Air Pollution and Children — An Unhealthy Mix

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Residents in urban areas may be worried about the air they breathe. In recent reports, air pollution has been linked to increased mortality, an increased risk of asthma, and decreased development of lung function in childhood. In this issue of the *Journal*, Kulkarni et al.[1] investigate this last finding. The authors show that carbon particles, similar to those in ambient air, are present in the airway macrophages of children and that an increased level of carbon in the macrophages correlates with decreased lung function.

Why should we care about lung function in children? The lungs develop steadily throughout childhood, with peak function occurring between 20 and 25 years of age. Lung function then remains stable for as long as 10 years before beginning to decline with increasing age. Superimposed on these lifetime patterns may be acute, disease-related episodes of reversible airflow obstruction. For a given degree of obstruction, the severity of symptoms may depend on the baseline level of function. A deficit in growth during childhood will most likely translate into a deficit in baseline function that is carried throughout life. Reduced lung function later in life has been described as second only to the exposure to tobacco smoke as a risk factor for death.[2]

It has long been known that air pollution can adversely affect human health. A classic example is the London fog of 1952, which was characterized by five days of sharply elevated pollution levels. This episode was followed by large short-term increases in mortality and in the rates of respiratory and cardiac disease, with mortality remaining above normal for several months. Since 1952, we have learned a great deal about the effects of air pollution on health, through both controlled trials and epidemiologic studies. Controlled studies, typically conducted in laboratory settings, have shown that air pollution is associated with acute responses such as short-term reductions in lung function and an increased risk of respiratory symptoms, as well as with the presence of inflammatory markers in blood and in bronchoalveolar lavage fluid. Epidemiologic studies, conducted mostly in Europe and North America, have shown both short- and long-term health effects of outdoor ambient air pollution.

Air pollution consists of both gaseous and particulate-matter pollutants. The former includes nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). The latter includes particulate matter of varying aerodynamic diameter, as defined by cutoff points — for example, diameters of less than 10 μm (PM_{10}) or less than 2.5 μm ($PM_{2.5}$). Ambient particulate matter in an urban environment is a complex mixture of many substances, including metals and elemental and organic carbon. Recent interest has focused on $PM_{0.1}$, or so-called ultrafine particles. As compared with PM_{10} and $PM_{2.5}$, ultrafine particles have a higher carbon content, larger total surface area, and greater potential for carrying toxic compounds. Because of their small size, these particles can be inhaled deeply into the lungs and deposited in the alveoli.

One might argue that air quality in urban environments has improved and therefore that we should be less concerned than we were in the past about the health effects of breathing outdoor air. In Los Angeles, for example, levels of O_3, NO_2, and PM_{10} recorded by fixed-site monitors have all decreased substantially over the past 30 years.[3] This improvement is attributable to emission-control strategies for vehicles, the use of cleaner-burning fuels, and the elimination of gross pollution sources such as backyard incinerators. The decrease in the levels of these pollutants is an environmental success story.

Improvements in general air quality, however, do not necessarily translate into reduced exposure for all residents of an urban environment. First, control strategies have been aimed at lowering the levels of contaminants that the Environmental Protection Agency terms "criteria" pollutants — O_3, SO_2, nitrogen oxides, carbon monoxide, lead, PM_{10}, and $PM_{2.5}$. It is not known whether the levels of other pollutants, such as ultrafine particles and important constituents of particulate matter such as metals and elemental carbon, have also decreased over time.

Second, the size of the population and the number of vehicles in use are increasing in many urban environments. To handle the growing population, housing tracts and schools are being built in previously undesirable locations, often near busy roadways or other sources of pollution (Fig. 1). The result is that many children are liv-

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Figure 1. Elementary School Near a Freeway Interchange in Los Angeles.
Courtesy of Carla Truax, University of Southern California.

ing and going to school in close proximity to important sources of air pollution. Elevated levels of several pollutants, including ultrafine particulate matter, elemental carbon, and NO_2, have been shown to be associated with a close proximity to main roads. Thus, even within an area considered to be "low-pollution" (according to measurements made at a central monitoring station), children living or going to school near a busy road may be exposed to unacceptably high levels of air pollution.

Decisions about whether to smoke cigarettes and whether to expose children to second-hand tobacco smoke are in the hands of individual persons. But although people may be able to modify some of their activities to minimize exposure to polluted ambient air, breathing it is often unavoidable, particularly in urban environments. The reduction of exposure through the improvement of air quality relies on a complex combination of federal, state, local, and personal choices, and international considerations are of increasing importance. Despite the recent improvements in air quality, scientific evidence shows that adverse health effects are associated with the current levels of PM_{10}, $PM_{2.5}$, NO_2, and O_3. There are a few possible explanations: the current maximum levels recommended for these pollutants are not low enough to protect human health, other pollutants that are not currently being routinely monitored are present at unhealthy levels in ambient air, or locally increased levels of air pollution that are not captured by central monitors are affecting health — or some combination of these.

Current research by scientists in the fields of exposure assessment, genetics, toxicology, and epidemiology focuses on identifying the specific sources and constituents of ambient air pollution that are responsible for health effects. Findings from their studies will provide necessary support for actions by policymakers and will guide the choice of specific control strategies. For example, is it worth reducing the levels of ultrafine particles with the use of a technology that may increase the level of an oxidant pollutant such as NO_2? The best control strategy from the standpoint of human health, supported by the scientific evidence to date, is to reduce the levels of all types of air pollutants. Our children's health depends on it.

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Influenza Control

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Influenza is an uncontrolled epidemic disease that occurs every winter. Epidemics, which vary in severity, are measured by excess mortality, but influenza is always the leading cause of acute respiratory tract infections that lead to health care visits or hospitalization. Therefore, when an epidemic is classified as "mild," this comparison is only with other flu epidemics; even mild flu epidemics result in the highest rates of health care encounters for the season. The effect on health care facilities is magnified by the usual sharp seasonality of influenza outbreaks. Many

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