Ambient Air Pollution: Respiratory Hazards to Children

Committee on Environmental Health

Levels of many outdoor air pollutants decreased substantially after the passage of the Clean Air Act of 1970; however, levels of ozone, carbon monoxide, and particulate matter are still high enough to present hazards to children. Failure to meet the federal standards for these pollutants was a major force driving the adoption of the revised Clean Air Act of 1990. In addition, recent research indicates that acidic aerosols, for which there are no health-based standards, may be associated with adverse respiratory effects.

As an ambient air pollutant, ozone is formed by the action of sunlight on nitrogen oxides and reactive hydrocarbons (both of which are emitted by motor vehicles and industrial sources). Ozone levels therefore tend to be highest on warm, sunny days, which are conducive to outdoor activities. In many areas ozone concentrations peak in the midafternoon, when children are likely to be playing outside. It is important to distinguish ground-level ozone air pollution from stratospheric ozone depletion by chlorofluorocarbons. These issues are unrelated. Carbon monoxide, a product of incomplete combustion, is emitted mainly from cars and other mobile sources. Airborne particulate matter is a variable and complex mixture of natural materials and substances released from numerous industries, motor vehicles, residential wood burning, construction and demolition, and other sources. Acidic aerosols are traceable mainly to combustion of sulfur-containing fossil fuels and to reactions of photochemical free radicals with nitrogen dioxide.

Exposure to ambient air pollution in North America has been clearly associated with acute and subacute effects in epidemiologic investigations and in controlled exposure studies in environmental chambers. For example, ozone causes airway inflammation and hyperreactivity, bronchial epithelial permeability, decrements in pulmonary function, cough, chest tightness, pain on inspiration, and upper respiratory tract irritation.[1–7] Nonrespiratory effects associated with ozone exposure include nausea, headache, malaise, and decreased ability to perform sustained exercise.[7–9] Epidemiologic studies link increased ozone concentrations with exacerbations of asthmatic symptoms.[10,11] Controlled chamber studies suggest that low concentrations of ozone do not cause dramatic bronchoconstriction in asthmatic volunteers, although at higher concentrations asthmatics experience greater airway obstruction than healthy study subjects.[12–14]

Although healthy children appear to experience losses in pulmonary function comparable with those observed in adults for a given dose of ozone, children do not report symptoms to the same extent.[15–18] This suggests that children may not experience or recognize somatic signals to curtail exposure. Field studies suggest that ozone effects on pulmonary function in children are much greater than would be predicted from chamber studies.[19] Moreover, decreased peak flow in children has been reported to persist for up to a week following exposure to ozone concentrations lower than 0.2 ppm, suggesting the presence of damage to the respiratory tract.[20] Repeated exposures may result in persistent bronchial hyperresponsiveness.[21]

Controlled exposures to low ozone concentrations (at and below the current federal standard of 0.12 ppm) involving moderate levels of exercise for several hours have resulted not only in pulmonary function changes and respiratory symptoms, but also in dramatic increases in inflammatory markers in bronchoalveolar lavage fluid.[1,2,5] These findings are consistent with animal studies indicating that repeated exposures to ozone concentrations found in typical urban air result in centriacinar inflammation and small-airway structural changes.[22–24] Epidemiologic studies suggest that repeated exposures to ozone and other photochemical oxidants and particulates are associated with an accelerated decline in lung function and with symptoms of chronic respiratory disease; however, the quantitative aspects of such a relationship have not been adequately explored.[25,26] One recent study links oxidants (primarily ozone) and other air pollutants in Los Angeles, CA, with daily mortality.[27]

Epidemiologic studies undertaken in a variety of locations indicate a relationship between outdoor air pollution and adverse respiratory effects in children. The pollutants most frequently implicated in these studies have been respirable particles (notably acidic sulfates) and ozone. Examples of health outcomes found to be correlated with air pollution levels include increased prevalence of chronic cough, chest illness and bronchitis (measured by questionnaire), hospital admissions for various respiratory conditions, and decrements in lung function.[28–33] The prevalence of respiratory symptoms was markedly increased among children with a history of asthma or wheezing.[34]

