



Airway effects of traffic-related air pollution on outdoor workers

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Purpose of review

Traffic-related air pollution has been well documented to be associated with increased risks of airway diseases in the general population. Particularly, susceptible subgroups have included children and endurance athletes exercising outdoors. Relatively little has been published on the risks for outdoor workers. The purpose of this review is to identify the relative airway risks of outdoor work in areas with increased vehicular air pollution.

Recent findings

We found a small body of recent literature published on this topic. Most of the relevant studies have focused on traffic police, petrol pump workers, and highway workers, especially in the urban areas of high traffic pollution. These studies suggest increases in respiratory symptoms and reduction in spirometric indices in nonsmoking workers in these occupations when compared with control individuals. Research is needed to investigate the relationship with duration of exposures in these workers, and to determine the duration and reversibility of effects in order to develop standards for safe working exposures.

Summary

A significant impact on airway function and respiratory symptoms has been reported from outdoor work with exposure to traffic pollution. Further research is needed to confirm these associations and to develop standards for safe outdoor work in urban settings.

Keywords

air pollution, occupation, pulmonary effects, respiratory health effects, work-related

INTRODUCTION

Gases and particles in outdoor air pollution, including sulfur dioxide, nitric oxide, particulate matter, and ozone, can have respiratory effects (Table 1). In an ambient setting, it is difficult to separate the effects of each individual pollutant and a composite grading of air pollution, such as an Air Quality Index, has often been used to indicate to the public the level of concern from outdoor air pollution. The effects relate to the levels of exposure, but even within a North American general population [1^{••}], airway effects can be seen at the 'moderate' range of the Environmental Protection Agency Air Quality Index in comparison to the 'good quality' range with effects relating to 1 and 2 day moving averages of ozone, nitrogen dioxide, and fine particulate matter (PM_{2.5}). Some exposed groups are more susceptible to adverse health effects of air pollution, for example, genetic factors appear to be associated with greater respiratory effects of ozone. Additionally, those with asthma generally have greater airway effects than nonasthmatics, and also greater air

pollution levels have been associated with increased incidence of adult-onset asthma [2].

Outdoor workers in urban settings are expected to have more exposure to air pollutants than the general population, especially in areas of high pollution such as in many large cities. However, there may be a 'healthy worker' effect reducing the observed adverse effects of air pollutants. The purpose of this review was to identify and assess the studies that have determined the respiratory effects of air pollutants on outdoor workers. Using a systematic search of Embase and Medline, journal articles were selected on the basis of our inclusion

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KEY POINTS

- Short-term exposures to outdoor air pollutants, even within the current allowable North American standards, have been shown to be associated with pulmonary function changes in a general population.
- Outdoor workers in urban settings are expected to have greater exposure to outdoor air pollutants compared with the general population and other workers.
- Studies from cities with high traffic pollution have shown reductions in lung function among outdoor traffic police and other workers.
- There is a need for additional study of the effects of air pollution in outdoor workers in order to understand the changes observed and assist in developing the standards of exposure for outdoor workers.

criteria, which consisted of 'air pollution', 'occupation/work-related', 'humans', 'adults', and 'pulmonary/respiratory health effects' (Table 2, Fig. 1). From the 127 articles identified, we have focused this review on English language studies assessing the effects of traffic-related pollutants on airways, and have excluded studies that have focused on exposures or effects on risks of lung cancer and on cardiovascular effects, though recognizing that these also can be significant effects [3–5].

RESULTS

Most of the identified relevant studies were performed among traffic police with fewer studies among other outdoor urban workers as detailed below.

Work as traffic police

Traffic police have been studied in several countries, mainly in some cities of high traffic pollution. Most of these studies have considered the role of tobacco smoking as a critical co-factor.

Various urban centers in India have been studied. Patil *et al.* [6[¶]] studied 50 nonsmoking male police who had worked for a mean of 8 years in traffic control, matched by age, height, and weight with 60 male general police workers in Dhule. Both groups had significant reductions in all spirometric variables including forced expiratory volume in one second/forced vital capacity (FEV1/FVC) ratio compared with the Indian reference values. The traffic police had increased nasal symptoms (19 versus 5%) and a significant reduction in both FEV1 and FVC with relatively greater reduction in FVC, and a resulting higher than predicted FEV1/FVC ratio (as might be expected to occur with significant ozone exposure). No concurrent air pollutant levels were reported, but the authors note that the levels of suspended particulates have exceeded the standards in major Indian cities most of the time in the last 14 years.

