# Air Pollution and its Effects on Health – Case Studies, India

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# Air pollution in Indian cities

## Critical [$PM_{10}$ > 90 µg/$m^3$]

Guwahati, Patna, Raipur, Delhi, Faridabad, Dhanbad, Nagpur, Bhopal, Indore, Jalandhar, Ludhiana, Jaipur, Howrah, Kolkata

## High [$PM_{10}$ 61 - 90 µg/$m^3$]

Hyderabad, Chandigarh, Ahmedabad, Panjim, Shimla, Bangalore, Mumbai, Pune, Bhubanshwar

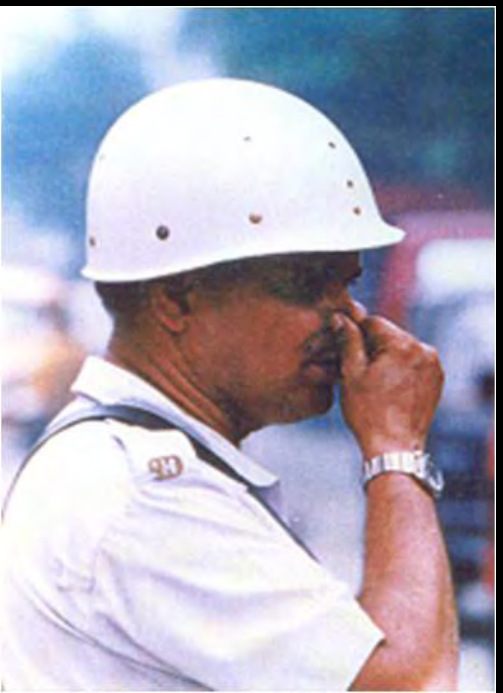
## Moderate [$PM_{10}$ 31 - 60 µg/$m^3$]