The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

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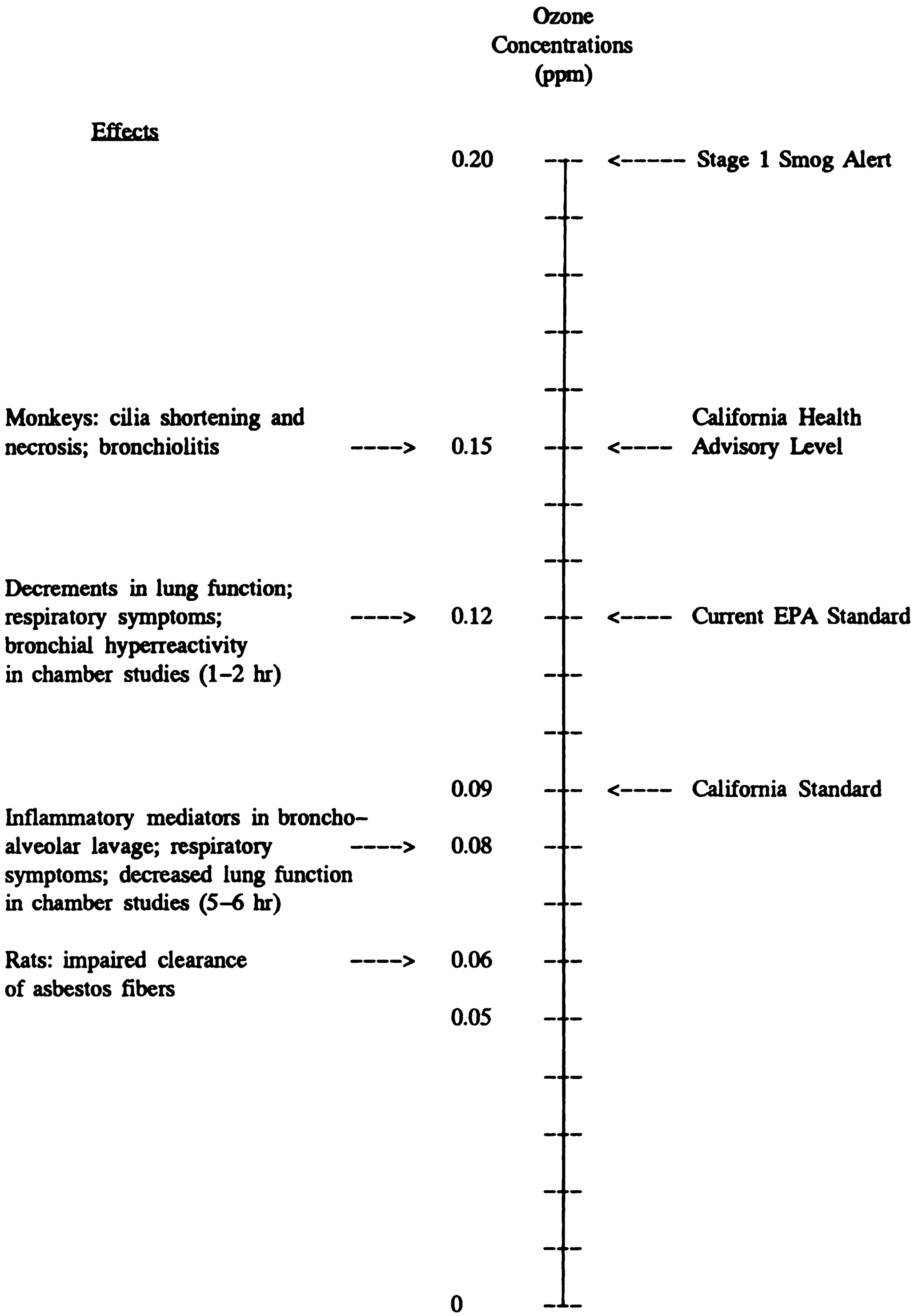

Figure. Relationship between ambient ozone levels and respiratory tract effects in humans and experimental animals. EPA, Environmental Protection Agency.

