Health impact of new generation pollutants: Ozone

Prof SK Chhabra
Vallabhbhai Patel Chest Institute
Delhi - 110007
The Problem of Ozone Air Pollution

• In India, monitoring of ozone in the ambient air is not done on a regular basis as it is done for particulates, sulphur dioxide and oxides of nitrogen

• Our present concerns about the adverse effects of air pollution have been related to the particulates

• However, the limited data available on levels of ozone in the ambient air in Delhi shows that the concentrations often exceed this limit
Where does Ozone come from?

- Ozone is a byproduct of the action of sunlight on oxides of nitrogen and VOC that are emitted in vehicular exhaust.

- With the ever-increasing number of vehicles, ozone air pollution already constitutes a major problem in India as well and is going to increase in the future.
Good Ozone & Bad Ozone

Good Ozone

• The ozone layer 10 - 30 miles above the earth protects life on earth from the sun's harmful ultraviolet rays

Bad Ozone

• Closer to earth, ozone is an air pollutant that can be harmful. It is created and hangs around in the layer of air near the ground
Harmful effects: Acute

Irritates the Respiratory System

• Coughing
• Throat irritation
• Uncomfortable sensation in the chest

These symptoms can last for a few hours after exposure to ozone and may even become painful
Harmful effects: Acute

- Reduces “Lung Function”
  - volume of air that we draw in when we take a full breath and **restrictive**
  - speed at which we are able to blow it out **obstructive**
- Difficulty to breathe deeply and vigorously
  - Uncomfortable breathing - dyspnoea
  - More rapid and shallow breaths than normal during an exercise
Harmful effects: Acute

Aggravates Asthma

• Increased frequency and severity of symptoms
• Increased use of medication
• Worsening of lung function
• Increases sensitivity to allergens
Harmful effects: Acute

- **Proximal**: Inflames and damages the epithelial lining of the Lung

- **Distal**: Damages the cells that line the air spaces in the lung
Harmful effects

Healthy Airways

Airways exposed to Ozone
Harmful effects: Chronic

• Long-term effects are less well-established

• Airway injury, inflammation, and repair continue to occur during repeated short-term exposure and may permanently injure the lung

• Repeated ozone impacts on the developing lungs of children may lead to reduced lung function as adults

• Induction of new asthma: some evidence of increased allergies
Effect of Ozone exposure on development of asthma in experimental model

Chhabra et al Indian J Med Res. 2010 (Jul);132:87-93.
Objectives

• To study the effects of exposure to ambient concentrations of ozone on induction of asthma in guinea pigs
• To study the oxidant-antioxidant balance in allergen-induced asthma and the effect of exposure to ozone on it
• To evaluate the protective effect of dietary supplementation with antioxidant vitamins - alpha-tocopherol and ascorbic acid on the Ozone-Allergen interaction
Material and Methods

- Study approved by Institutional Animal Ethics Committee
- Male guinea pigs (250-350g)
- Baseline bronchial reactivity to histamine measured
- Animals were sensitized with ovalbumin and divided into three groups, and one control was taken:
  - **Group A (Nonsensitized).** Control group without any intervention
  - **Group B (Sensitized).** Animals sensitized to ovalbumin
  - **Group C (Sensitized + Ozone).** Animals sensitized to ovalbumin and also received daily inhalation of ozone, 0.12 ppm for 2 hours
  - **Group D (Sensitized + Ozone + Diet).** Animals with intervention as in Group C. Also received a diet supplemented with vitamin C (2mg/Kg body wt) and E (7 IU/Kg Body wt)
- The study parameters were evaluated at 4 weeks
Effect of Ozone on Physiological Response to Allergen

In sensitized animals exposed to ozone, there was:

• a greater increase in bronchial reactivity
• enhanced effect of allergen inhalation producing a greater early bronchospasm
• A more sustained late bronchospastic response

• These observations suggest that sensitized animals had a more intense response to allergen challenge after ozone inhalation
Effect of Ozone on Biochemical Response to Allergen

In sensitized animals exposed to ozone, there was:

• Greatest disturbance in oxidant-antioxidant balance
  - Increased lipid peroxidation
  - Increased generation of superoxide radicals by BAL cells
  - Decreased Superoxide dismutase
  - More intense inflammatory response to allergen challenge
Effect of addition of vitamins E and C on ozone-exposed animals

- Prevented post-sensitization increase in bronchial reactivity
- Reduced early bronchospastic response after ovalbumin challenge
- Reduced late bronchospastic response after ovalbumin challenge
- These results show that Vitamin E and C largely countered the physiological effects of ozone
Effect of addition of vitamins E and C on ozone-exposed animals

- Less disturbance in oxidant-antioxidant balance
  - Lesser lipid peroxidation than non-diet supplemented animals
  - Lipid peroxidation similar to sensitized animals
  - Lack of decrease in Superoxide dismutase as compared to non-diet supplemented animals
  - Less intense inflammatory response to allergen challenge
- These results show that Vitamin E and C largely countered the biochemical effects of ozone
Conclusions of Ozone Study

• Current levels of ambient ozone are likely to aggravate the response of allergic bronchial asthma patients to allergen inhalation

• Likely mechanism is a potentiation of oxidative stress

• Dietary supplementation with vitamin E and C may have a protective role against the allergen-ozone interaction
What are the harmful levels?

• The lowest concentration at which effects are observed depends upon
  ➢ the level of activity
  ➢ the duration of exposure
  ➢ the sensitivity of each individual to ozone

➢ Thus, effects can occur at 40, 80 or 120 ppb
➢ National Ambient Air Quality Standards 2009:
  8 hrs, 100 ug/m³ (50 ppb)
  1 hr, 180 ug/m³ (90 ppb)
Adverse health effects of air pollution: Beyond The Lungs

• Cardiovascular system
• Systemic inflammation

• Pro-inflammatory
• Prothrombotic
• Pro-atherosclerosis
• Arrhythmogenic