Kochi, Shillong, Chennai

## Low [$PM_{10}$ up to 30 µg/$m^3$]

Aizwal

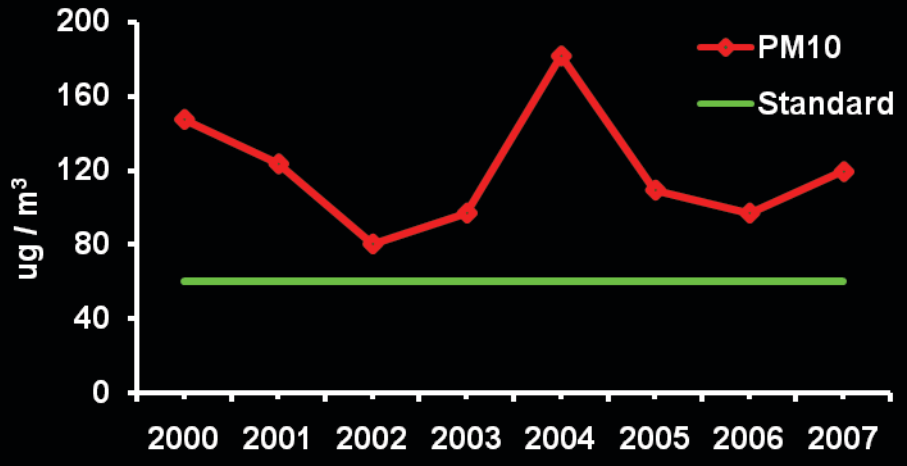
CPCB, 2009

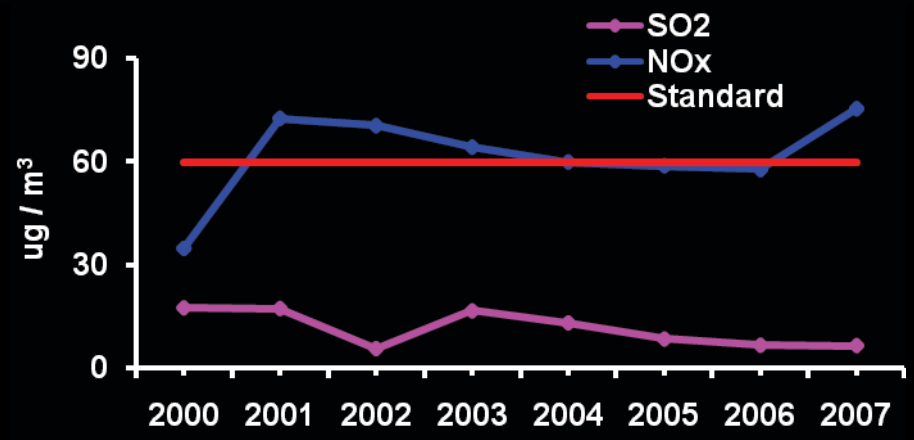


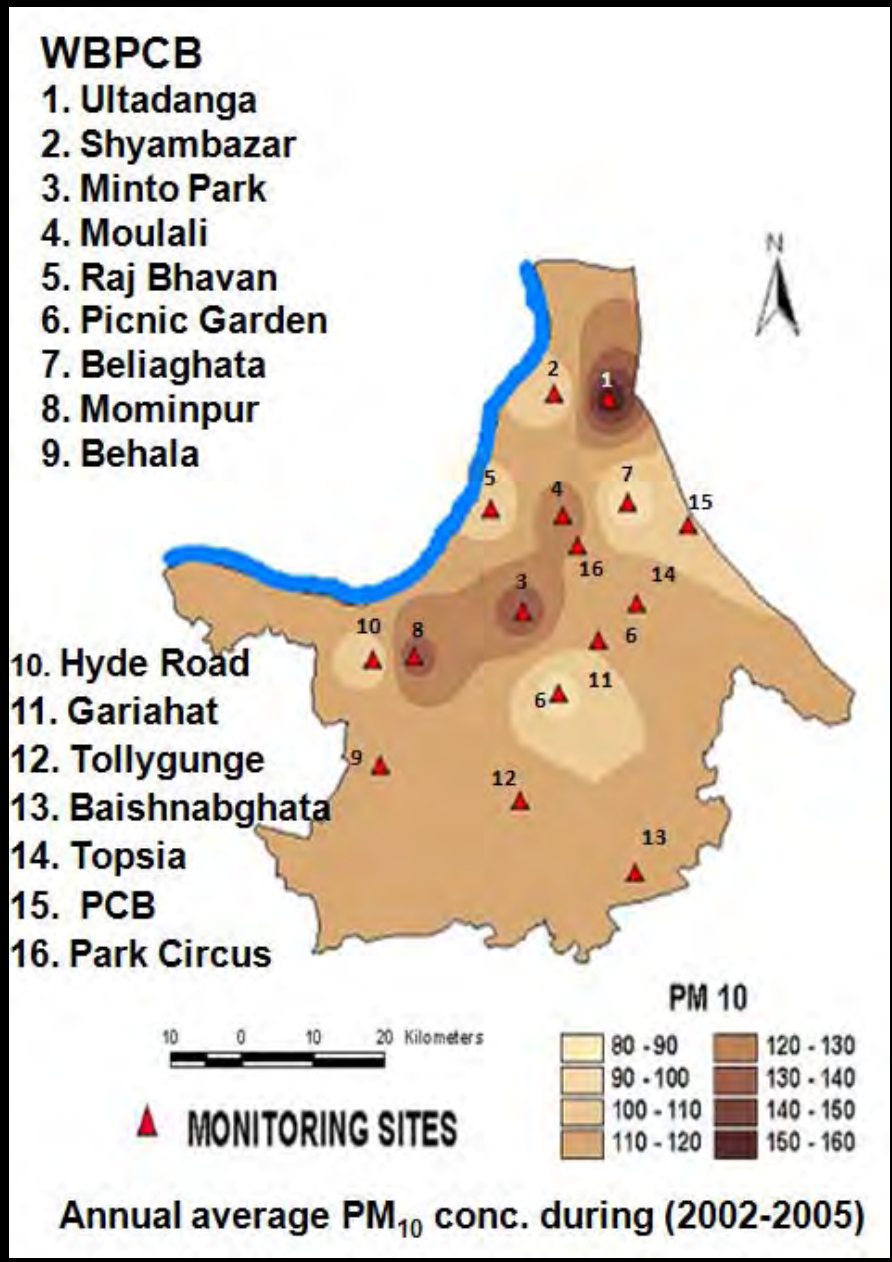
# Air Pollution in Kolkata

**Particulate pollutant levels in past 10 years were far above NAAQS**

**Vehicular emission** contributes to **70%** of pollution load



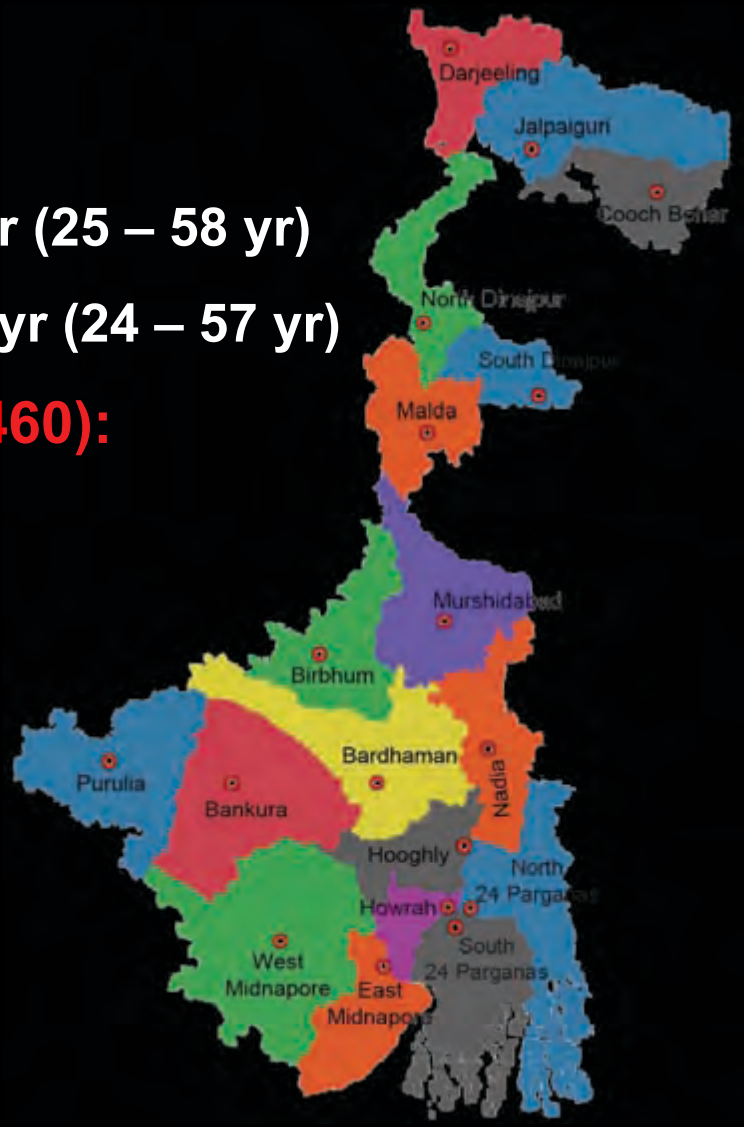
# Objectives

- To prepare a database on the impact of chronic exposure to urban air pollution on the respiratory and systemic health of the residence of Kolkata (former Calcutta)
- To investigate the underlying mechanism of air pollution-related health impairments at the cellular and subcellular levels for better understanding and management of the problem

# Study protocol

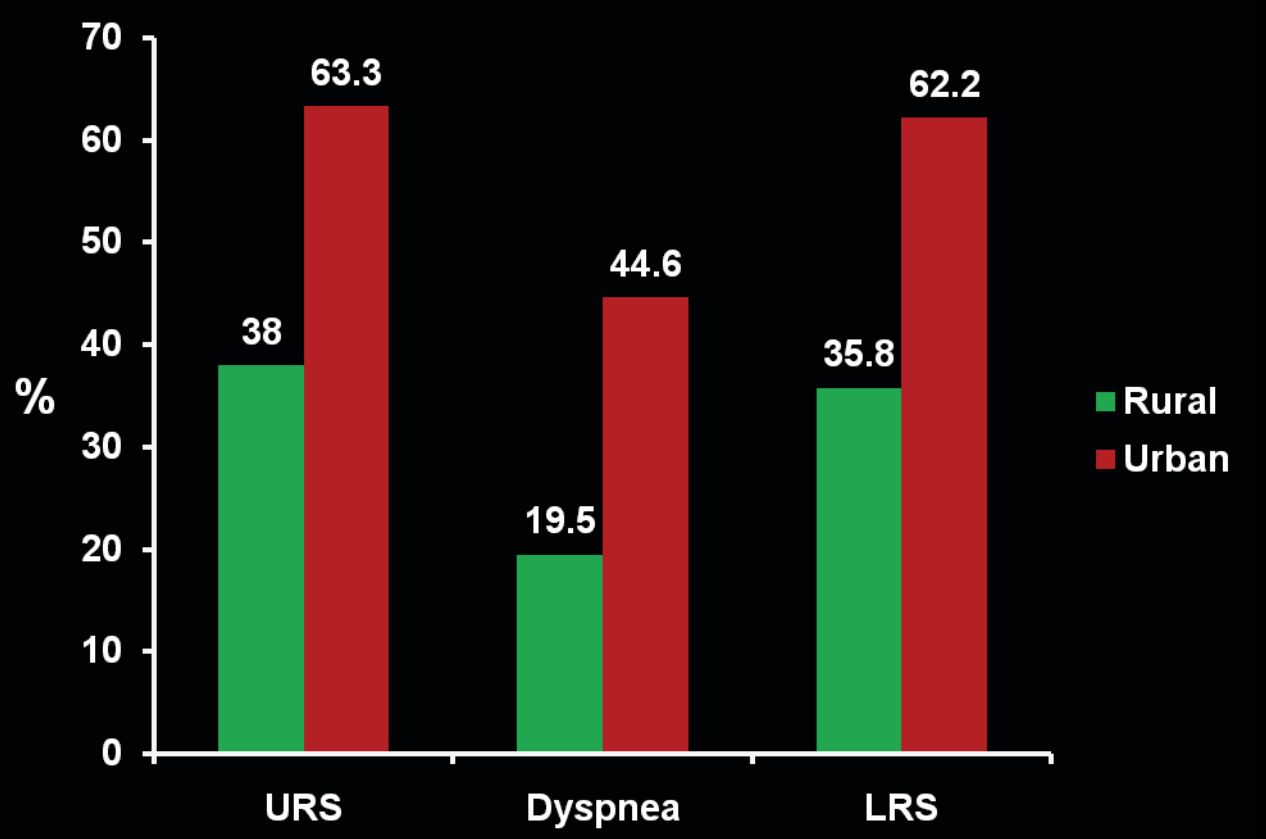
- **Type of study : Cross sectional with matched controls**
- **Area: Kolkata & Rural West Bengal**
- **Participant :**
  - 932 urban male, median age : 44 yr (25 – 58 yr)
  - 812 rural control, median age : 43 yr (24 – 57 yr)
- **Urban, occupationally exposed (n = 460):**
  - Traffic policemen - 56
  - Road-side hawker - 188
  - Auto-rickshaw driver – 82
  - Bus driver – 78
  - Motor mechanic – 56