Two earlier studies in Indian cities found similar results. Pal *et al.* [7] compared 30 male traffic police and 30 other male police workers in Pondicherry matched for age and BMI, divided by the smoking status. They found significant reductions in all spirometric variables in the traffic police, both among the smokers and nonsmokers, compared with the other police workers. In Jaipur city, Singh [8] also found a mean reduction in FEV1 and increased respiratory symptoms in nonsmoking traffic police compared with a control group.

Suresh *et al.* [9] found that exposure to air pollutants, a major portion of which is because of emissions from vehicles, increases oxidant stress, and decreases the levels of both antioxidants in red blood cell lysates, and levels of plasma nitric oxide in Indian traffic police. They hypothesize that the resulting imbalance in the oxidant/antioxidant system may lead to lung damage.

Another urban area with very high traffic pollution is Bangkok, where Tamura *et al.* [10] examined the relationship between traffic-based air pollution and chronic, nonspecific respiratory symptoms among 1603 traffic policemen, who lived and worked in three areas, each with different levels

Table 1. Main outdoor air pollutants that can cause airway effects

Component	Effects
Particulate matter (PM)	Wide ranging effects from respiratory symptoms to cardiopulmonary morbidity and mortality; negative effects of both short-term and long-term exposure. Effects vary with particle size and composition
Sulfur dioxide	Can cause bronchoconstriction, especially in asthmatics during exercise
Nitrogen oxides	Possible airways effects: increasing effects of respiratory viral infections, small airway inflammation
Ozone	Increases airway inflammation and increases allergen effects in asthmatics. Increases respiratory symptoms – inspiratory discomfort
Acrolein	Mucous membrane and respiratory irritant

Table 2. Criteria used to select articles

Exclusion criteria	Inclusion criteria
Residential/ambient air pollution	Occupation/work related
Indoor	Outdoors
Nonrespiratory health effects	Respiratory/pulmonary/lung diseases
Silica or asbestos related pollutants	Humans
Nonhuman	Adults
Children	Air pollutants/traffic exhaust/forest fires

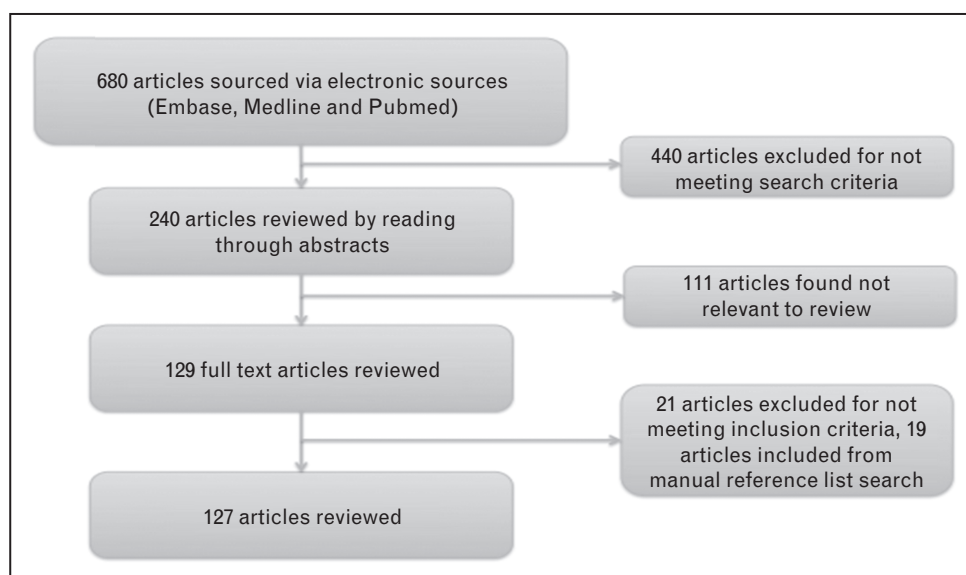
of airborne particulates (one with high pollution, one with moderate pollution, and one suburban). The age-adjusted prevalence of respiratory symptoms among nonsmokers was significantly higher among those working in polluted versus suburban areas, with an odds ratio of 1.11 for each $10 \mu\text{g}/\text{m}^3$ of ambient particulate matter.

Karita *et al.* [11] investigated the prevalence of cough and sputum in a cross-sectional study of policemen and their wives in Bangkok. They found that in the policemen, the increased risk of frequent cough or phlegm was related both to smoking and working in heavy traffic locations, whereas in their wives, symptoms related to the residential locations.

