The Year of the Lung: outdoor air pollution and lung health

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Summary

With reference to the Year of the Lung, current knowledge of the respiratory effects of current ambient air pollution is reviewed. Acute respiratory effects are well established.

Key words: air pollution, lung function, asthma, traffic, COPD, bronchiolitis, PM10

Introduction

The year 2010 has been proclaimed the international Year of the Lung to emphasise the importance of healthy lungs. The major threat to lung health is undoubtedly smoking. The emphasis of this short review will be a more ubiquitous and entirely involuntary threat to health, namely ambient air pollution, which is an established cause of morbidity and mortality [1]. Air pollution affects 100% of the population from cradle to grave. Large sections of European populations continue to live in areas with unhealthy air quality. For some pollutants and in some regions this situation is not improving and is even deteriorating. Moreover, changes in combustion and fuel technologies, industrial production, movement of goods and urban planning affect the constituents and thus possibly the toxicity of air pollution as well as the population’s exposure. Thus, while air quality improved in many areas in recent decades, the problem is by no means resolved and nor are all adverse effects well understood. The aim of this review is to provide a key selection of information around the respiratory health effects of ambient air pollution, with discussion of open questions and future prospects. While the evidence for adverse effects of air pollution beyond the involvement of the lung alone is steadily growing, embracing a wide range of cardiovascular outcomes including atherogenic effects, these are not the subject of this paper [2, 3]. An overview of the evidence has been published by the European Respiratory Society for the 2010 Year of the Lung and is freely available online at several languages [4]. This review lists only a selection of the key references, but more can be provided on request.

Air pollution composition and sources

Air pollution is a complex mixture of thousands of pollutants. This mixture may consist of solid and liquid particles suspended in air (particulate matter – PM), and different type of gases such as ozone (O3), nitrogen oxides (NOx or NO2), volatile organic carbons (VOCs), and carbon monoxide (CO). While particles vary in number, size, shape, surface area and chemical composition, both particles and gases may vary in solubility and toxicity. The most important processes causing air pollution relate to the combustion of fossil fuels used in cars and trucks, aircraft, marine vessels or other engines, as well as in industry, power plants, or household heating systems. Due to the close proximity between people and emissions, transport-related activities, in particular involving cars and trucks, are an important source of air pollution. Traditionally, health studies have used markers of air pollution to study its effects, e.g. the mass of size specific PM fractions – such as PM10 or PM2.5 – or distance to main roads.

Air pollutants orchestrate pathophysiologies

While experimental studies confirm a range of effects related to single pollutants, it should be emphasised that the effects of ambient air pollution cannot be attributed to one single pollutant in the mixture. In contrast – as in case of tobacco smoke – many pollutants act together in a series of partly interrelated mechanisms, which result in the observed associations between current levels of air pollution and a range of health outcomes. Oxidative stress and both local and systemic inflammation are suggested as main mechanisms following the inhalation of these pollutants [5]. A first step may be the release of reactive oxygen species of lung cells (e.g. through contact with inhaled particles where toxic substances such as metals are adsorbed). Particulate matter of various sizes, as well as highly oxidative gases (e.g. O3 or NO2) have been shown to induce local pulmonary reactions related to oxidative stress [6, 7]. Both local and systemic inflammatory reactions, mediated through cytokines and chemokines, have been described in experimental studies in cellular systems, animals, and in chamber studies with human subjects [8].

Respiratory health effects

The respiratory tract is the portal of entry of air pollutants, and thus the lung is the first affected organ. The range of respiratory diseases due to air pollution may be expressed within hours or days of exposure, but other health effects of air pollution result from long-term exposures leading to chronic pathologies. While the acute and chronic effects of air pollution are partly interrelated, the distinction is important when planning and interpreting epidemiological studies and for policymaking.

Short-term respiratory effects of air pollution

Daily mortality

A large number of epidemiological studies have shown that the daily number of deaths, mainly from cardiovascular and respiratory diseases, follows the daily fluctuation of air pollution [9]. APHEA, the seminal European multicentre time series analyses carried out in 29 study centres including three Swiss cities, found an increase in deaths from illness of 0.6% per 10 µg × m-3 increase in PM2.5 concentration, and data from hundreds of cities around the world observed similar results. Studies on short-term mortality showed that in general the air pollution-related relative risk is higher for respiratory outcomes. However, as more people die from cardiovascular diseases, the number of cardiovascular deaths related to air pollution is as large or larger than the number of respiratory deaths attributable to air pollution.

Daily respiratory disease exacerbations

The daily variation in disease burden due to urban pollution is also shown by increases in the numbers of emergency visits and hospital admissions due to respiratory diseases, including asthma. APHEA found increases of 1.2% for asthma in children; 1.1% for asthma in adults aged up to 64 years; and 0.9% for all respiratory diseases (including COPD, asthma and other respiratory diseases) in the elderly per 10 µg × m-3 increase in PM2.5.