**Urban, with office job (n = 472)**



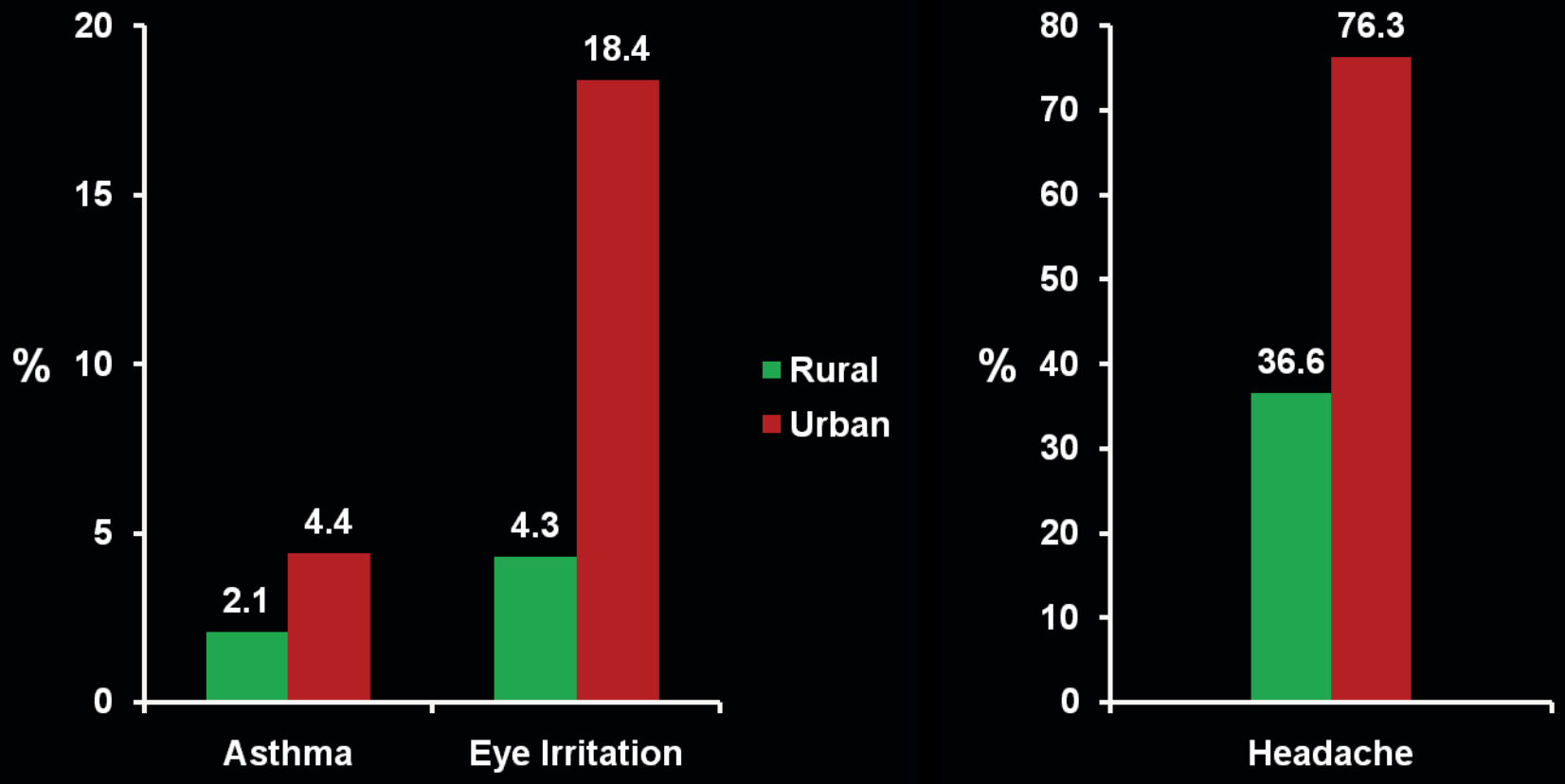
# Air pollution

## Increases prevalence of upper respiratory symptoms

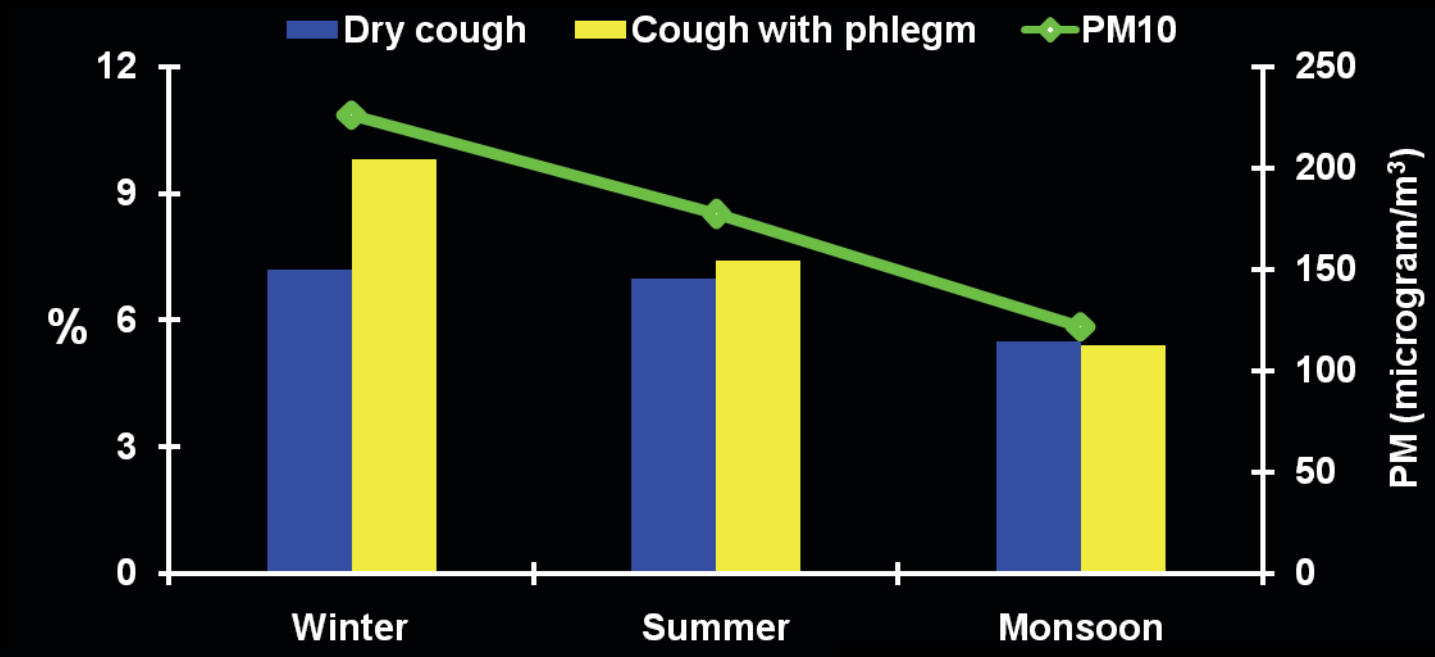


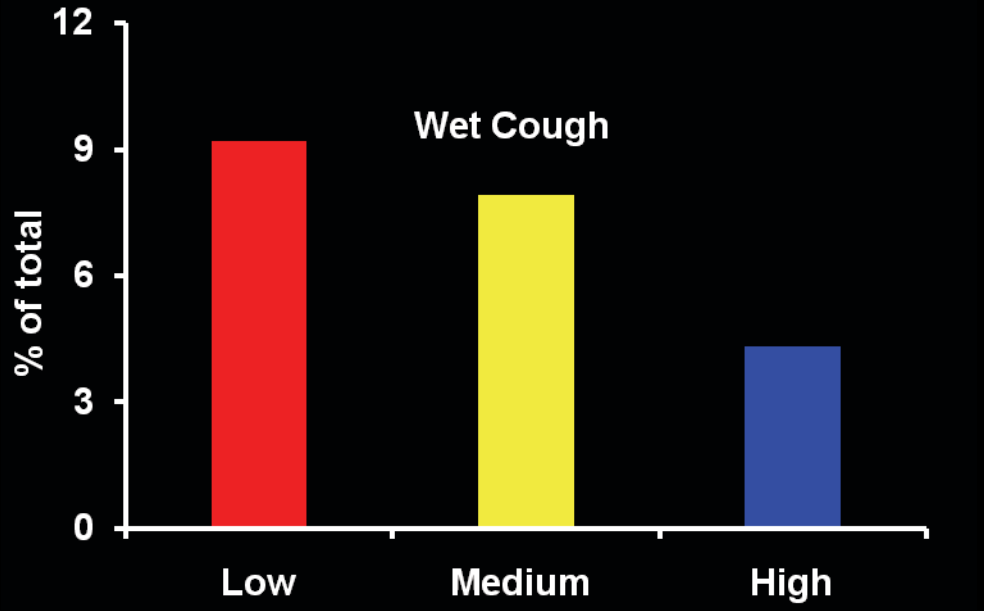
# Air pollution

## Increases prevalence of upper respiratory symptoms …



# Seasonal impact on LRS




## Inverse correlation with SES

| SES | Dry cough | Wet cough |
|---|---|---|
| High | 1 | 1 |
| Medium | 2.31* | 1.72* |
| Low | 3.34* | 2.20* |

