Air Pollution and Health

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Approaches to study health effects

- Toxicologic
- Controlled human exposure studies
- Epidemiological studies

Toxicological studies

Live Animal studies

- Quick
- Dose response relations can be studied
- Single pollutant can be studied
- Observed effects may not always be relevant to humans
- Only short-term effects can be studied

In Vitro studies

- Mechanisms of toxicity can be studied
- Effects of drugs can be studied
- Expensive
- Only short-term effects can be studied

Controlled human exposure studies

Advantages

- Single pollutant affects can be studied
- Dose-response relationships can be studied

Disadvantages

- Only short-term effects can be studied
- Chronic or Irreversible effects cannot be studied
- Ethical constraints

Epidemiological studies

Advantages

- Studies performed in natural environments
- Acute/chronic effects can be studied
- Risk factors can be identified

Disadvantages

- Single pollutant effects cannot be studied
- Confounding factors not easy to control
- Time-consuming
- Causation not established
- Methodology and analysis require careful considerations

Adverse Effects of Air Pollution

- Excessive cardiorespiratory mortality
- Increased health-care utilization
  - Hospitalizations
  - Emergency room visits
- Asthma exacerbations
  - Increased physician visits
  - Decreased peak flow readings

Adverse Effects of Air Pollution

- Increased respiratory illness
  - Increased physician visits
  - Greater respiratory symptoms
- Impaired lung function
  - Poorer spirometry
  - Lower peak flow readings
- Increased airway reactivity

Adverse Effects of Air Pollution

- Increased lung inflammation
- Cardiovascular effects
  - Promotion of thrombosis in vessels
  - Promotion of atherosclerosis (cause of angina, heart attack)
  - Heart rhythm irregularities: potentially fatal
- Altered host defenses
  - Altered immune response (reduced defense against infection)
  - Altered mucociliary function of lungs

Hospitalization rates and air pollution: AIIMS Study Pande et al

Disease	Observed	Expected	Extra	%Increase
Asthma	7.23±7.82	5.96±4.55	1.27±4.93	21.3
COPD	4.37±4.97	3.50±2.48	0.87±3.34	24.9
Ac Coronary	10.09±7.09	8.11±3.07	1.97±5.70	24.3
Total	21.65±17.7	17.44±9.54	4.20±11.4	24.1

Ambient air pollution and chronic respiratory morbidity in Delhi

Chhabra et al Arch Environ Health 2001; 56:58-64

- Residential areas within 1 Km of permanent monitoring stations were sampled
- Three colonies around each station (lower, middle and higher income groups)
- Inclusion criteria: Age > 18 yrs and residence in area for > 10 years
- n = 4141

Methodology

- Standardized Respiratory Symptoms Questionnaire
- History and examination by chest physicians
- Lung function tests (Spirometry/Peak flow recordings)

Outcome measures

- Chronic respiratory symptoms
- Lung function in asymptomatic nonsmokers

Definitions

- Chronic cough: Cough on most days for 3 consecutive months or more for at least last 2 years
- Chronic phlegm: Sputum on most days for 3 consecutive months or more for at least last 2 years
- Dyspnoea: Breathlessness on walking, requiring the subject to stop or slow down for breath
- Wheezing: Whistling sound in breathing associated with breathlessness

