluated at baseline and after bronchodilator administration. Spirometric measurements were interpreted by blinded assessment by an expert on the subject (pulmonologist) for the final report.

Respiratory disorder diagnosis

A diagnosis of lower respiratory tract disorder was defined as being a report of a respiratory symptom (cough, expectoration, wheezing or dyspnea) and/or the presence of clinical signs of impaired breathing (stridor, wheezing, crackles) and/or the presence of spirometric impairment. A diagnosis of upper respiratory tract impairment was defined as being a reported upper respiratory symptom (runny nose, nasal itching, throat clearing, facial pain, etc.) and/or presence of clinical signs of upper respiratory tract disorder (nasal mucosa hyperaemia, profuserhinorrhoea, turbinate hypertrophy, nasal bleeding or stigmata of bleeding, pale nasal mucosa, facial pain on palpation of sinuses, runny posterior epistaxis, oropharynx failure).

SPSS 18.0 for Windows (Chicago, IL, USA) and STATA 9.0.) was used for analyzing the data; Chi-square or Fisher's exact tests were used for finding differences between categorical characteristics' frequency between groups. The F test was used to find differences between the groups' average values. Bivariate analysis involved finding differences between exposed and control groups concerning respiratory symptoms using stratified analysis by estimating and comparing odds ratio (OR), with the respective 95 % confidence interval (95 % CI). Multivariate analysis (logistic regression model) weighed each factor regarding the outcome or degree of association. A p-value below 0,05 was considered statistically significant.

RESULTS

Population study

Most of the 574 individuals evaluated were male (average age = 29.9 years-old);there were statistically significant differences between groups regarding gender and educational level (i.e. categorical variables). Higher average age, length of time residing in Bogota and seniority were found in the police office-based group.

The exposed group had greater prevalence regarding a record of respiratory disease (bronchitis, pneumonia, asthma and tuberculosis) (15.5 % cf 10.5 %) and higher frequency concerning a history of occupational exposure to dust, gases and smoke (40.2 % cf 31.2%) compared to office-based police. Natural gas was the most widely used fuel in the agents' homes. The use of personal respiratory protection devices was very low in both study groups (Table 1).

Respiratory symptoms and diagnosis

Regarding respiratory symptoms, the traffic-police group had a higher prevalence of cough (18.6 % cf 6.2 %; OR 3.4: 1.5-8.2 95 % CI) and expectoration (19.9 % cf 8.2 %; OR 2.8:1.3-5.9 95 % CI). Reports of lower respiratory tract symptoms were higher in the traffic-police group compared to the office group (37.1 % cf 30.9 %; OR1.3: 0.8-2.1 95 % CI). The traffic-police group had more prevalent diagnosis of lower (58.7 % cf 48.5 %; OR1.5: 0.9-2.3 95 % CI) and higher respiratory disorder (79.7 % cf 72.2 %; OR1.5: 0.9-2.5 95 % CI); however, no statistically significant differences were found (Table 2).

Toxicological medical assessment

The exposed group had a high prevalence of ocular irritation (32.9 %; OR 6.3: 2.8-13.9 95 % CI) and signs of nasal irritation (62.3%; OR3.7: 2.3-5.9 95 % CI) compared to controls (Table 2).

Table 1. A description of the study groups as categorical and continuous variables