# Epidemiological study on health hazards of air pollution is in progress

Questionnaire survey for
respiratory symptoms and neurobehavioral problems

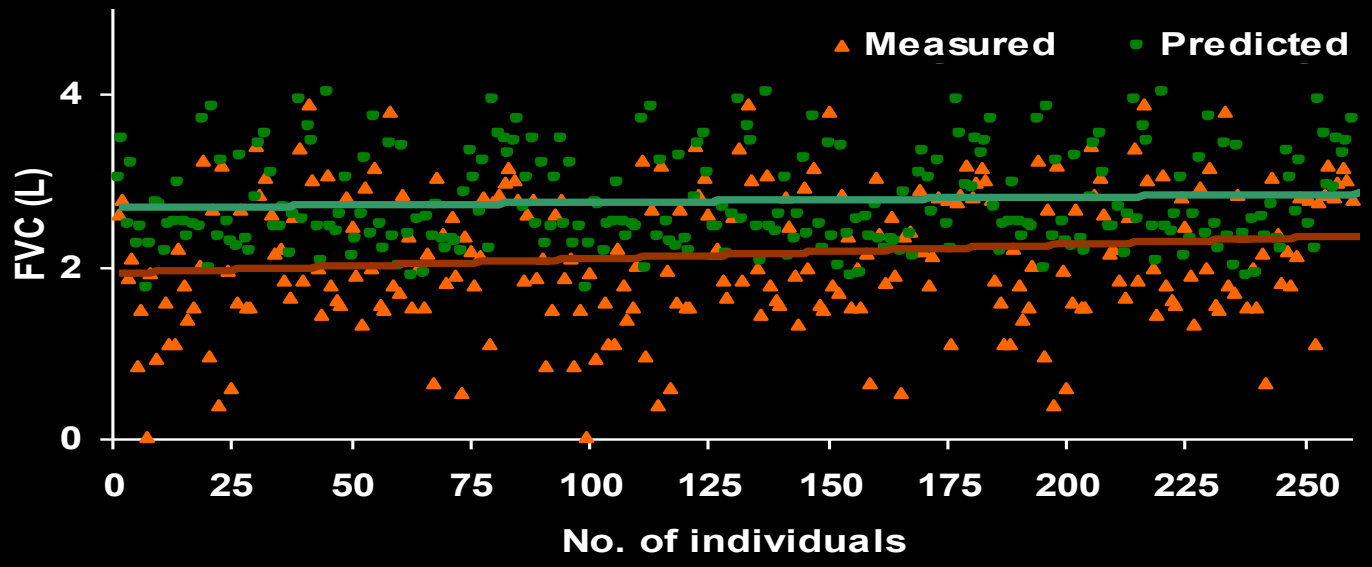
# Pulmonary function test by spirometry

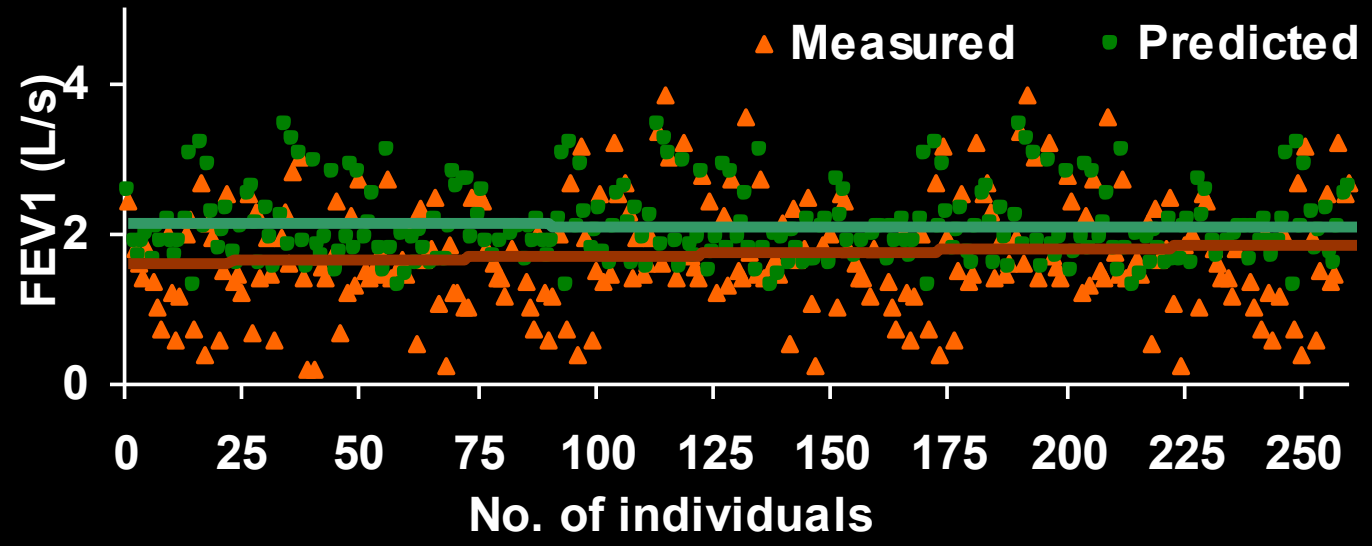


Parameters measured

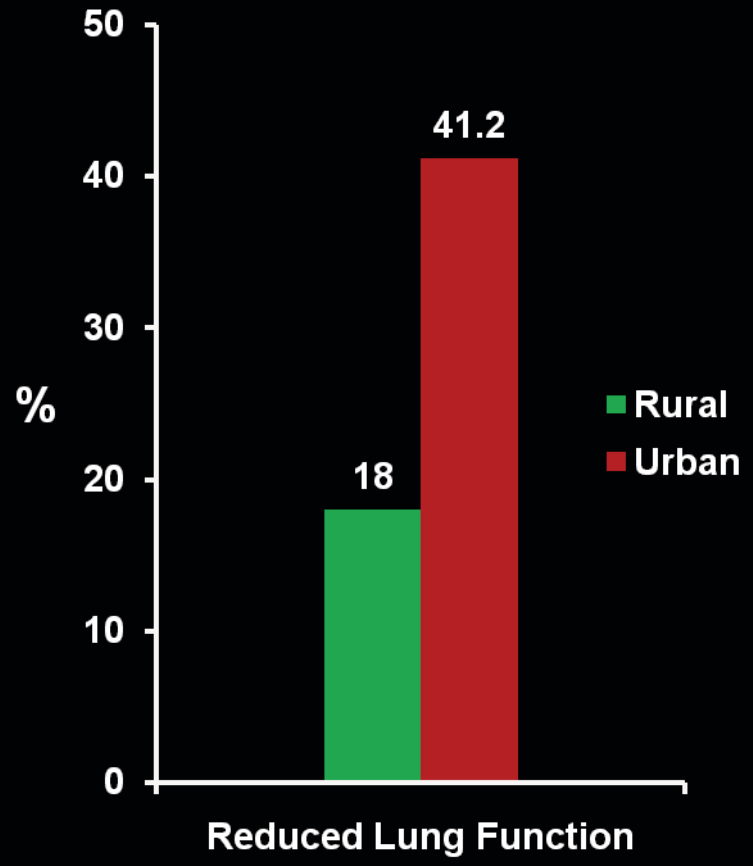
**FVC, $FEV_1$, $FEV_1$ / FVC, PEFR, $FEF_{25-75\%}$**