An earlier cross-sectional study was conducted by Wongsurakiat *et al.* [12] to evaluate whether traffic policemen ($n=620$) working in Thonburi district of Bangkok had poorer respiratory health than the general Thai population. In the final

analyses, only nonsmokers were considered and among these, traffic police reported significantly more cough or phlegm and more rhinitis symptoms than the control individuals ($n=129$). A significantly higher prevalence of abnormal air flow and significantly lower mean values of FEV1 and FVC were found in the traffic policemen compared with the control group. Traffic policemen who did not use protective masks had a significantly higher prevalence of both abnormal FEV1 and FVC than the control group. They also had higher relative risks of abnormal FEV1 and FVC than those who used protective masks. Multivariate analyses, controlling for age, height, and pack-years of cigarette smoking, revealed that work as a traffic policeman was significantly and independently associated with lower FEV1 and FVC. They concluded that traffic policemen who work in Thonburi had more cough and rhinitis symptoms, and lower FEV1 and FVC than the general Thai population, and traffic policemen who did not use protective masks had higher relative risks of abnormal FEV1 and FVC than those who used them.

In contrast to the findings in India and in Bangkok, an Italian study by Volpino [13] found no significant difference in the resting spirometric results or blood gas parameters between male traffic police and controls. However, during exercise testing, 26 of the 68 traffic police and none of the 62 controls had changes on ECG, hypertension, or oxygen desaturation, suggesting that chronic occupational exposure to urban pollutants increases the risk of cardiovascular and respiratory changes. These more subtle findings may be a reflection of the relatively lower levels of traffic pollution in Italian

**FIGURE 1.** Search strategy and the articles obtained.

cities compared with the cities in India and with Bangkok.

Another Italian study by Guarnieri *et al.* [14] evaluated whether the acute exposure to air pollution in a group of policemen was correlated with increased inflammatory biomarkers and alterations of bronchiolar cells. The study compared 44 healthy nonsmokers who were exposed to traffic and office workers (controls). The results suggested that healthy and nonsmoking individuals exposed to traffic air pollution had subclinical inflammation and decrease of bronchiolar epithelial function.

Kiosk workers

Kiosk workers in large Greek cities would also be expected to also have greater exposure to traffic air pollutants. An exposure study was performed by Sichletidis [15] to investigate air pollution exposures as reflected by the levels of expired carbon monoxide. Ambient carbon monoxide was greatest in winter, mean 3.64 ± 1.45 ppm. However, most expired carbon monoxide in these workers related to smoking, increasing with the number of cigarettes smoked, with a lesser component because of environmental pollution.

Workers exposed to aircraft emissions

Aircraft is a further source of traffic pollution. Over the last few decades, commercial air traffic has increased considerably. Aircraft emissions from engines may potentially cause health effects on a local scale for those personnel working at airports. As recently reviewed by Kumar *et al.* [16[•]], aircraft engines together with the auxillary power unit as well as the ground handling equipment contribute significantly to a high concentration of pollutants (such as particulate matter, carbon monoxide, nitrogen oxides, and polycyclic aromatic hydrocarbons), and aircraft fuel has a higher sulfur content compared with road vehicle fuel, leading to increased sulfur dioxide and sulfates in air pollutants [17,18]. Equipment handled on the ground uses diesel or gas engines, resulting in emissions similar to road traffic exhaust.

Currently, not much information exists in the literature to set the standards for aircraft emission factors or ambient concentrations. Several studies [17,19–22] have assessed exposures or effects of these fine and ultrafine particles on health. Buonanno *et al.* [23] conducted a study to analyze the occupational exposure to airborne particles and other pollutants in a high performance jet engine airport. They found that small particles between the diameters of 10–40 nm dominated the aircraft

emissions [16[•]]. However, there is currently a lack of toxicologic and epidemiologic studies of airport workers.

Gasoline workers

Petrol or gasoline pump workers are exposed not only to the hazardous exhaust of vehicles, but also to the vapors of petrol or gasoline. Three studies [24[•],25,26] have assessed the lung function according to the duration of occupational exposure in petrol pump workers. Aprajita [26] included 150 petrol pump workers, categorized into three groups depending on the duration of the exposure, and compared the findings with 50 age-matched healthy controls. All three studies found declines in pulmonary function in the gasoline pump workers.

Toll booth workers

A Turkish study by Arbak [27] evaluated the annual change in forced expiratory flows in a small group of toll collectors ($n=58$), and found no significant differences between toll collectors and controls ($n=37$). Further study with larger study populations is needed to elucidate whether such a relationship exists.

