

OZONE HEALTH EFFECT

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I.

II. INTRODUCTION

Ozone (O₃) has become a significant pollutant as a result of increased population growth, industrial activities, and use of the automobile. Ozone is at present the primary air pollution problem in the United States. The adverse health effects of ozone have been studied since 1952. Ozone exerts adverse effects on the public's health, especially those living in industrialized cities. The United States Environmental Protection Agency (EPA), has classified ozone as a criteria pollutant. EPA has established National Ambient Air Quality Standards (NAAQS) of 0.12 parts per million (ppm) averaged over 1 hour (not to be exceeded more than three times in a 3-years period), and 0.08 ppm averaged over 8 hour. However, recent epidemiological studies have shown that 1-hour ozone levels lower than 0.12 ppm and 8-hour levels lower than 0.08 ppm produce adverse health effects in

the general population.

III. DEFINITION

Ozone is a colorless, pungent, highly reactive gas, considered as a secondary pollutant (It is not emitted into the air directly). It is composed of three oxygen atoms. It is the principal component of smog, which is caused primarily by automobile emissions, predominantly in urban areas. Distinct from the stratospheric ozone layer, which lies 10 km above the earth's surface, the pollutant ozone is in the troposphere and is formed by photochemical reaction driven by the action of ultraviolet light on the precursor pollutants oxides of nitrogen (NO_x), and volatile organic compounds (VOCs). Ozone concentrations in urban areas rise in the morning, peak in the afternoon, and decrease at night. The highest levels of ozone, as well the frequency of their recurrence, reflect the dependence are dependent on overall weather conditions, and occur most frequently when atmospheric inversions trap the pollutants near the ground.

III. BIOREACTIVITY

Several pathophysiologic pulmonary processes result from ozone exposure. As a potent oxidant, ozone is extremely irritating to the respiratory system. It is capable of reacting with a variety of extracellular and intracellular biomolecules, and produces disruptive changes that may be measured by alterations in pulmonary function. In addition, ozone is less soluble than other irritant gases. It can penetrate more effectively through the tracheobronchial tree to the pulmonary regions of the respiratory system, inducing injury in resident lung cells, and causing an influx of inflammatory cells (5,15). Exposures lower than 0.08 ppm are sufficient to induce alterations of enzyme activity and to initiate an inflammatory reaction in the lung, inducing significant increases in neutrophils, protein, prostaglandin E₂, interleukin-6, lactate dehydrogenase, and antitrypsin (5). These enzymes and mediators are usually associated with cell edema and at sufficient ozone concentrations, cell death.

IV. OZONE HEALTH EFFECTS

The human health effects of ozone have been studied for over 30 years. The respiratory system is the primary target of this oxidant pollutant. Respiratory tract responses induced by ozone include reduction in lung function, aggravation of preexisting respiratory disease (such as asthma), increased daily hospital admissions and emergency department visits for respiratory causes, and excess mortality. The degree of adverse respiratory effects produced by ozone depends on several factors, including concentration and duration of exposure, climate characteristics, individual sensitivity, preexistent respiratory disease, and socioeconomic status (1,15, 16, 17).

Both the level of physical activity and the sensitivity of the individual are factors in determining the adverse health effects of ozone. Four groups of people are particularly sensitive to ozone when they are active outdoors: children, healthy adults doing outdoor exercise, people with preexistent respiratory disease, and the elderly. Children and healthy adults are more sensitive

to ozone when they are active outdoors, because physical activity causes people to breathe faster and more deeply, permitting more and deeper penetration of ozone into the lungs and resulting injury. In addition, children are at high risk from ozone exposure because they spend a large period outdoors engaged in vigorous activities.

Another factor that increases adverse effects of ozone is socioeconomic status. People with low incomes are less likely to have air conditioners in their homes and thus are more likely to keep their windows open during the summer months when ozone levels are highest. Differences in areas of residence, also related to socioeconomic status, may affect the likelihood of being exposed to peak concentrations of certain air pollutants (1, 19)

Weather also plays an important role in the relationship between ozone pollution and health. Meteorological conditions influence the chemical and physical processes involved in formation of ozone. In a study conducted in Belgium during the summer, outdoor temperatures combined with high ozone concentrations were assumed to be likely causes of the important excess mortality (9). In another study conducted in New Jersey a strong relationship between summertime ozone concentration and emergency department visits for asthma was observed (8).