Controlled studies involving adolescents with asthma have found that exposure to acidic aerosols affects results of pulmonary function tests.[35,36] A recent study of asthmatic adults found a significant association between ambient airborne acidity and daily fluctuations of asthmatic symptoms, including cough and shortness of breath.[37] Acidic aerosols also have been found to provoke changes in tracheobronchial clearance and increased airway reactivity in normal subjects.[38,39]

The effects of exposures to multiple pollutants are difficult to study in humans. A few controlled investigations and field studies indicate, however, that exposures to complex mixtures of air pollutants may have synergistic acute effects on pulmonary function and, possibly, on symptoms.[19,40,41] A recent report suggests that even brief exposure to ozone can potentiate allergic asthmatic responses to aeroallergens.[42] There is, moreover, a substantial body of experimental evidence in animals indicating that ozone can lower resistance to infection, facilitate sensitization and airway responses to airborne allergens, and act synergistically with airborne acidity to damage deep lung tissues.[43–47]

CONCLUSIONS

Existing epidemiologic and toxicologic data indicate that exposure to ambient air pollution is associated with respiratory toxicity. The decrements in pulmonary function observed in epidemiologic and experimental studies involving children exposed to ozone and other pollutants may last longer than the episodes of pollution that initiate these changes.

A factor that increases children's vulnerability to airborne pollution is that their airways are narrower than those of adults. Thus, irritation caused by air pollution that would produce only a slight response in an adult can result in potentially significant obstruction in the airways of a young child. Moreover, children have markedly increased needs for oxygen relative to their size. They breathe more rapidly and inhale more pollutant per pound of body weight than do adults. In addition, they often spend more time engaged in vigorous outdoor activity than adults. Experimental and epidemiologic data provide grounds for concern about chronic lung damage from repeated exposures.

Current strategies in the United States for attaining clean air and protecting public health have been only partially successful. Thus, the American Academy of Pediatrics offers the following recommendations:

Recommendations to Government Agencies

1. *Ambient standards.* The federal ambient air standard for ozone of 0.12 ppm (averaged over 1 hour) contains little or no margin of safety for children engaged in active outdoor activity. In view of recent research indicating the occurrence of adverse effects at ozone concentrations lower than the current standard, the Academy recommends that the standard be reconsidered for possible lowering (see Figure). Similarly, epidemiologic evidence has shown that the current federal standard for particulate matter provides less than optimal protection of public health and should be lowered.

2. *Smog alerts.* State and local government agencies have a responsibility to issue pollution or smog alerts in a clear and timely manner. These alerts should warn specifically of the hazards that air pollution presents to children. Furthermore, recent evidence indicates that respiratory toxicity occurs at ozone concentrations lower than the stage 1 smog alert concentration (0.20 ppm, 1 hour average) recommended by the US Environmental Protection Agency, suggesting the need for reconsideration of this advisory level. Among other things, the stage 1 alert level triggers advisories to schools that outdoor activities should be restricted.

3. *Source control.* State and federal governments must act more vigorously in the arena of pollution prevention, in terms of both technologic requirements and public education. Regulatory agencies should act aggressively to implement the requirements of the Clean Air Act of 1990.

Recommendations to Pediatricians

1. Pediatricians should become informed about air pollution problems in the community.
2. Pediatricians caring for children at special risk, such as those with asthma and cystic fibrosis, should be aware that current levels of air pollution may cause deterioration in these children's pulmonary function and may aggravate their symptoms.
3. Pediatricians who serve as physicians for schools and for students participating in team sports need to be aware of the health implications of pollution alerts in order to provide appropriate guidance to schools and other public agencies on the health hazards of air pollution.
4. Pediatricians can make parents aware of the predictable daily variation in ozone, especially the tendency to peak in the afternoon. This awareness is essential in areas with recognized high ozone levels. When ozone levels are elevated, it may be possible to decrease children's exposure by scheduling outdoor sports earlier in the day.
5. Pediatricians can help children by expressing their concern about the child health hazards of air pollution to their representatives and to policymakers within state and federal governmental agencies.

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