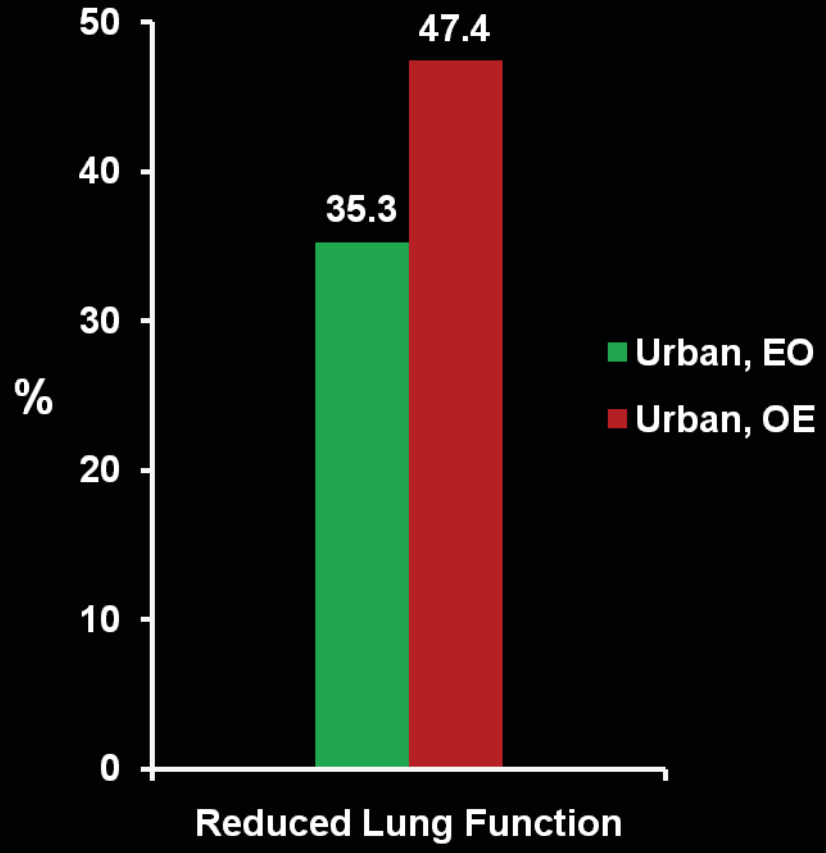
# Lung function of urban group



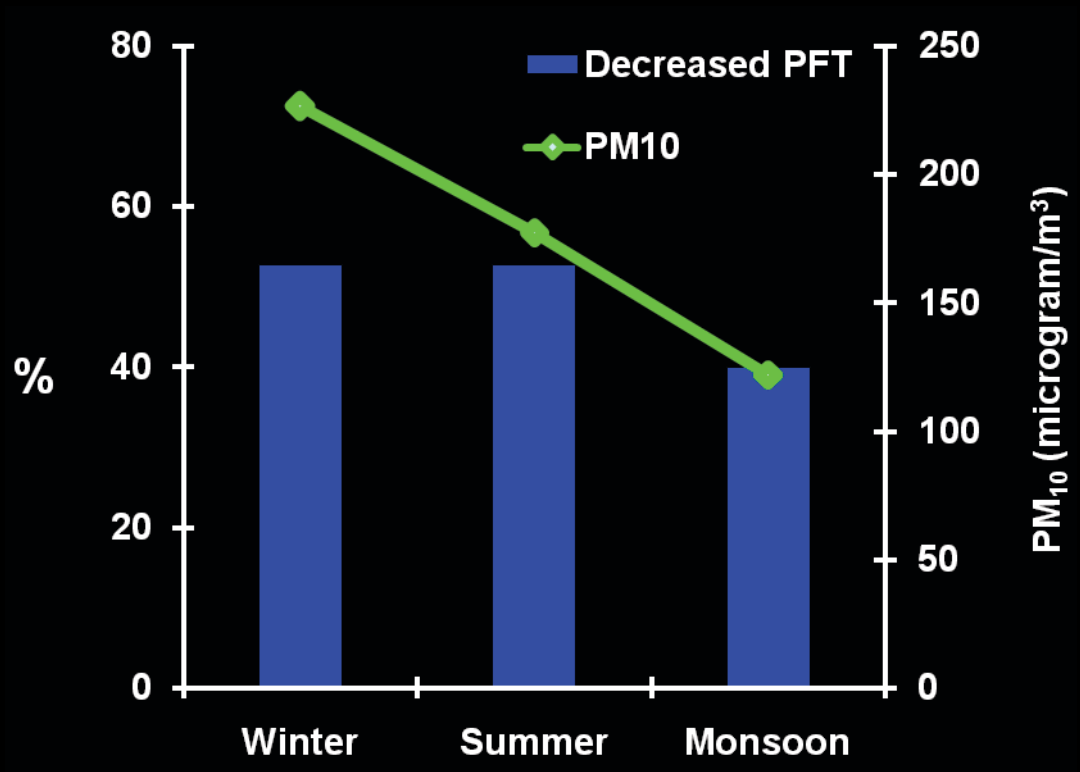



# Air pollution adversely affects lung function

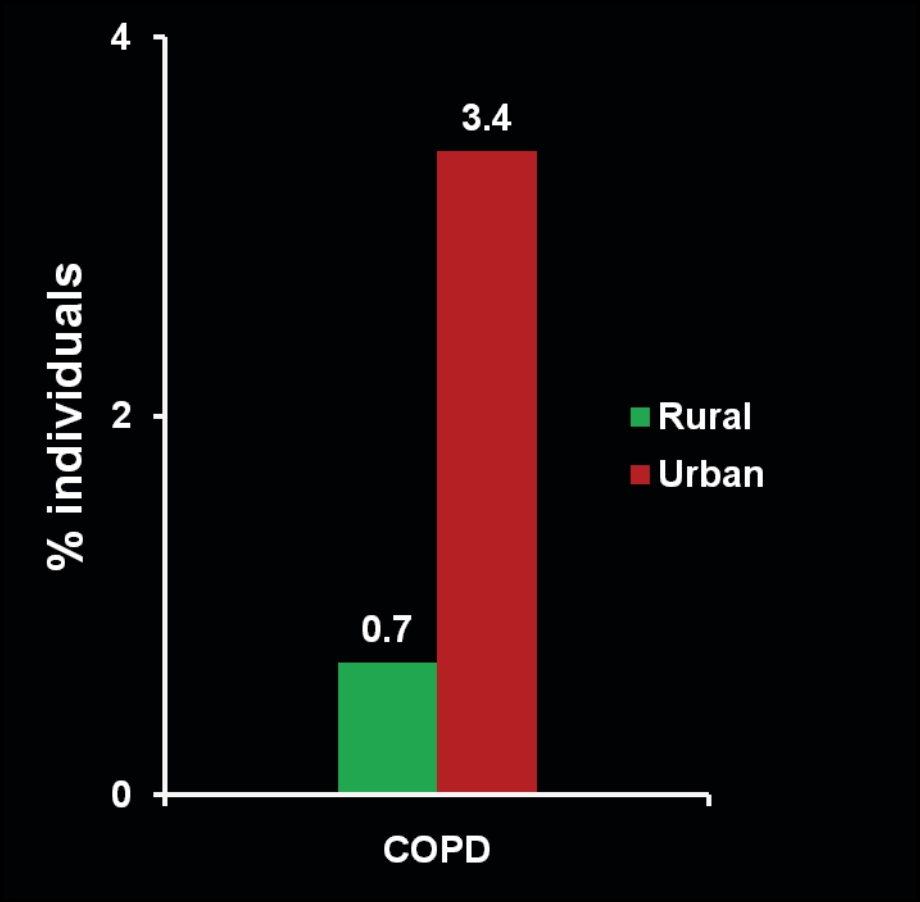


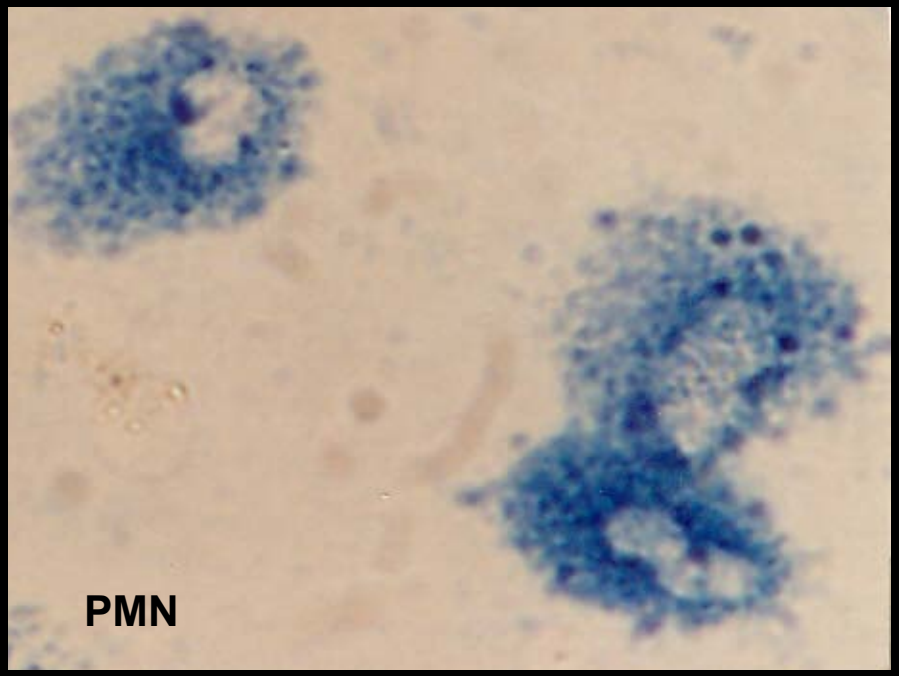



# Reduced lung function

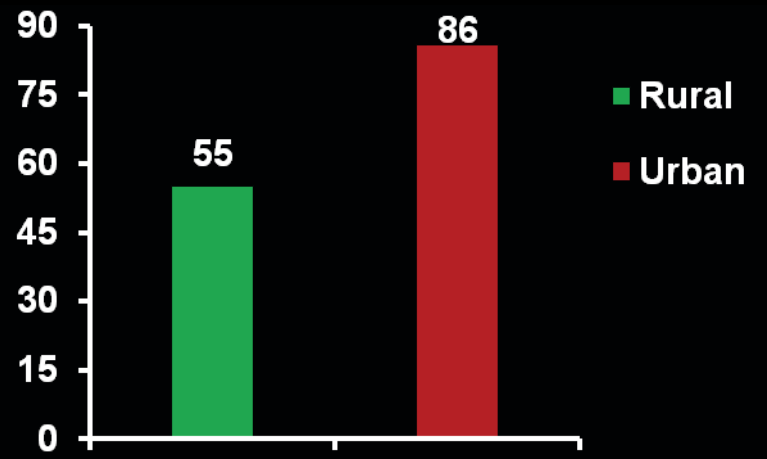