Two of the most important factors are the concentration of ozone and duration of exposure. Numerous epidemiological studies show the relationship between health effects and specific ozone ranges. EPA has gathered information about health effects through research, studies comparing health statistics and ozone levels in the communities, and controlled testing of human volunteers.

The EPA has developed the Air Quality Index (AQI) for reporting the levels of ozone and other pollutants, and their effects on human health. The AQI scale has been divided in different categories, which range from 0 to 300. Each category corresponds to a different health impact (Table1). The NAAQS for ozone are 0.120 ppm averaged over 1 hour and 0.08 ppm averaged over 8 hours.

Table1. EPA Air Quality Index

8-hour average ozone Concentration (ppm)	Air Quality Index Values	Air Quality Descriptor	Health Effects
0.0 to 0.064	0 to 50	Good	No health effects are expected.
0.065 to 0.084	51 to 100	Moderate	Usually sensitive individuals may experience respiratory effects from prolonged outdoor exertion if you are unusually sensitive to ozone.
0.085 to 0.104	101 to 150	Unhealthy for Sensitive Groups	Member of sensitive group may experience respiratory symptoms (coughing, pains when taking a deep breath).

0.105 to 0.124	151 to 200	Unhealthy	Member of sensitive group have higher chance of experiencing respiratory symptoms (aggravated cough or pain), and reduces lung function.
0.125 (8-hr) to 0.404 (1-hr)	201 to 300	Very Unhealthy	Members of sensitive groups experience increasingly severe respiratory symptoms and impaired breathing.

0.125 (1-h) TO 0.404 (8-h) ppm (VERY UNHEALTHY)

At ozone concentrations from 0.125 to 0.404 ppm, sensitive people experience severe respiratory symptoms and impaired breathing.

Recent studies of humans exposed to these ozone concentrations have shown pulmonary function impairment during heavy exercise (7). Another study, conducted in Mexico City, shows that exposures from 0.170 to 0.250 ppm 1-h, increase the occurrence of respiratory symptoms, such as cough, phlegm, difficulty in breathing, and reduce PEFs among children with mild asthma (2). In addition, ozone exposure to 0.30 ppm 1-h induces lower airway inflammation. This is manifested by PMN influx measured by bronchoalveolar lavage (3). Also, at this concentration with continuous exercise, FEV1 decreases.

0.105 to 0.124 ppm (UNHEALTHY)

1 HOUR EXPOSURE. A study conducted in Atlanta indicated that when the maximum 1-h ozone level equaled or exceeded 0.110 ppm, the number of emergency visits to the hospital for asthma or reactive airway disease increased in children. During this exposure, many children and adults progressively developed substernal pain on deep inspiration, coughing, and reduction of vital capacity and FEV1 (1).

8 HOURS EXPOSURE. Reduction in lung function is observed with exposures of <0.12 ppm over 6-8 hours with moderate exercise, manifested by decrements in FEV1. (4,5).

0.085 TO 0.104 ppm (UNHEALTHY FOR SENSITIVE GROUPS)

1 HOUR EXPOSURE. Sensitive people, active children and adults, and people with respiratory

disease under **heavy** outdoor exertion, may experience respiratory symptoms such as coughing or pain when taking a deep breath, and reduced lung function. Other studies have associated 0.100 ppm ozone concentrations with increased respiratory hospital admission in elderly (12).

8 HOUR EXPOSURE. In accordance with AQI, sensitive people, active children and adults, and people with respiratory disease under **prolonged** outdoor exertion, may experience respiratory symptoms such as coughing or pain when taking a deep breath, and reduced lung function, which can cause some breathing discomfort.

A series of studies conducted in the USA (1,3,6) demonstrated that with 0.09 ppm ozone, the number of hospital visits for asthma increased and people undergoing moderate exercise increased their sensitivity to ozone. Also, 0.100 ppm ozone induces neutrophilic influx into the airway and resulting inflammation, and a decrease in forced expiratory volume (FEV1) and PEFr in asthmatic people (children and adults).