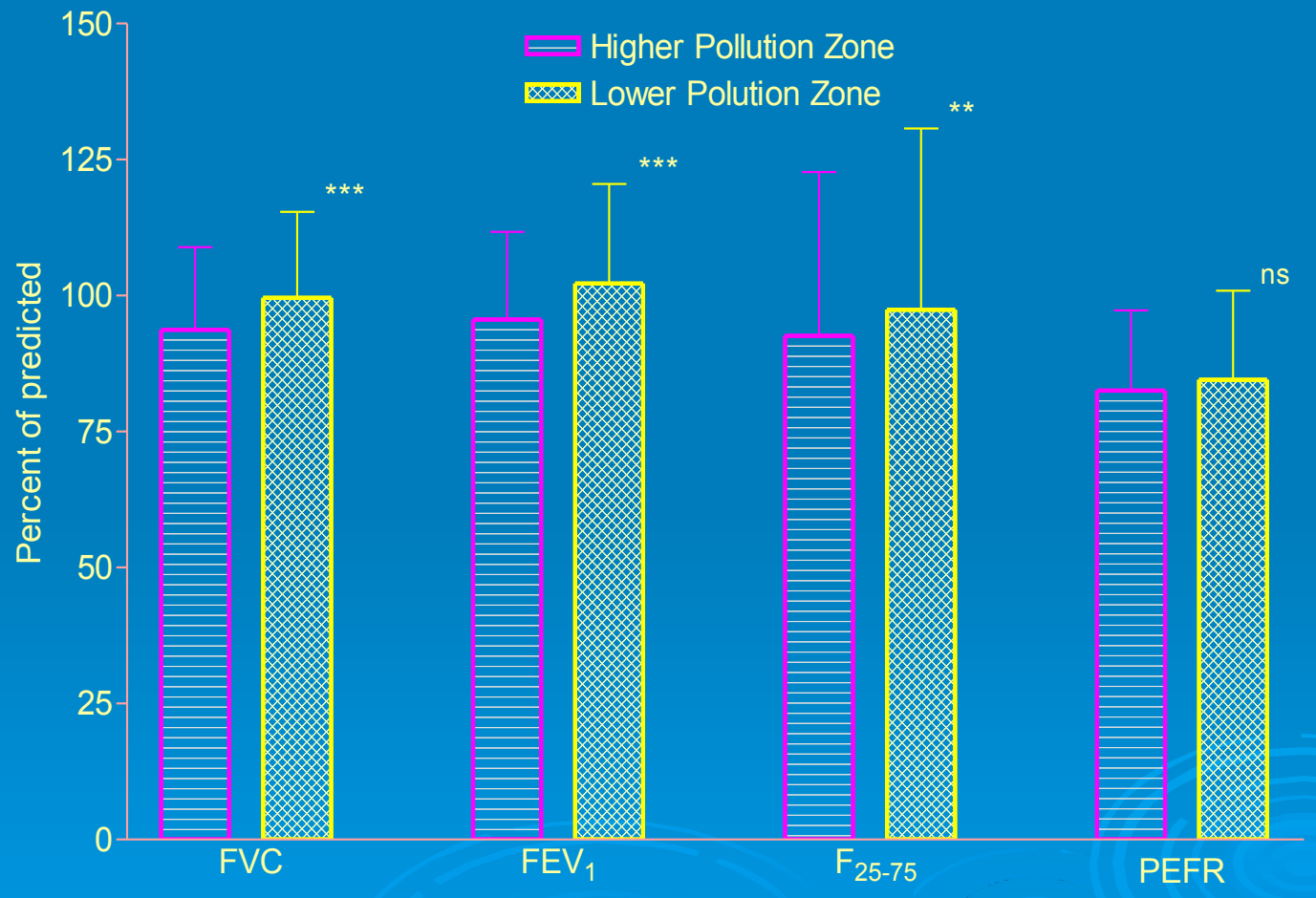
Definitions

- Asthma: Recurrent episodes of breathlessness associated with wheezing, with or without cough and phlegm
- Chronic bronchitis: Cough and phlegm on most days for 3 consecutive months or more for at least last 2 years
- Chronic Obstructive Pulmonary Disease (COPD): Symptoms of chronic bronchitis associated with breathlessness on exertion