Railroad workers

Hart *et al.* [28,29] have reported chronic obstructive pulmonary disease (COPD) in railroad workers and found increased mortality [odds ratio (OR) 1.61; 95% confidence interval (CI) 1.12–2.30] related to years of exposure to diesel locomotives after adjustment for age, race, and smoking, and a 2.5% increased risk of death from COPD for each year of this work. Acute excessive exposure has also been reported to cause irritant-induced asthma in three cases [30].

Construction workers and street cleaners

Highway and heavy construction workers have been reported to be at increased risk of asthma and chronic bronchitis, especially tunnel workers in whom FEV1 is often reduced [31]. Street cleaners in Copenhagen were also found by the questionnaire to be at increased exposure to air pollutants and risk of asthma (OR 2.3) and chronic bronchitis (OR 2.5) compared with cemetery workers [32].

DISCUSSION

Traffic-related air pollution is becoming a growing concern as the number of automobiles increases

worldwide. One of the fastest rates of automobile traffic growth is in China. Our understanding of air pollution has evolved considerably after events such as the Great Smog of 1952 that occurred in London and affected thousands of people.

Several factors can affect the level of outdoor air pollution in addition to the load of vehicular traffic. Coal-burning emissions from industrial or domestic sources played a major role in earlier high pollution levels in Europe and North America, and can also contribute to outdoor pollution in developing countries as can biomass burning and forest fire smoke. Levels of traffic-related pollution can also be affected by sunlight (leading to increased ozone levels), thermal inversions, time, weather, and geographic factors. Exposure to air pollutant compounds released by the mobile sources is heightened when traveling in motor vehicles or even being near major roadways or near public transportation. In these locations, the mean concentration of air pollutants is significantly higher than both indoor and ambient air levels [33–37]. Some of the highest concentrations have been measured for individuals who ride motorcycles or bicycles in or near traffic [38,39]. A Swedish study [40] investigated the energy expenditure and air pollution exposure for bicycle messengers. Their results showed that the levels of air pollution exposure when cycling seemed to be comparable with the levels of exposure when sitting inside a vehicle, but pulmonary ventilation during cycling was four times higher than resting value, leading to increased exposure to air pollution. Details of individual exposure levels to air pollution have not been included in the published studies reporting airway effects in outdoor workers.

Much evidence has been published on the worldwide harmful effects of air pollutants from large epidemiologic studies [41], from meta-syntheses [42], and formal reviews from large population studies [43], and it is now acknowledged that these traffic emissions play a role in the cause and prognosis of several illnesses, including asthma and COPD. The workers' studies reviewed above have shown reduction of spirometric measures and increases in respiratory symptoms, but have not provided detailed clinical assessments to determine whether these are acute or chronic changes, and whether they reflect fixed or reversible airflow limitation.

Occupational exposures to biological dusts, mineral dusts, gases, and fumes have been associated with increased incidence of COPD of at least moderate severity [44]. In addition, an analysis of participants in the Lung Health Study [45] with COPD showed an association between an

increased rate of decline of FEV1 and ongoing occupational exposure to fumes among male participants.

Since the 1950s, Fletcher and other pulmonary epidemiologists have recognized the importance of occupational exposures as a risk factor for COPD. Later in the 1970s and 1980s, more studies [46–49] on occupational cohorts and the general population were published, which demonstrated occupational exposure to gases, dusts, and fumes as risk factors for COPD and accelerated decline of FEV1. A review done in 2002 concluded that the fraction of COPD attributable to occupational exposures was 15–20% [50]. The data suggested that an extra decline in FEV1 of 7–8 ml per year could be attributed to occupational exposures.

Outside workers such as traffic police, highway workers, and gas station workers are more heavily exposed to traffic, and the published studies as reviewed here indicate that exposures in these workers can result in increased respiratory symptoms and declines in spirometric values. Potentially, there may be also adverse airway effects of traffic-related air pollutants on other outdoor workers such as construction workers in urban settings with increased exposure to traffic pollution.

There have been few studies of interventions, but the use of masks by traffic police in Bangkok appeared to offer some protection [12]. Additional studies are needed to determine the exposure levels and to assess the possible effectiveness of preventive measures.

CONCLUSION

Air pollution due to road traffic is a serious health hazard and those who have greater exposure because of their work may be at higher risk. Several studies have confirmed the ill effects of air pollutants on the lung function of workers such as traffic policemen, but more studies are needed to investigate the relationship with the duration of exposure in these workers [51], and also to determine the duration and reversibility of effects. In addition, further epidemiologic studies are needed among other urban outside workers to supplement controlled human exposure studies [52] in providing further understanding of associated changes and to allow recommendations for standards of exposure for outdoor workers.

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Conflicts of interest

The authors have no conflicts of interest.

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