0.065 to 0.84 ppm (MODERATE)

1 HOUR EXPOSURE. In this specific range, based on the AQI standards, ozone health effects are not expected. However, in a study of 154 children aged 10-12 years in Tennessee, 0.078 ppm of ozone was associated with decrements in FEV1 and FEF₂₅₋₇₅ (5), and with 0.082 ppm an increase in asthma-related hospitals visits was observed.

8 HOURS EXPOSURE. Sensitive people may experience respiratory effects from prolonged exposure to ozone during outdoor exertion. In addition, other studies (1,6,8) have demonstrated that ozone concentrations at 0.080 ppm produce adverse effects on human health such as PEFr decrements in asthmatic children (6), decrements in FEV1 with intermittent exercise in healthy men (5,7), and increased hospital visits for asthma (1,8).

0. to 0.064 ppm (GOOD)

In accordance with NAAQS and AQI, at ozone levels from 0.0 to 0.64 no health effects are expected and the air quality is considered "GOOD". However, recent studies have demonstrated that at these concentrations ozone can exert adverse health effects.

1 HOUR EXPOSURE. A study conducted in Brisbane, Australia by Simpson et al. demonstrated an association between 0.030 ppm ozone and daily mortality in the elderly (11). In a study in Mexico, the relationship between ozone exposure in asthmatic children (5-13 years of age) and mild asthma was evaluated. Exposure to 0.050 ppm increased the occurrence of lower respiratory symptoms such as cough, phlegm and difficulty breathing, and reduced PEFrs. A different study suggests that 0.065 ppm ozone increases respiratory symptoms in asthmatic children. (5).

8 HOURS EXPOSURE. No information available.

24 HOURS EXPOSURE. Sartor and co-authors (1994) analyzed low levels of ozone and daily mortality in Belgium. This study demonstrated a relationship between 0.050 ppm ozone, high temperatures, and the number of daily deaths (9). An increase in elderly deaths with 0.034 ppm for 24-h was also observed (9, 11). Schwartz utilized Medicare records for the years 1986-1989 to study the association between ozone concentrations and respiratory admissions among elderly. In this study a significant relationship was observed between 0.050 ppm 24-h ozone

concentration and hospital admission for pneumonia. (12).

V. CONCLUSIONS

Serious respiratory tract responses are induced by ozone, such as reduction in lung function, aggravation of preexisting respiratory disease (such as asthma), increases in daily hospital admission and emergency department visits for respiratory causes, and excess mortality. The adverse effects produced by ozone on the respiratory system depend on factors such as individual sensitivity (children, healthy adults doing outdoor exercise, people with preexistent respiratory disease and elderly), socioeconomic status, climate characteristics, and concentration and duration of exposure (1,15, 16, 17).

EPA has established National Ambient Air Quality Standards (NAAQS) of 0.12 parts per million (ppm) ozone averaged over 1 hour (not to be exceeded more than three times in a 3-year period), and 0.08 ppm averaged over 8 hours. The Air Quality Index (AQI) reports the levels of ozone and other pollutants, and their effects on human health. According to the AQI, NAAQS and recent epidemiological studies, ozone concentration from 0.080 to 0.404 ppm in 1-h or 8-hr exposure, can in sensitive groups produce adverse health effects including lung function decrements, aggravation of preexisting respiratory disease, increases in daily hospital admissions and premature mortality. Those people may experience respiratory symptoms such as coughing, pain when taking a deep breath, and reduction in lung function, which can cause breathing discomfort. These symptoms worsen when ozone concentration increases. Other less severe effects such as decreased lung function and diminished athletic performance have been observed in this ozone range in healthy individuals.

According to the AQI, adverse health effects are not expected at 0.0 to 0.065 1-h and 8-hr ozone exposure. However, epidemiological studies have provided information that adverse effect of ozone can be observed with exposure to low ozone concentrations over 1-hour, 8-hours and 24-hours (2,4,9,10,11,12,13). Sensitive groups are more influenced by these adverse effects. In addition, a number of studies have shown that the existence of other pollutants and weather conditions may worsen the adverse health effects seen with low-level ozone exposure.

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