

Traffic, diesel and asthma: A literature review

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Abstract

This article details the major pollutants from motor vehicle exhaust, mainly particulate matter, nitrogen dioxide and polycyclic aromatic hydrocarbons. The emphasis is on motor vehicle emissions from diesel powered engines, which have become a significant source of air pollution in urban areas. The impact of motor vehicle pollutants on respiratory health is explored, and the major studies relating asthma to high volume of traffic and proximity to major traffic arteries are reviewed.

Key words

Asthma, traffic, diesel, pollution

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Introduction

There are at least three decades of evidence supporting the link between air pollution from coal and oil combustion and related adverse health and environmental concerns. However, focus has now shifted to motor vehicle related air pollution, with a particular interest in respiratory health especially in children. This is because the introduction of various environmental restrictions on coal and oil combustion has resulted in motor vehicle exhaust dominating the air pollution scene.¹ Motor vehicles pollute via combustion and evaporation of fuel, producing carbon monoxide, particulate matter, nitrogen oxides, hydrocarbons, ozone (indirectly) and a cocktail of other hazardous air pollutants (HAPs).

The association between motor vehicle exhaust and asthma is now being investigated. Both motor vehicle emissions and asthma prevalence have increased dramatically over the past two decades, suggesting a correlation between the two. There are also financial implications; in the US alone, the estimated total cost related to asthma was \$12.7 billion in 2000.²

Particulate matter

Particulate matter (PM, specifically measured as PM₁₀ - particles 10 microns or smaller in mean aerodynamic diameter - and PM_{2.5}, a subfraction of PM₁₀) was identified by the Air Resources Board (based in California, USA) as a pollutant in 1998. PM consists mainly of aggregates of spherical elemental carbon particles coated with organic and inorganic substances. The particles have a sponge-like structure and large surface area which attracts compounds of low volatility to the inside or surface of the particles. The primary organic compounds associated with the particles include aliphatic hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and PAH-derivatives.

PM₁₀ is small enough to reach the lower respiratory tract and has been associated with a wide range of serious health effects. Coarse particles (diameter between 2.5 and 10 microns) include windblown dust from dirt roads or soil and dust particles created by crushing and grinding operations. Fine particles (PM_{2.5}) are emitted from combustion processes especially diesel-powered engines, power generation, and wood burning. Heavy-duty trucks and buses and off-road construction equipment are a significant source of particulate matter in urban areas.³

The main source of particulate emissions is diesel-powered engines. Sandoval *et al.* (1985) indicate that approximately 74 percent of PM in Santiago is from diesel sources.⁴ Figures from London are similar, with diesel emissions accounting for 87 percent of particulate matter emissions from vehicles.⁵

In Malta, results from an air quality surveillance station in Floriana indicate high levels of PM; the daily European Union (EU) threshold of 50µg/m³ was exceeded on 126 out of 310 days surveyed in 2005. At Kordin, 81 out of 292 days surveyed were above the daily EU threshold. Annual averages were 48.9µg/m³ at Floriana and 42.2µg/m³ at Kordin, exceeding the 40µg/m³ threshold recommended by the EU.⁶

Nitrogen Dioxide

Nitrogen dioxide is a gaseous pollutant produced by high-temperature combustion. The main outdoor sources of nitrogen dioxide include diesel and gasoline-powered engines and power plants. Overall production of nitrogen oxides has increased in the past 20 years because of an increase in nitrogen dioxide emissions from diesel vehicles.⁷ In Malta, the annual nitrogen dioxide concentrations exceeded EU standards in 2 localities only, Floriana and Hamrun.⁶

Polycyclic Aromatic Hydrocarbons (PAH)

Diesel exhaust particulate contains approximately 1% PAHs by weight. More than 50 nitro-PAHs have been identified in diesel exhaust. Most of them are found adsorbed on PM. Immunosuppressive effects have been reported in animals as a result of PAH exposure, particularly when exposed early in life, especially in utero. PAH-DNA can be identified in foetuses and neonates exposed to PAH. This may increase cancer risk in later life. PAHs have also been associated with intrauterine growth retardation and low birth weight in animals and humans.⁸

The European Union

It comes as no surprise, therefore, that the European Union is taking measures. Directive 70/220/EEC specifies the European Union regulations for emissions of light vehicles. This is a basis directive, which was amended a number of times. The fifth modification, known as Euro 5, is currently under way, and a draft proposal was published in July '05. The official Euro 5 proposal should become effective from mid-2008 or later. The emphasis of this proposal is on particulate emissions from diesel engines, limiting PM emissions to 5mg per kilometre. This represents an 80 percent reduction over the current EURO 4 proposal.⁹

Discussion

There have been numerous studies related to air pollution and respiratory health. A community based pilot study by Kinney *et al.* (2000) surveyed the amount of particulate matter in various areas of Harlem, New York City. They found a positive correlation between the amount of elemental carbon and the magnitude of local diesel sources, and calculated an average total diesel exhaust particle (DEP) mass of 5.7µg/m³ for the areas studied.^{10,11} Continuous exposure to a DEP mass of 5µg/m³ consistently demonstrated reduced pulmonary function, reproductive and developmental effects in animal studies.¹²

In a study by Lin *et al.* (2000) in New York City, asthma hospitalisations were increased in children with high volumes of traffic passing within 200 metres of their homes.¹³ Similarly, a cross sectional study in Holland demonstrated that cough, wheeze, runny nose, and doctor-diagnosed asthma were significantly more often reported for children living within 100 metres from the freeway.¹⁴ Venn *et al.* (2004) obtained similar results in an Ethiopian study, which concluded that for individuals living within 150 metres of a major traffic artery, the risk of wheeze increased significantly in linear relation to proximity to the road.¹⁵

Balzan *et al.* (2004), in a study conducted in Malta, also found an association between heavy traffic and prevalence of asthma related symptoms. Three areas within 250m of a major traffic artery in Fgura had a higher prevalence of physician diagnosed asthma, wheeze and nocturnal symptoms compared to a sub-urban area with much less traffic.¹⁶

Oosterlee *et al.* (1996) present data indicating that children may be disproportionately impacted by traffic-related pollutants. Respiratory symptoms in children (up to 15 yrs of age) living along streets with estimated traffic density of 10,000 to 30,000 vehicles/day were compared to those of children living in the same neighbourhoods on streets with little traffic. Results were significant for wheezing, dyspnoea and respiratory medication use, and suggest that girls may be more affected than boys. Current asthma medication use was significantly higher for all children living along busy streets, but not for adults.¹⁷ Similarly, a two year Italian study sampling 39,275 children also found a clear association between a high flow of heavy traffic, and cough and wheeze in children.¹⁸

Only one study failed to find an association. In this study by Nicolai *et al.* (2003), all associations between asthma and air pollution disappeared after adjustment for a family history of asthma, early childhood respiratory disease and socio-economical status.¹⁹

Conclusion

Motor vehicle exhaust has become the major air pollutant in urban areas. Particulate matter, aggregates of carbon particles coated with PAHs, can enter the lower airways and cause multiple adverse respiratory effects. Diesel powered engines, particularly heavy duty vehicles, are the major source of particulate matter emissions. Numerous studies, including one from Malta, have shown increased prevalence of cough, wheezing and asthma in individuals exposed to heavy traffic.

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