General characteristics	Exposed prevalence N (%)	Unexposed prevalence N (%)	Overall prevalence N (%)	p-value
Group Gender:				
Male	574 (83.1)	97 (16.9)	574 (100)	
Female	458 (96)	59 (60.8)	517 (90.1)	0
Educational level:				
High school	366 (76.7)	61 (62.9)	427 (74.4)	0.01
Technical	85 (17.8)	23 (23.7)	108 (18.8)	
University	24 (5.03)	13 (13.4)	37 (6.5)	
A background of lung disease	50 (10.5)	15 (15.5)	65 (11.3)	0.2
Past exposure to PM, gases and fumes	150 (31.4)	39 (40.2)	189 (32.9)	0.1
Cooking fuel used:				0.1
Gas	456 (95.9)	91 (93.8)	547 (95.3)	
Electricity	14 (2.9)	6 (6.2)	20 (3.5)	
Another type of fuel	7 (1.5)	0	7 (1.2)	
Personal protection device used	18 (3.2)	4 (4.1)	22 (3.8)	0.9
Being a smoker	202 (42.3)	35 (36.1)	237 (41.3)	0.3
Dwelling having a kitchen separate room	467 (97.9)	96 (99)	563 (98.1)	0.5
Demographic/work-related characteristics	Exposed X ± SD	Unexposed X ± SD	Overall X ± SD	p-value
Age (in years)	28.1 ± 5.1	35.1 ± 7.1	29.3 ± 6.1	0
Length of time residing in Bogota (months)	186.5 ± 123.1	243.3 ± 178.6	196.2 ± 135.6	0
Time of service (in years)	6.8 ± 4.5	11.5 ± 7.1	7.6 ± 5.3	0
Time average workday (in hours)	11 ± 2.4	11.1 ± 2.3	11.1 ± 2.3	9.9
Average pm10 concentration (in $\mu g/m^3$)	139.4 ± 76.5	86 ± 39.8	124.6 ± 40.2	0.01
Lung function parameters				
Forced vital capacity (FVC – in litres)	4.8 ± 0.8	4.6 ± 0.8	4.8 ± 0.8	0.5
Post-bronchodilator forced vital capacity (PBFVC – in litres)	4.9 ± 0.8	4.6 ± 0.8	4.8 ± 0.8	0.6
Forced expiratory volume in 1second (FEV1 - in litres)	3.9 ± 0.7	4.8 ± 0.7	3.9 ± 0.7	0.7
Post-broncho dilator forced expiratory volume in 1 second (PBFEV1 - in litres)	4.1 ± 0.7	3.8 ± 0.7	4.0 ± 0.7	0.4
Vital capacity (VC – in litres)	4.8 ± 0.8	3.9 ± 0.7	4.7 ± 0.8	0.4
Post-bronchodilator vital capacity (PBVC –in litres)	4.8 ± 0.8	4.6 ± 0.9	4.8 ± 0.8	0.5

X=average; SD= standard deviation

Lung function test

The exposed group suffered more spirometric changes (8.4 %; OR1.5: 0.9-2.4 95 % CI), this being the most common obstructive pattern for both groups. Post-bronchodilator spirometry pattern suggested airway irritability syndrome in 29.4 % of the exposed group and 29.9 % ofthe control group (OR 0.97:0.6-1.6 95 % CI) (Table 2). There were no statistically significant differences between the study groups regarding mean values for lung function parameters (FVC, FEV1, CVF/VEF1, CV) during pre-orpost-bronchodilator spirometry (Table 1).

Table 2. The prevalence of symptoms, signs and diagnosis with their measurements of association as study groups

	Prevalence exposed group (%)	Prevalence unexposed group (%)	Overall prevalence (%)	OR (95%CI)
Reported symptoms				
Cough	18.6	6.2	16.6	3.8 (1.5-8.2)
Expectoration	19.9	8.2	17.9	2.8 (1.3-5.9)
Wheezing	19.5	21.6	19.9	0.9 (0.5-1.5)
Dyspnoea on medium and large efforts	5.5	11.3	6.4	0.5 (0.2-0.9)
Lower respiratory tract symptoms	37.1	30.9	36.1	1.3 (0.8-2.1)
Rhinosinusitis symptoms	59.4	55.7	58.5	1.2 (0.7-1.8)
Rhinitis symptoms	24.3	35.1	26.1	0.6 (0.4-0.9)
Conjunctivitis symptoms	54.5	47.4	53.3	1.3 (0.9-2.1)
Present clinical signs				
Ocular irritation	32.9	7.2	28.6	6.3 (2.8-13.9)
Nasal irritation	62.3	30.9	57	3.7 (2.3-5.9)
Lung function test				
Spirometry alteration	8.6	6.2	8.2	1.5 (0.9-2.4)
Bronchial hyper-reactivity	29.4	29.9	29.4	0.9 (0.6-1.6)
Diagnosis				
Upper respiratory tract alteration	79.7	72.2	78.4	1.5 (0.9-2.5)
Lower respiratory tract alteration	58.7	48.5	57	1.5 (0.9-2.3)

PM_{10} exposure

Average PM_{10} value was higher in the exposed group (139.4±76.5 μg/m^3) than in the control group (86.0±29.8 μg/m^3), the difference being statistically significant (Table 1). None of the measurements exceeded the permissible occupational exposure limit proposed by the ACGIH (3 mg/m^3). PM_{10} monitoring of work areas revealed the highest concentrations in area 8 (242.9 μg/m^3), the road construction group (180.1 μg/m^3), those working at the bus terminal (161.3 μg/m^3) and in area 7 (176.6 μg/m^3). The average overall exposure values regarding work shift were higher for afternoon working hours (139.4 mg/m^3), followed by the morning (136.1 μg/m^3) and night (111.2 μg/m^3) (Table 4).