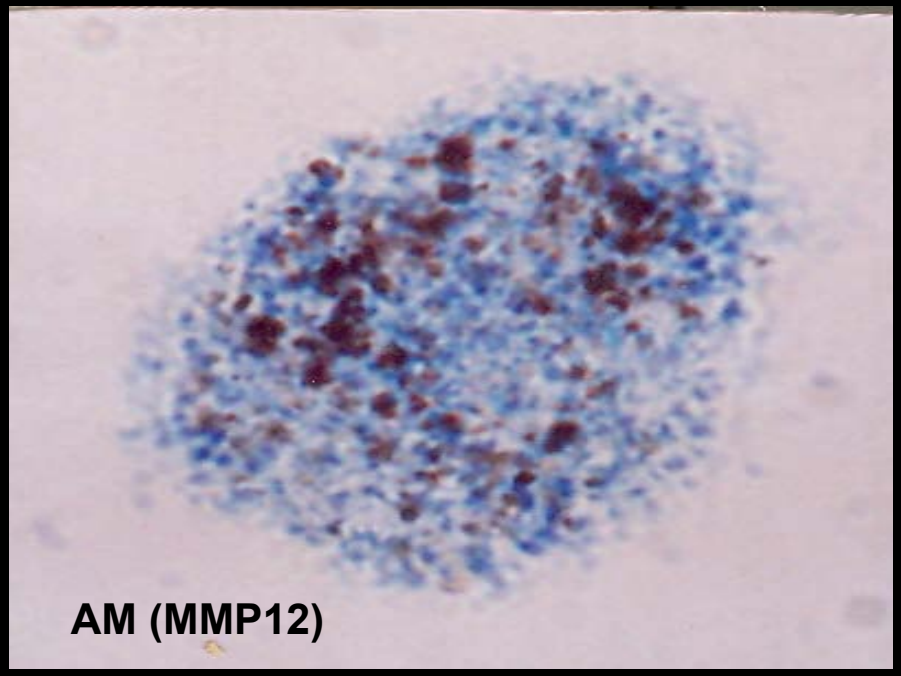
# Air pollution and COPD

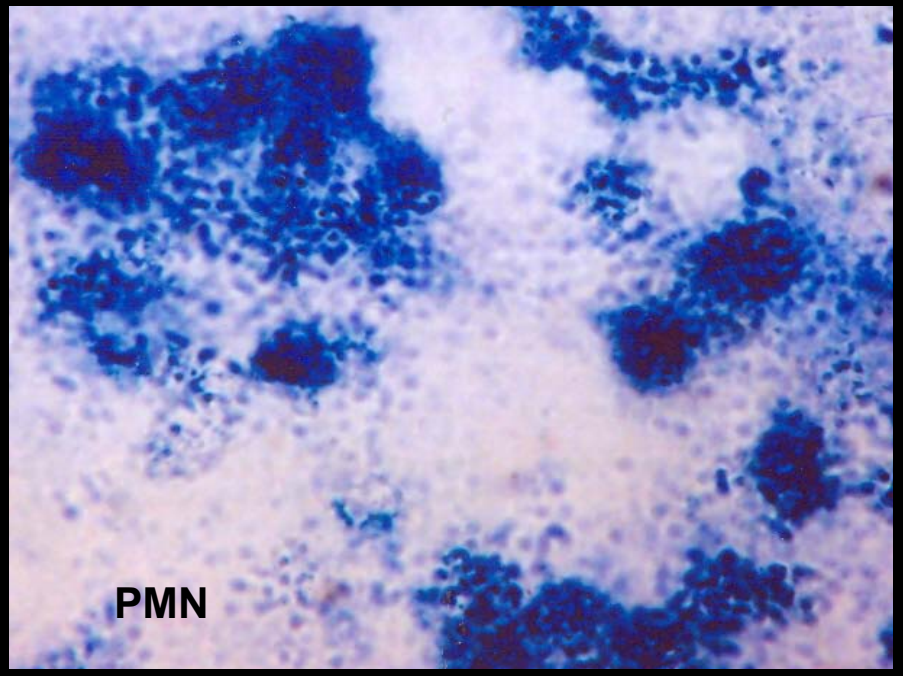





# Elastase

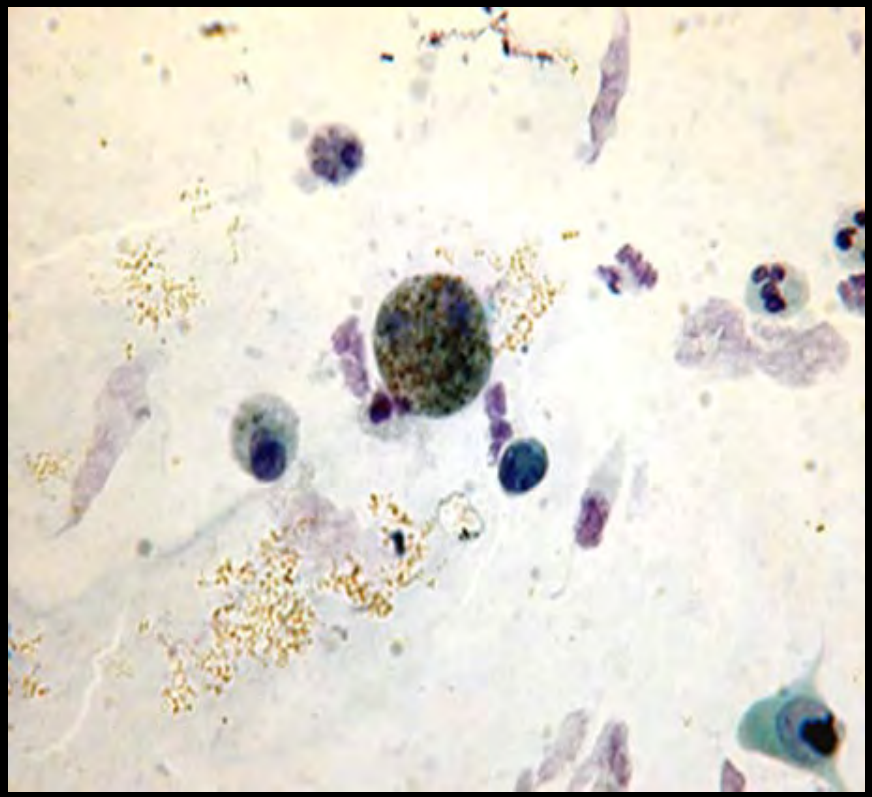


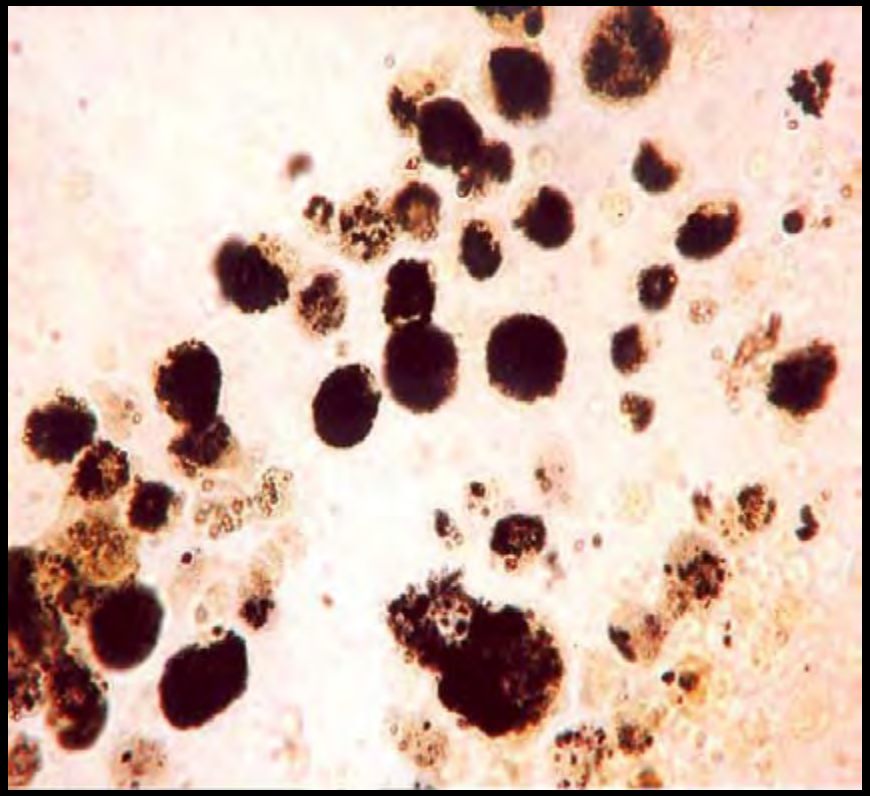



# Fate of airborne pollutants after inhalation

# Alveolar macrophages engulf inhaled PM

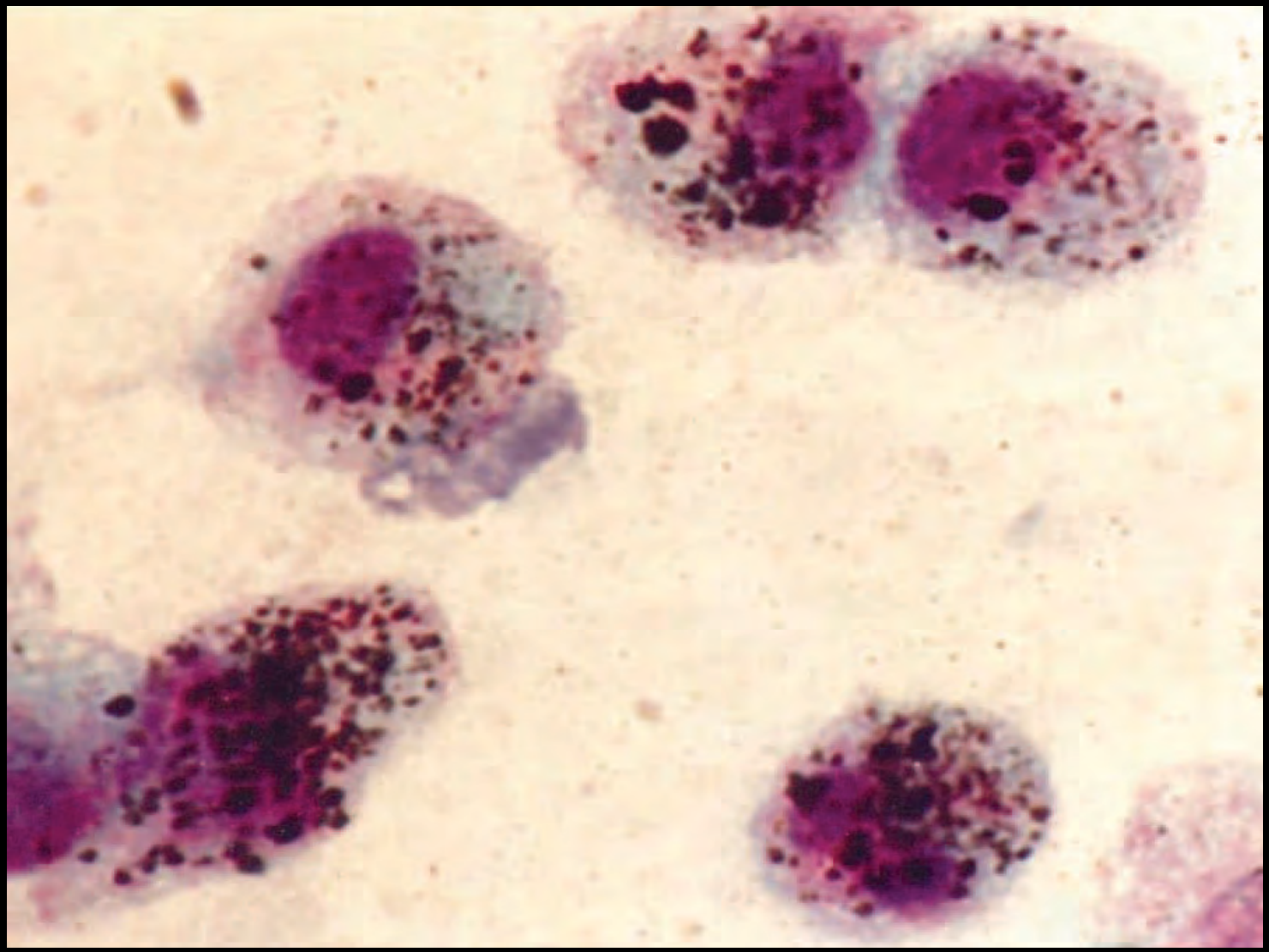


