

# Health Update

## Repetitive Ozone Exposure

July 25, 2002



California Air Resources Board

California Environmental Protection Agency

Good morning Chairman Lloyd and members of the Board.

Staff from the Air Resources Board and the Office of Environmental Health Hazard Assessment are beginning to review the literature on the health effects of ozone exposure in preparation for bringing you recommendations for the ozone ambient air quality standard late next year. In the past, ozone standards have been based primarily on controlled human studies. Controlled studies will continue to be important for the current review, and will be supplemented by field and epidemiological studies.

This morning's presentation will focus on a recent controlled exposure study, which measured human responses to ozone exposure on four consecutive days. The protocol was designed to simulate a real world condition -- a lingering, multi-day ozone episode. Episodes of this sort happen every summer, and the results of this paper can help us better understand how repeated ozone exposures affect people.

# Introduction

- ◆ **Short exposures to O<sub>3</sub> cause adverse health effects**
- ◆ **With repeated brief exposures:**
  - **Magnitude of some impacts diminishes**
  - **Magnitude of other impacts persists**
- ◆ **“Adaptation” versus “Attenuation”**
- ◆ **Effects proportional to amount of O<sub>3</sub> inhaled**
- ◆ **Most at risk: people who are active outdoors**
  - **Children**
  - **Athletes**
  - **Outdoor workers**

Previous research has shown that short exposures to ozone have important health impacts, including decrements in various measures of lung function, increased respiratory symptoms such as difficulty breathing and lung inflammation.

With repeated exposures to ozone on consecutive days, the magnitude of some effects diminishes, including symptoms. Some investigators have termed this phenomenon “adaptation”, and have suggested that this is a beneficial response.

However, as you will see from this morning’s presentation, the magnitude of other impacts persists with repeated ozone exposures on consecutive days. This combination of some diminished and some persistent responses actually represents what is known as attenuation.

Research has also shown that the magnitude of ozone-induced health effects is proportional to the amount of ozone inhaled. Consequently, the people most at risk are those who inhale the most ozone, namely those who are active outdoors. These groups include children, athletes and outdoor workers. People with compromised health status are generally not physically active and do not inhale enough ozone to induce significant effects.

## **“Repetitive Ozone Exposure of Young Adults: Evidence of Persistent Small Airway Dysfunction”**

**by Dr. Robert Frank and colleagues**

### **Protocol:**

- **2 hour exposures**
- **Exposures repeated daily for 4 days**
- **O<sub>3</sub> concentration = 0.25 ppm**
- **Measured lung function and inflammation before and after each exposure**

The paper we will look at this morning is entitled “Repetitive Ozone Exposure of Young Adults: Evidence of Persistent Small Airway Dysfunction.” by Dr. Robert Frank and colleagues from Johns Hopkins University and the National Heart, Lung and Blood Institute.

Eight healthy, nonsmoking men and women between 25 and 31 years of age were exposed for 2 hours to 0.25 ppm ozone on each of four consecutive days. Either three weeks before or three weeks afterward they completed the same series while exposed to filtered air as a control condition. Several aspects of lung function were measured before and after each daily exposure, and airway inflammation was assessed 24 hours after the last exposure in each series.

Although the ozone concentration used in the study is higher than has been measured in recent years, at one time it occurred frequently in California. And, since ozone-induced responses are proportional to the inhaled dose, a longer exposure to a lower ambient ozone concentration can result in responses of a similar magnitude. So, in spite of the relatively high ozone concentration used in the study, it provides important insight into how people respond to repeated ozone exposures.

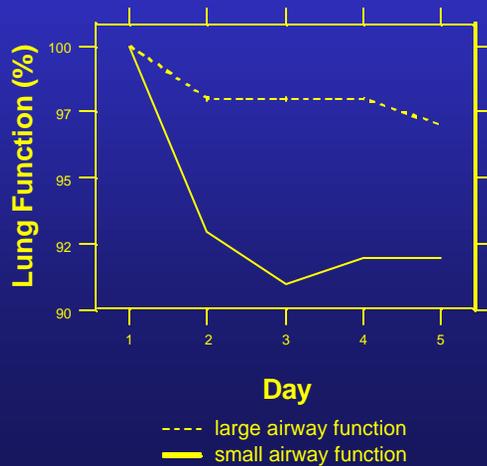
## Results

- ◆ **With repeated brief O<sub>3</sub> exposures:**
  - **Daily changes in some lung functions become smaller**
  - **Some lung functions remain persistently reduced**
  - **Airway inflammation persists**
- ◆ **Adverse effects can be present without our being aware of them**

The results of the study show that daily changes in the magnitude of respiratory symptoms, such as cough and chest tightness, and some lung function responses, become smaller with repeated ozone exposures. At the same time, however, airway inflammation, and reductions in some other measures of lung function persist. Inflammation is indicative of damage to the airway tissues.

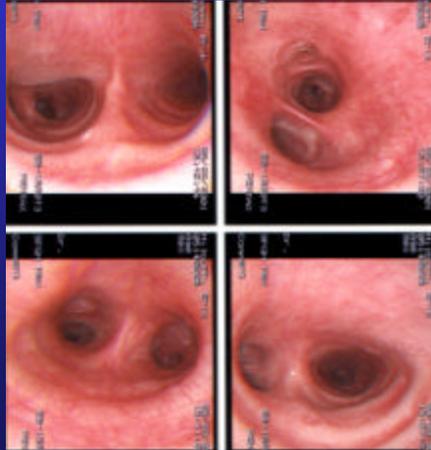
It is important to understand that the effects that attenuate with repeated ozone exposures are typically ones that are readily perceived by an individual or are easily measured. In contrast, the persistent effects are observed in functions that give no outwardly apparent signs of abnormality and are difficult to measure. So, a person can experience significant adverse effects without being aware of them.

## Some Lung Functions Remain Depressed With Daily O<sub>3</sub> Exposures: Persistence



This slide illustrates a persistent effect. It shows measures of large and small airway function obtained before each daily exposure began. Large airways are in the upper part of the lungs, while small airways are the narrow, delicate airways of the deep lung. As you can see from the figure, both large and small airway function was depressed on days 2 through 5 compared to the measurement made immediately before the first ozone exposure, which is represented as 100% in the figure. This indicates a persistent effect, and means that recovery was not complete between the exposures.

## Airway Inflammation Was Still Evident 24 Hours After the Last O<sub>3</sub> Exposure: Persistence



Airway inflammation was still evident 24-hours after the last ozone exposure. These photographs are examples of the appearance of inflamed human airways.

All of the subjects had evidence of airway inflammation, although there were significant differences in the degree of inflammation among the subjects. The subjects with the greatest degree of lung inflammation also had the greatest decrements in large and small airway function following ozone exposure.

# Implications

- ◆ **Attenuation in some lung functions <sup>1</sup> no risk**
- ◆ **The persistent changes observed are risk factors for development of chronic lung disease**
- ◆ **Risk is greatest for people who are active outdoors:**
  - **Children**
  - **Athletes**
  - **Outdoor workers**

The combination of diminished and persistent effects this study reports does not represent adaptation as some would assert, but rather attenuation, and attenuation clearly does not imply lack of risk.

We should be concerned about the persistent lung inflammation, and persistent depression of some aspects of large and small airway function observed with repeated ozone exposures because these are known to be risk factors for development of chronic lung disease. As we noted earlier, this risk is greatest for people who are active outdoors, especially children, athletes and outdoor workers.

If there are questions, we would be happy to respond to them at this time.