Multivariate analysis

Analysis of smoking. Smoking prevalence was higher in the exposed group (42.3 % cf 36.1 %). The results were included in multivariate analysis for adjusting the degree of association regarding other variables to enable studying this factor's influence.

Table 3. A multivariate analysis of factors related to symptoms and diagnosis of respiratory alteration

Symptom	Cough	Expectoration	Wheezing	Dyspnoea	Lower respiratory tract symptom
Variable	Adjusted OR 95%CI	Adjusted OR 95%CI	Adjusted OR 95%CI	Adjusted OR 95%CI	Adjusted OR 95%CI
Age (in months)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.9 (0.9-1.0)	1.0 (0.9-1.1)	1. (0.96-1.0)
Gender:					
Female	1	1	1	1	1
Male	0.5 (0.2-1.10)	0.6 (0.3-1.4)	0.7 (0.3-1.4)	1.2 (0.4-3.8)	0.7 (0.4-1.3)
Group:					
Indoor police office jobs	1	1	1	1	1
Traffic police	5.4 (2.2-13.2)	3.8 (1.7-8.4)	1.1 (0.6-2)	0.7 (0.3-1.8)	1.82 (1.1-3.1)
Time residing in Bogota (in months)	0.9 (0.9-1)	0.9 (0.9-1)	0.9 (0.9-1)	0.9 (0.9-1)	0.9 (0.9-1)
Having a background of respiratory disease:					
No	1	1	1	1	1
Yes	1.0 (0.5-2.1)	1.5 (0.8-2.8)	2.1 (1.2-3.7)	1.1 (0.4-3)	1.1 (0.6-1.9)
Previous work-related exposure to PM:					
No	1	1	1	1	1
Yes	0.9 (0.6-1.5)	1.3 (0.8-2)	1.0 (0.7-1.6)	1.5 (0.7-2.9)	1.1 (0.7-1.5)
Time of service (in years)	1.0 (1-1.1)	1.0 (1-1.1)	1.0 (1-1.1)	0.9 (0.8-1.0)	0.9 (0.8-1.0)
Average workday (in hours)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.9 (0.9-1.1)	0.9 (0.8-1.1)	1.1 (0.9-1.1)
Cooking fuel used:					
Electricity	1	1	1	1	1
Natural gas	2.8 (0.3-21.8)	3.4 (0.4-25.7)	2.1 (0.5-9.1)	1.3 (0.2-10.2)	2.8 (0.8-9.7)
Other type of fuel	2.1 (0.1-39.4)	2.2 (0.1-41.8)	N.C.	N.C.	0.8 (0.1-8.8)
Average concentration of exposure PM10 (µg/m³)	0.9 (0.9-1)	0.9 (0.9-0.9)	0.9 (0.9-1)	0.9 (0.9-1)	0.9 (0.9-0.9)
Smokier:					
No	1	1	1	1	1
Yes	1.3 (0.9-2.11)	1.34 (0.9-2.1)	1.2 (0.8-1.8)	1.2 (0.6-2.4)	1.5 (1.1-2.1)
Personal protection device used:					
No	1	1	1	1	1
Yes	1.3 (0.4-4.2)	1.5 (0.5-4.4)	1.6 (0.6-4.3)	0	0.9 (0.4-2.3)
Dwelling having a kitchen as a separate room:					
No	1	1	1	1	1
Yes	2.2 (0.3-17.8)	0.61 (0.2-2.4)	2.2 (0.3-18.2)	0.6 (0.1-5.2)	1.5 (1-2.1)

Smoking was associated as a risk factor regarding a diagnosis of lower respiratory tract disorder (OR1.4: 0.8-2.4 95 % CI); however, there was no statistical significance. Belonging to the exposed group, being male, having a history of lung disease and being a smoker were also statistically associated with symptoms and diagnosis. PM_{10} concentration was not significantly associated with outcome in the multivariate model. Seniority and age were significantly associated with symptoms such as cough and dyspnoea in multivariate analysis.