Rural

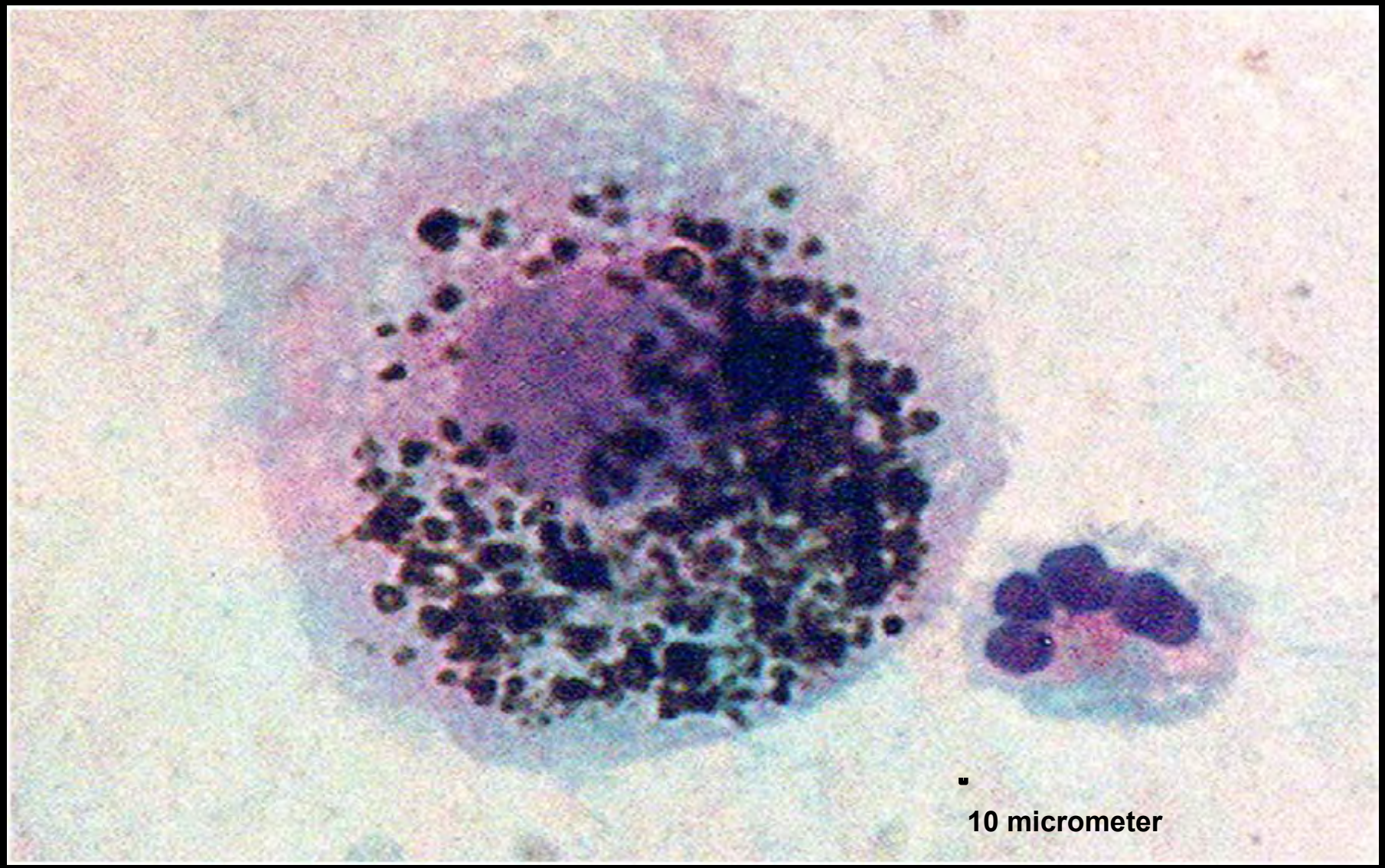


Urban

# Alveolar Macrophage with engulfed carbonaceous PM

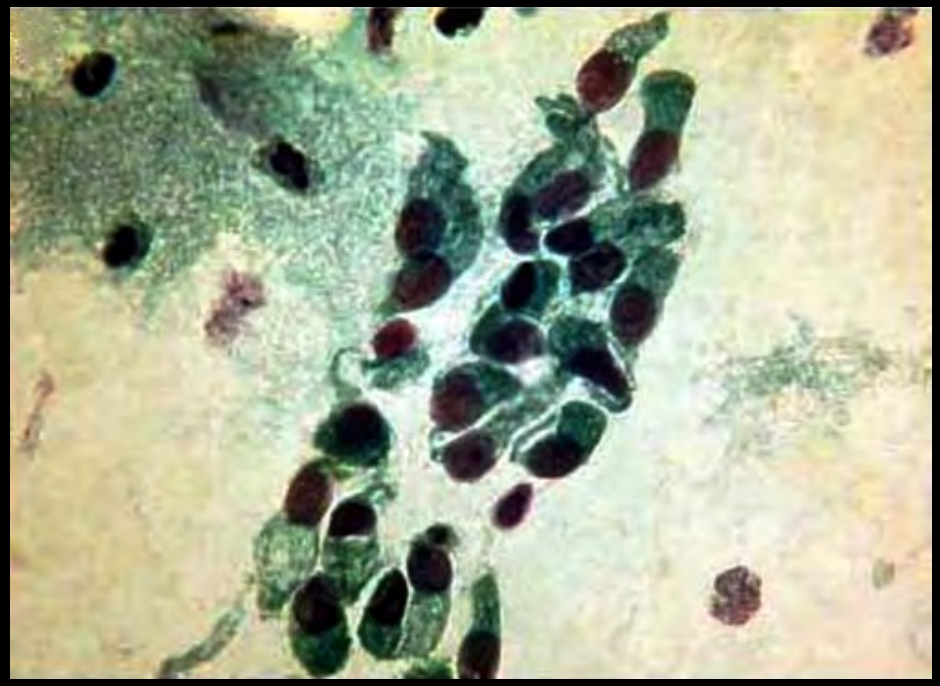


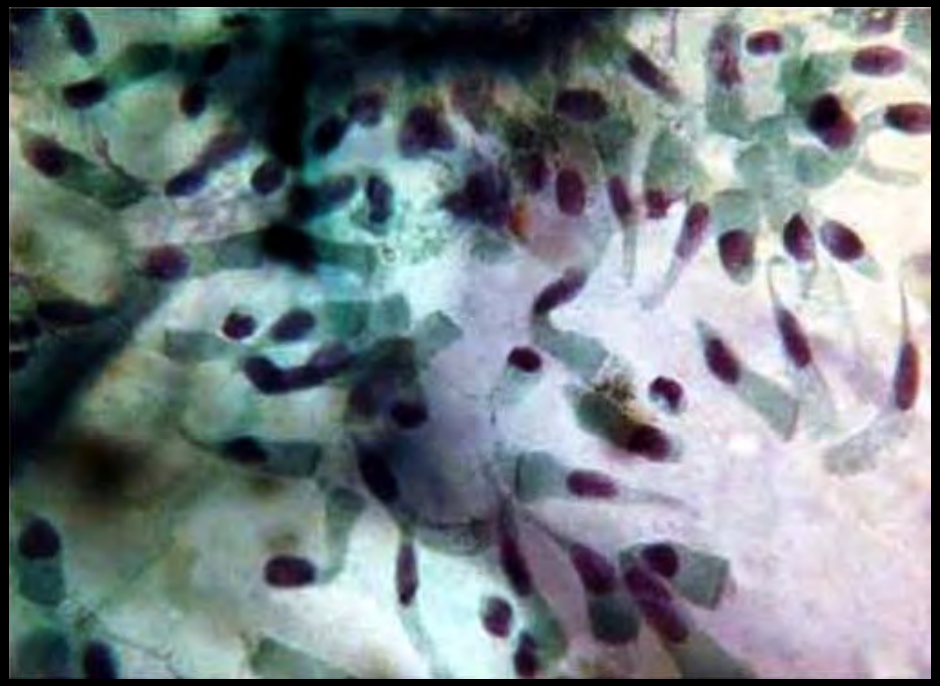
# Phagocytosis of ultrafine particles by AM



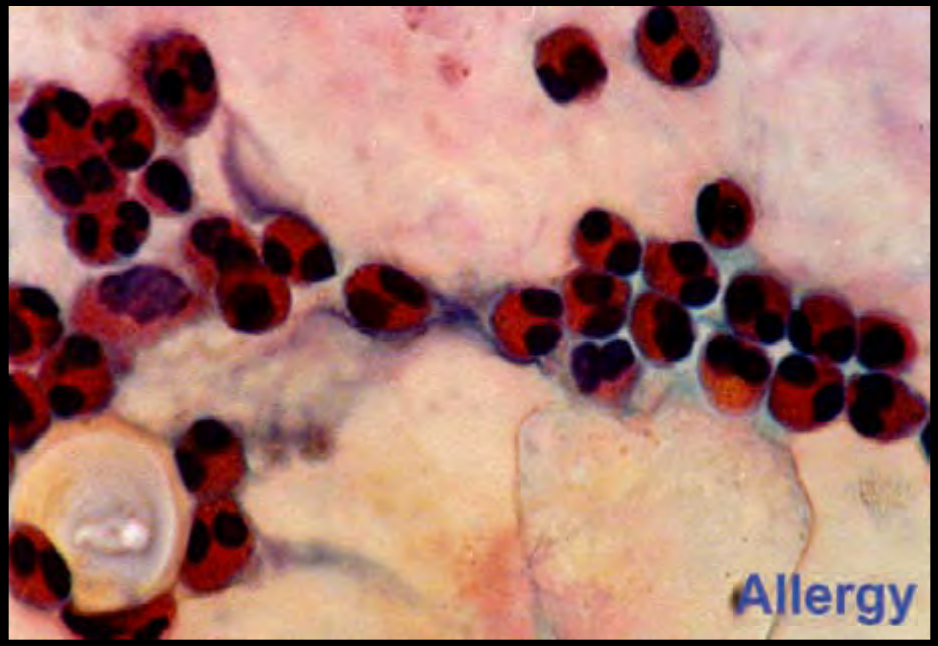
# Air pollution and pulmonary inflammation