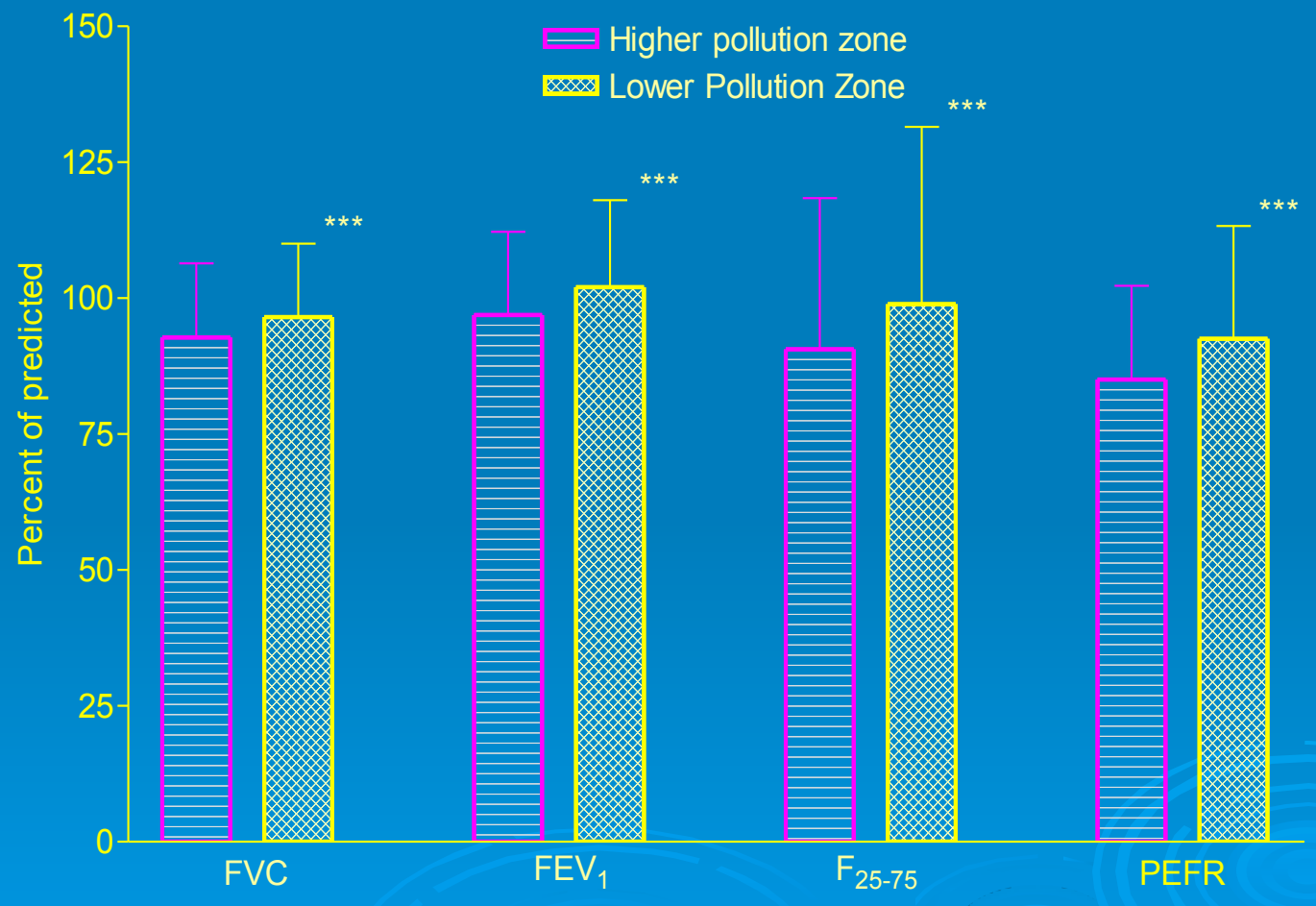
Results

- Nearly 25% of residents of Delhi have chronic respiratory symptoms
- Females residing in higher pollution areas had higher prevalence of chronic cough and chronic phlegm
- Smoking was the major determinant of respiratory morbidity
- Lower socioeconomic status, older age and male sex were other significant risk factors
- Area of residence (Lower or higher pollution zone) was not a significant risk factor in MLR
- Lung function was superior among both males and females in residents of lower pollution areas

Spirometry (Female subjects)