Table 4. Ranges of personal exposure to PM_{10} by traffic police areas of work in Bogota, Colombia

	PM10 concentration (µG/M³)				
Area/location	Average	N	Standard deviation	Minimum value	Maximum value
Area 1: Usaquén	85.9	22	56.8	11.4	249.0
Area 2: Chapinero	95.3	22	51.8	17.5	200.8
Area 3: Suba	117.8	22	47.9	23.1	201.2
Area 4: Barrios UnidosandTeusaquillo	103.1	20	46.6	16.5	193.4
Area 5: FontibónandEngativá	85.2	20	39.8	24.4	167.7
Area 6: Kennedy	134.7	22	43.9	77.4	240.5
Area 7. Bosa	147.6	26	65.0	47.2	261.4
Area 8: Ciudad Bolívar andUsme	197.3	24	72.7	26.9	289.1
Area 9: Mártires, Candelaria, Santa Fe, Puente Aranda	129.1	20	62.3	26.9	270.9
Área 10: Rafael Uribe, Antonio Nariño, San CristóbalandTunjuelito	118.8	24	56.8	21.3	218.0
Area 11: AvenidaNorte Quito Sur	130.4	18	61.4	40.0	281.6
Area 12: AutopistaNorte	89.6	20	51.4	11.0	190.4
Ecology	121.7	13	53.3	29.6	206.4
Trafficpolice	135.7	25	63.8	46.2	273.6
Airport police	114.5	9	55.3	13.1	190.1
Bus terminal police	153.4	8	52.1	43.3	200.4
Sanitation office Z workers (control group)	115.0	22	61.5	35.3	254.9
The road work group	156.4	11	64.5	30.0	244.0
Total	123.4	348	62.5	11.0	289.1

DISCUSSION

The study's findings were consistent with reports in the pertinent literature concerning the negative effect of environmental exposure at work to air pollutants, thereby validating the present results. Traffic police had a higher prevalence of respiratory symptoms, such as cough and expectoration, these being similar findings to those reported by Karita in 2001 who contrasted occupational exposure to different levels of PM10 in three police groups in Bangkok (10). It was found that the prevalence of cough (12.8 %), expectoration (24.4 %) and wheezing (3.8 %) was higher in individuals having traffic duties, but their differences were not statistically significant given the small number of subjects in the study groups. Dyspnoea was more prevalent in the control group; this symptom had the same association in our study. Another study in Bangkok by the same authors in 2004 reported a higher prevalence of cough, expectoration, wheezing and dyspnoea in traffic-police compared to the control group and a significant association between smoking and the area where an officer was working (12). A study carried out in 2005 by Ingle in Jalga on (India) found even larger symptom prevalence than the present study, reporting that cough (40 %), dyspnoea (10 %) and upper respiratory tract irritation symptoms (29 %) were the most frequently occurring, compared to a group of healthy workers having different PM10 exposure levels; the strength of symptom association with the highest PM10 levels (traffic-police group) was significant (OR>1) (13). Smoking was deliberately controlled by this study's design as smokers were not included; the association obtained did not relate to this factor. Our study was controlled for smoking in the analysis, a significant association only being obtained with the presence of lower respiratory tract symptoms but not each specific symptom (cough, expectoration, etc.).

A study of traffic policemen in Ankara (Turkey) reported 48 % smoking prevalence (higher than ours) and 53 % lower respiratory tract symptom frequency, such as chest tightness, dyspnoea, cough and chronic cough in the traffic-police group (14). Thippanna conducted a study in Hyderabad (India) in 1999 involving 665 traffic-police; the study reported that respiratory symptoms were correlated with the number of years of exposure to air pollution. Individuals having at least 5 years of exposure primarily reported coughing and chest tightness. Symptoms such as allergies, respiratory distress, increased coughing and tightness appeared as age and exposure increased (more than 5 years) (15). The above was seen in our study's multivariate analysis, in which being in the traffic police and being older were significantly associated with symptoms such as cough and dyspnoea. Altered nasal signs were significantly associated with working in the traffic-police. Multivariate analysis suggested that this group had a greater risk of symptoms, such as cough, sputum production and lower respiratory tract symptoms, as well as diagnosis of upper and lower respiratory tract disorders. Such associations corroborated reports in the literature (10,12,13) and revealed that working in the traffic police created risks regarding the aforementioned symptoms. Information bias should be taken into account regarding the results of our study because some people experienced side-effects which they ignored or tried to hide such situation because they expected negative consequences regarding their career chances (16,17). This may have been reflected in the low prevalence for some respiratory symptoms in the highest exposure group. Another aspect concerned healthy-worker bias because such population was subject to a rigorous selection process (*ipso facto* their income) and their respiratory response physiological mechanisms were better able to adapt to a hostile work environment (18,19). It should be noted that cross-sectional studies tend to underestimate the prevalence of events, particularly regarding acute symptoms, as outcomes are evaluated during a single moment of time (16,17).

No significant differences were found in our study regarding mean pulmonary function values; this contrasted with that reported by other authors who have evaluated traffic-police as they have found decreased lung function compared to control groups (10,13,15). Low prevalence regarding spirometric changes in populations occupationally exposed to particulate matter has been reported, i.e. Colombian studies on cement workers in 1999 where Giraldo found 92 % normal spirometry (20). The FEV1 pulmonary function and 25 % peak expiratory flow rate regarding vital capacity (V25) were significantly lower in traffic-police compared to officers in rural areas in a study conducted in Bangkok in 2001(10). Multiple regression analysis showed that age and job-site were significant factors in explaining variations in FEV_1 and V25 (smoking making no significant contribution to such variation) (10). A study in Jalga on (India) fixed samplers in high traffic density roads, average224 $\mu g/m^3$ values being obtained which exceeded that country's PM_{10} air quality standards (120 $\mu g/m^3$) (13). Monitoring in our study involved using personal samplers and reflected lower average concentrations than those found by another study in India. Although the two studies evaluated similar occupational groups (traffic-police), the parameters for determining whether exposure levels came within permissible ranges were different, as were the measurement methodologies. Exposure levels in our study came within the permissible occupational limits proposed by the ACIGH. However, Colombian air quality standards for the general population regarding PM_{10} (150 $\mu g/m^3$) were exceeded in some areas, and the scientific evidence has shown toxic effects even with particulate levels below air quality standards, including those set by the World Health Organization.

It is worth noting the approach of other studies, such as that by Watts in 1995, which have highlighted monitoring personnel's crucial role in determining health effects attributed to different air pollutants (8). The personal measuring PM_{10} in traffic-police for two weeks in this study reported higher concentrations than those provided by fixed monitoring stations, this being consistent with that found by other studies, such as that by Violante (2006) or Lioy (1990) (7,21). The concentrations obtained by Watts in 1995 were similar to those found in our study, although not comparable, given the conditions in each work environment which may have altered PM_{10} chemical composition and its toxic effect on health (14,22).

Personal monitoring is a valuable and reliable tool when quantifying the concentration of PM_{10} or the dose to which an individual has been exposed during their workday, and relating it to the presence of respiratory outcomes, regarding many environmental factors and an individual's type of activity leading to variability between and within work areas (micro) and different days. Regarding domestic risk factor, natural gas was used most frequently in the agents' kitchens; this fuel represents a low source of PM production. However, households lacking adequate technical conditions concerning their gas appliances can be sources for other pollutants being produced, such as carbon monoxide, which can cause neurological and cardiovascular injury. Factors such as a high prevalence of smoking, personal pulmonary history, combined with chronic exposure to doses above permissible PM_{10} limits are multi-causal risk factors for developing respiratory health disorders in such an occupationally-exposed population. Ideally, the PM_{10} sampled here should be characterised to determine each monitored environments' chemical components. This leads to debate about the adequacy of air-quality standards for protecting public health and, equally, assessment of populations occupationally-exposed to air pollutants, not only in such work-related environment, but also to settings outside their work. List of abbreviations: PM, particulate matter; RSP, respirable particle; VC vital capacity; FVC, forced vital capacity; FEV1, forced expiratory volume in one second; GDP, gross domestic product ♦

Acknowledgements: We would like to thank the Colombian Police's Health Department and Traffic and Transport Department, Bogota's Metropolitan Police Traffic Commanders and Occupational Health Group for their collaboration during the study. We would like to thank the Universidad Nacional de Colombia's Research Office (Bogotá) and Bogota's Environmental Protection Agency (Secretaría de Ambiente de Bogotá) for their funding and we would also like to thank Universidad Nacional de Colombia Toxicology Department staff (in Bogotá) for their support.