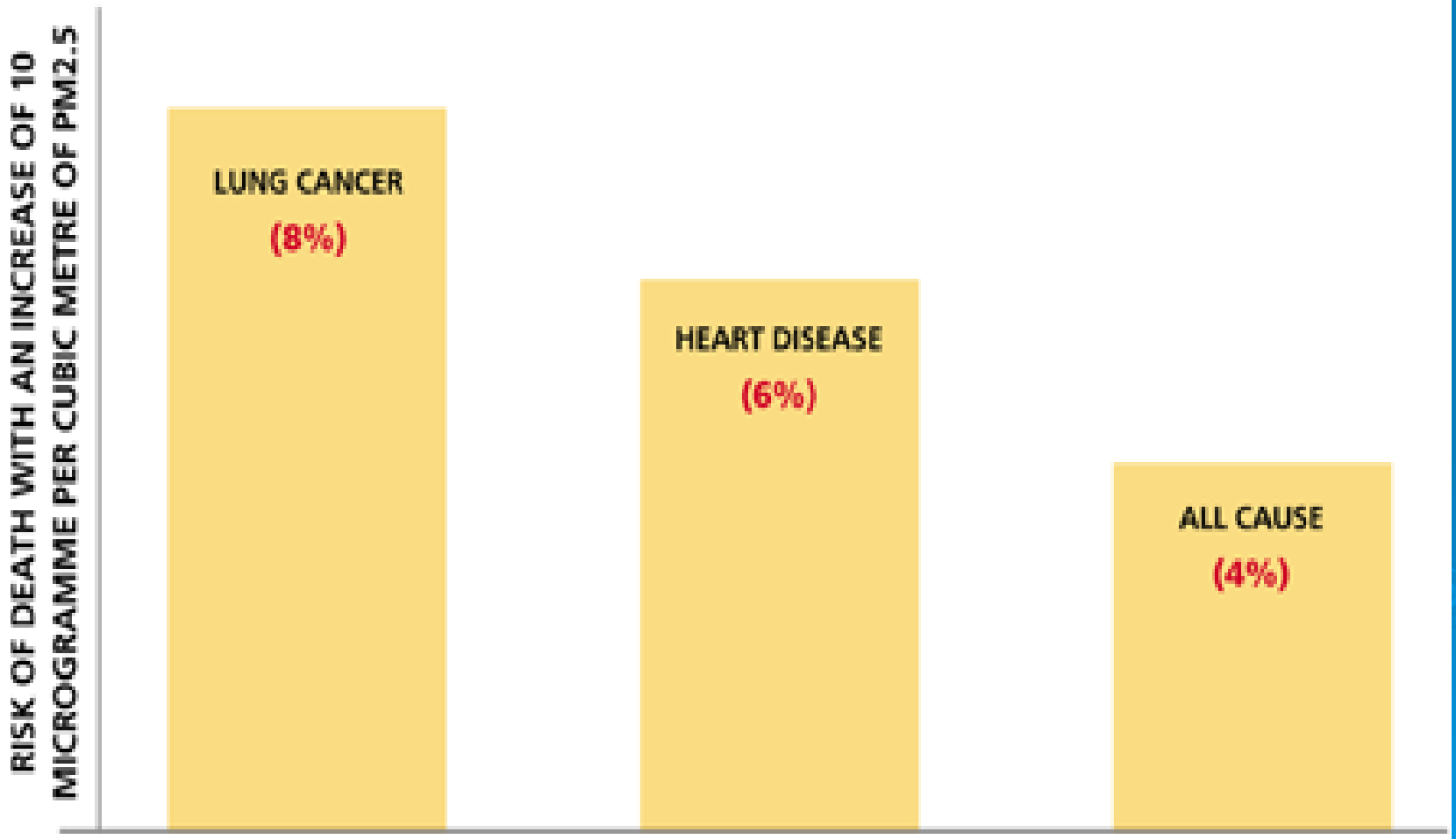
Spirometry (Male subjects)



Increased cardiovascular mortality and morbidity

- London smog episode of December 1952: 4000 excess deaths in 1 week
- *A key finding was that sudden deaths were increased*
- Philadelphia: Comparison of high and low pollution days showed increase in sudden deaths Schwartz Environ Res 1994;64:26–35
- Significant increase in risk of ventricular arrhythmias
- Increased hospital admissions for heart failure
- Increased risk of acute myocardial infarction

Risks of death with increase of $PM_{2.5}$



Source: C A Pope el at 2002, JAMA, Vol 287, No 9

AIR POLLUTION AND MORTALITY

Global Evidence

Place	PM_{10} ↑	Mortality ↑
USA (6 cities)	10μg/m^3	1%
Inchon, Korea	10μg/m^3	1.2%
Bangkok, Thailand	10μg/m^3	3-6%
Lyon, France	50μg/m^3	4%
Barcelona, Spain	100μg/m^3	10%
Paris, France	100μg/m^3	17%

Time-series study on air pollution and mortality in Delhi

Res Rep Health Eff Inst. 2011 Mar;(157):47-74

- to identify changes in the daily all-natural-cause mortality rate that could be attributed to changes in air quality
- 3-year study period included the years 2002 through 2004
- Increased concentrations of PM_{10} and of NO_2 were associated with increased all-natural-cause mortality
- 10- $\mu g/m^3$ change in PM_{10} was associated with 0.15% increase in total all-natural-cause mortality
- Daily all-natural-cause mortality increased 0.84% for every 10- $\mu g/m^3$ increase in NO_2

Health impact of new generation pollutants:
Ozone

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 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

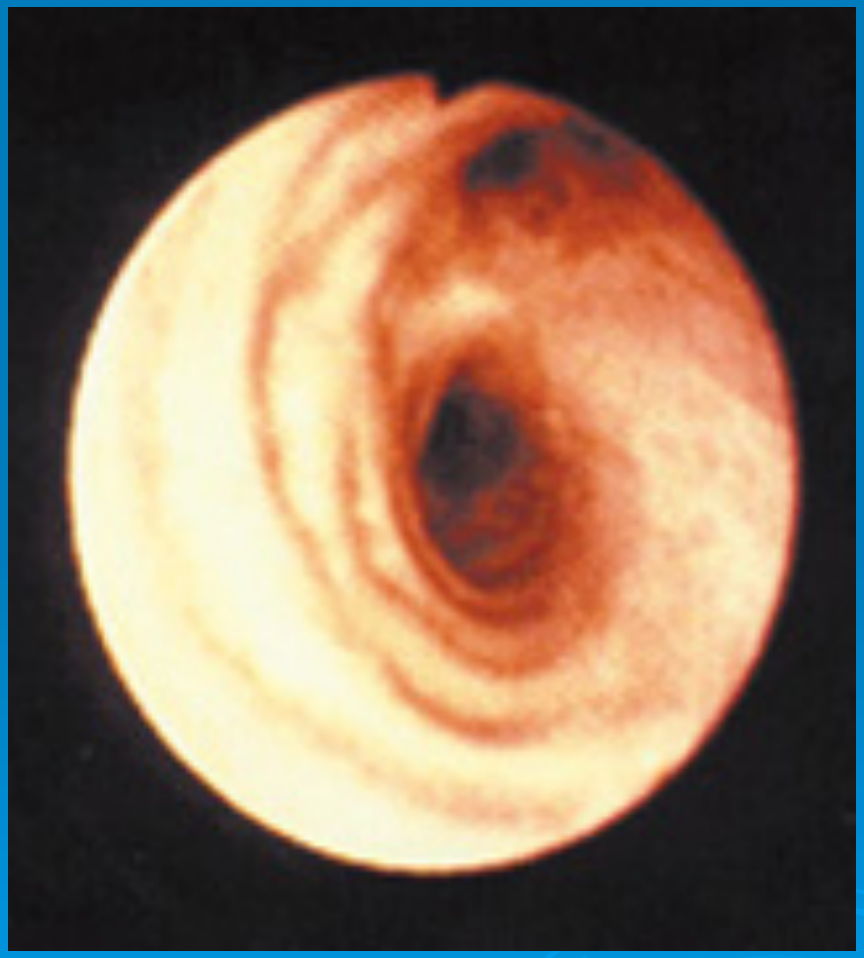
Aggravates Asthma

- 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 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/m^3 (50 ppb)
  1 hr, 180 ug/m^3 (90 ppb)

CENTRAL POLLUTION CONTROL BOARD

CONTINUOUS AMBIENT AIR QUALITY

Date : Monday, November 07, 2011
Time : 2:40:57 PM

Air Quality Monitoring Station: Delhi College of Engineering
Type of Area: Residential
Current Air Pollution Levels

Parameters	Date	Time	Concentration	Concentration (previous 24 Hours)/ Prescribed Standard	Remarks
Sulfur Dioxide	27/10/2011	11:45:00	NA	-36.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Nitric Oxide	27/10/2011	11:45:00	2.0 µg/m3	5.0 µg/m3	
Nitrogen Dioxide	27/10/2011	11:45:00	NA	-6.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Oxides of Nitrogen	27/10/2011	11:45:00	NA	0.0 ppb	
Carbon Monoxide	27/10/2011	11:45:00	664.0 µg/m3	643.0 µg/m3 * Prescribed Standard : 4,000.0 µg/m3	
Ozone	27/10/2011	11:45:00	472.0 µg/m3	286.0 µg/m3	

* Prescribed Standard for CO is one hourly Average

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CENTRAL POLLUTION CONTROL BOARD

CONTINUOUS AMBIENT AIR QUALITY

Date : Monday, November 07, 2011
Time : 2:39:23 PM

Air Quality Monitoring Station: ITO
Type of Area: Kerbside
Current Air Pollution Levels

Parameters	Date	Time	Concentration	Concentration (previous 24 Hours)/ Prescribed Standard	Remarks
Sulfur Dioxide	27/10/2011	11:45:00	8.0 µg/m3	6.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Nitric Oxide	27/10/2011	11:45:00	9.0 µg/m3	4.0 µg/m3	
Nitrogen Dioxide	27/10/2011	11:45:00	63.0 µg/m3	78.0 µg/m3 Prescribed Standard : 80.0 µg/m3	
Oxides of Nitrogen	27/10/2011	11:45:00	41.0 ppb	45.0 ppb	
Carbon Monoxide	27/10/2011	11:45:00	943.0 µg/m3	767.0 µg/m3 * Prescribed Standard : 4,000.0 µg/m3	
Ozone	27/10/2011	11:45:00	200.0 µg/m3	105.0 µg/m3	

* Prescribed Standard for CO is one hourly Average

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Adverse health effects of air pollution: Beyond The Lungs

- Cardiovascular system
- Systemic inflammation

- Pro-inflammatory
- Prothrombotic
- Pro-atherosclerosis
- Arrythmogenic

Thank You

Questions?