Competing interest: None

REFERENCES

1. Bell M, Davis D, Gouveia N, Borja-Aburto V, Cifuentes L. The avoidable health effects of air pollution in three Latin American cities: Santiago, Sao Paulo, and Mexico City. Environmental research. 2006; 100(3):431-440.
2. Onursal B, Gautam S. Vehicular air pollution: experiences from seven Latin American urban centers. The World Bank Latin American and the Caribbean Region Technical Department; 1997.
3. Ramgolam K, Chevaillier S, Marano F, Baeza-Squiban A, Martinon L. Proinflammatory effect of fine and ultrafine particulate matter using size-resolved urban aerosols from Paris. Chemosphere. 2008; 72(9):1340-1346.
4. Baulig A, Garlatti M, Bonvallot V, Marchand A, Barouki R, MaranoF, et al. Involvement of reactive oxygen species in the metabolic pathways triggered by diesel exhaust particles in human airway epithelial cells. American Journal of Physiology-Lung Cellular and Molecular Physiology. 2003; 285(3):L671-L679.
5. Larsen B. Colombia, Cost of Environmental Damage: A socio economic and environmental risk assessment. Bogotá, Colombia. Ministerio de Medio Ambiente, Vivienda y Desarrollo Territorial; 2004.
6. Behrentz E, Sánchez N, Rodriguez P. Definición de elementos técnicos para la formulación de políticas distritales encaminadas al mejoramiento de la calidad del aire en Bogotá. Reporte Final. Parte B. Inventario de Emisiones Provenientes de Fuentes Vehiculares. Secretaria Distrital de Ambiente, Bogota DC, Colombia; 2009. p.1-120.
7. Lioy PJ, Waldman J, Buckley T, Butler J, Pietarinen C. The personal, indoor and outdoor concentrations of PM10 measured in an industrial community during the winter. Atmospheric Environment. 1990; 24:57-66.
8. Watt M, Godden D, Cherrie J, Seaton A. Individual exposure to particulate air pollution and its relevance to thresholds for health effects: a study of traffic wardens. Occup Environ Med. 1995; 52:790-792.
9. Baulig A, Poirault J, Ausset P, Schins R, Shi T, Baralle D. et al. Physicochemical characteristics and biological activities of seasonal atmospheric particulate matter sampling in two locations of Paris. Environ Sci. Technol. 2004; 38(22):5985-5992.
10. Karita K, Yano E, Jinsart W, Boudoung D, Tamura K. Respiratory symptoms and pulmonary function among traffic police in Bangkok, Thailand. Archives of Environmental Health: An International Journal. 2001; 56(5):467-470.
11. McCammon C. Manual of Analytical Methods. General Considerations for Sampling Airbone Contaminants.4th edition. National Institute for Occupational Safety and Health (NIOSH); 1998.
12. Karita K, Yano E, Tamura K, Jinsart W. Effects of working and residential location areas on air pollution related respiratory symptoms in policemen and their wives in Bangkok, Thailand. European Journal of Public Health. 2004; 14:24-26.
13. Ingle S., Pachpande B, Wagh N., Patel V., Attarde S. Exposure to vehicular pollution and respiratory impairment to traffic policemen in Jalgaon city, India. Industrial Health. 2005; 43:656-662.
14. Atimtay A, Emri S, Bagci T, Demir A. Urban CO exposure and its health effects on traffic policemen in Ankara. Environmental Research Section. 2000; 82:222-230.
15. Thippanna G, Lakhtakia S. Spirometric Evaluation of Traffic Police Personnel Exposed to Automobile Pollution in Twin Cities of Hyderabad and Secunderabad. Ind J Tub. 1999; 46:129-132.
16. Hulley S. Designing clinical research. 3th edition. Lippincott Williams & Wilkins; 2007.
17. Kestenbaum B. Cross-Sectional Studies. Epidemiology and Biostatistics: an introduction to clinical research. Springer. 2009; p 29-31.

18. Checkoway H, Pearce N, Kriebel D. Research methods in Occupational epidemiology. Second edition. New York:Oxford University Press; 2004; p:211-241.
19. Simkhovich B, Kleinman M, Kloner R. Air Pollution and Cardiovascular Injury: Epidemiology, Toxicology, and Mechanisms. Journal of the American College of Cardiology. 2008; 52(9):719-726.
20. Giraldo L, Bouzas M. Prevalencia de síntomas respiratorios en trabajadores expuestos a material particulado. Colombia Médica. 1997; 28(2):62-66.
21. Violante F, Barbieri A, Curti S, Sanguinetti G, Graziosi F, Mattioli S. Urban atmospheric pollution: Personal exposure versus fixed monitoring station measurements. Chemosphere. 2006; 64(10):1722-1729.
22. Bono R, Piccioni P, Traversi D, Degan R, Grosa M, Bosello G, et al. Urban air quality and carboxyhemoglobin levels in a group of traffic policemen. Science of the Total Environment. 2007; 376:109-115.