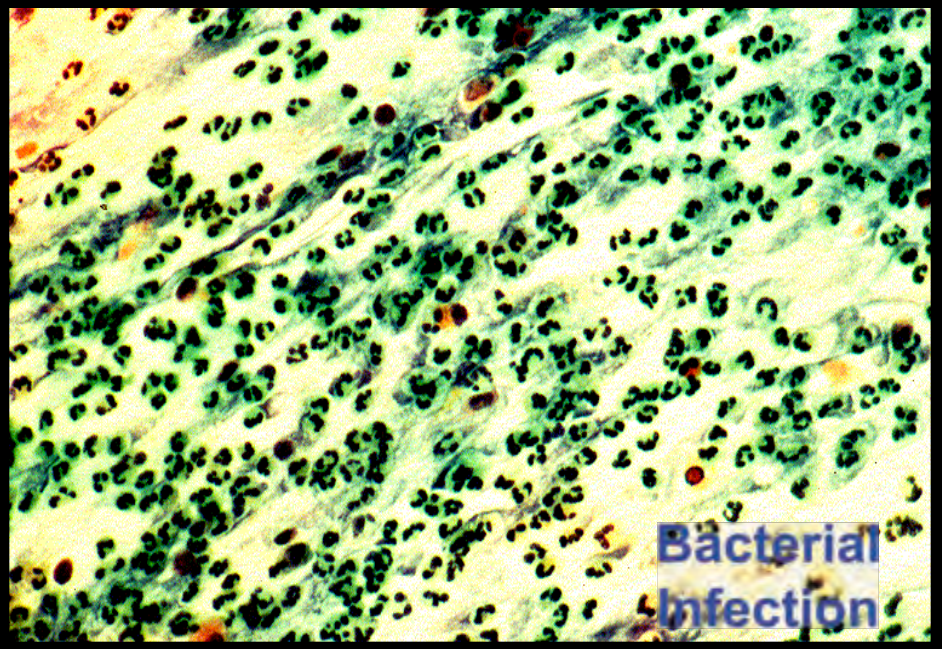
# Adverse cellular lung reaction

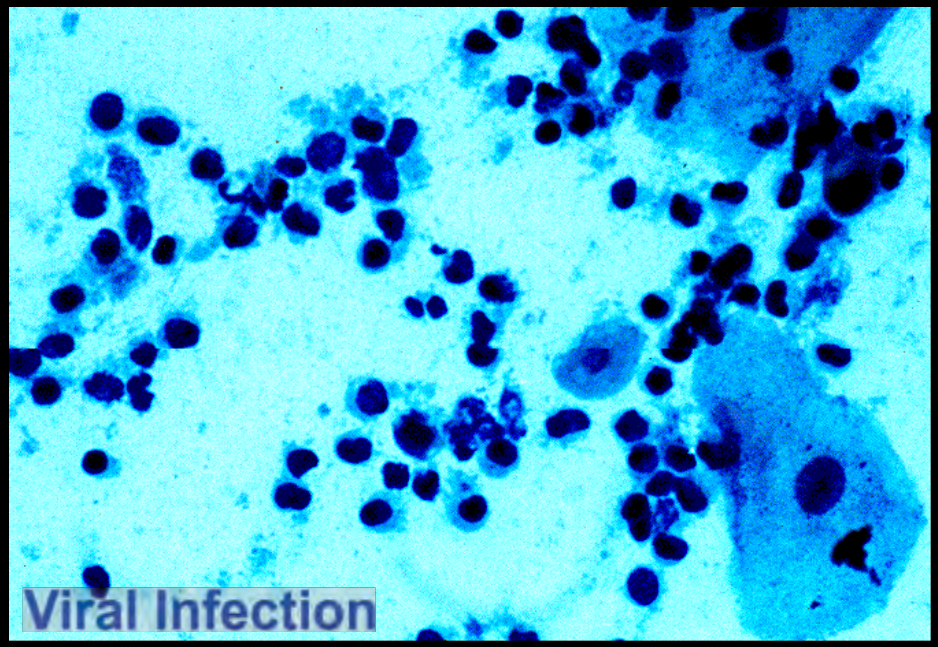




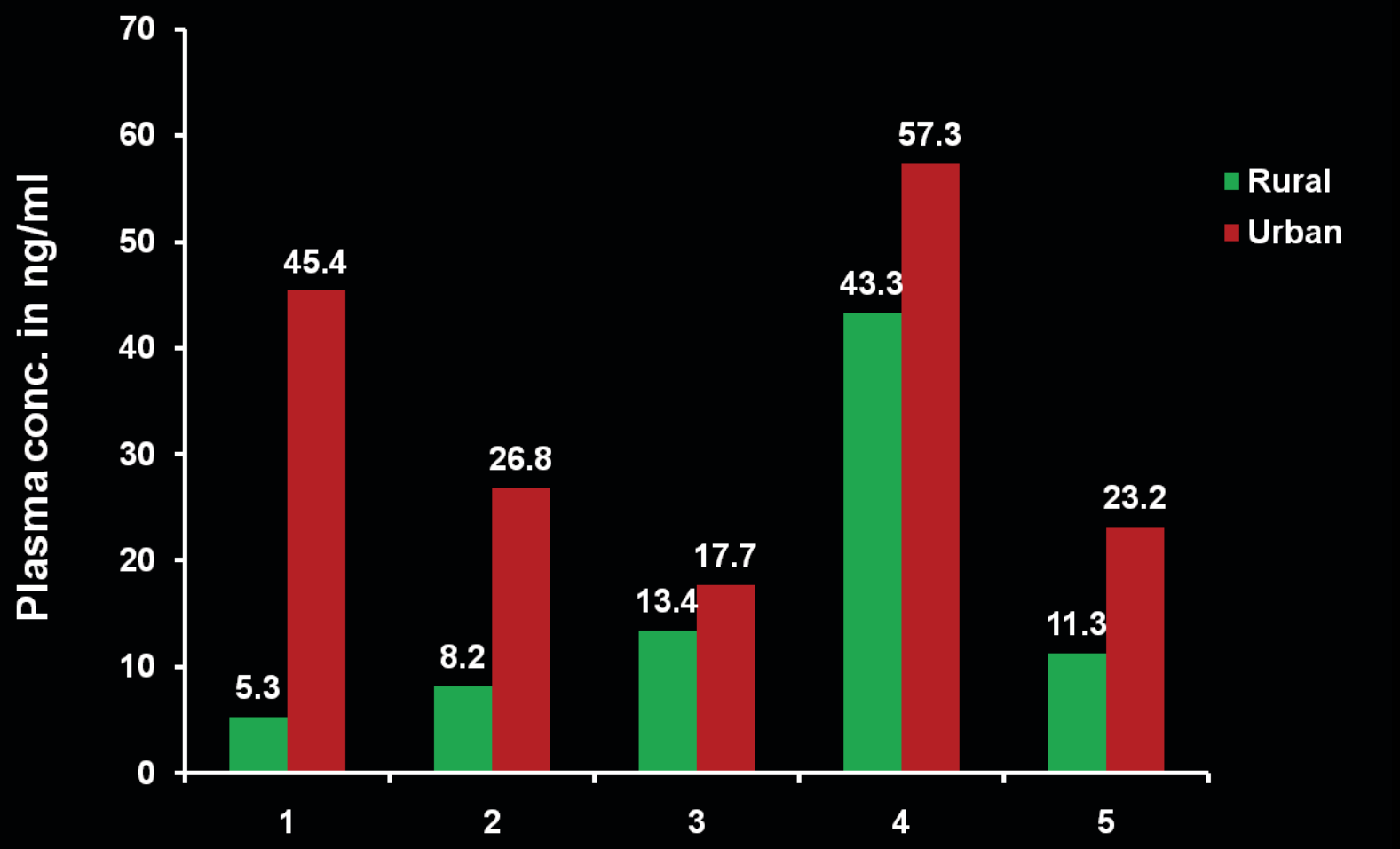
# Airway infection & inflammation



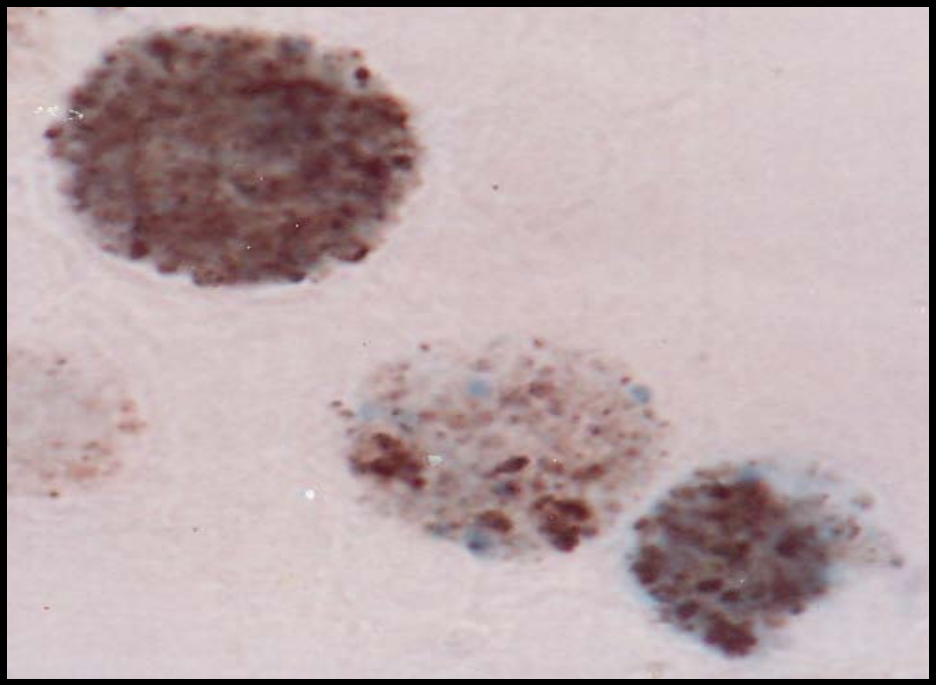



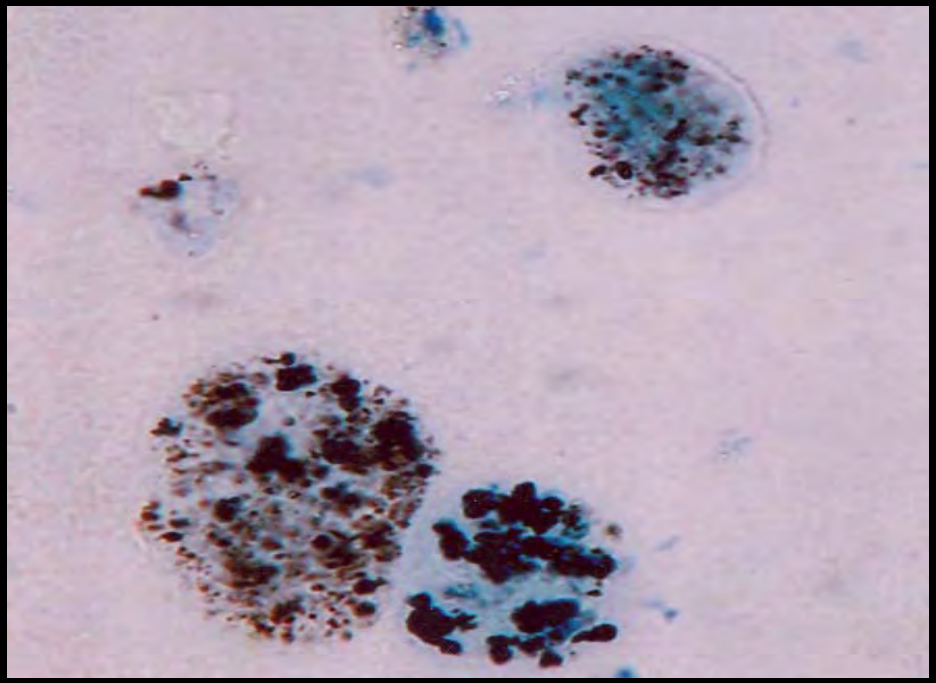

# Air pollution and inflammatory cytokines

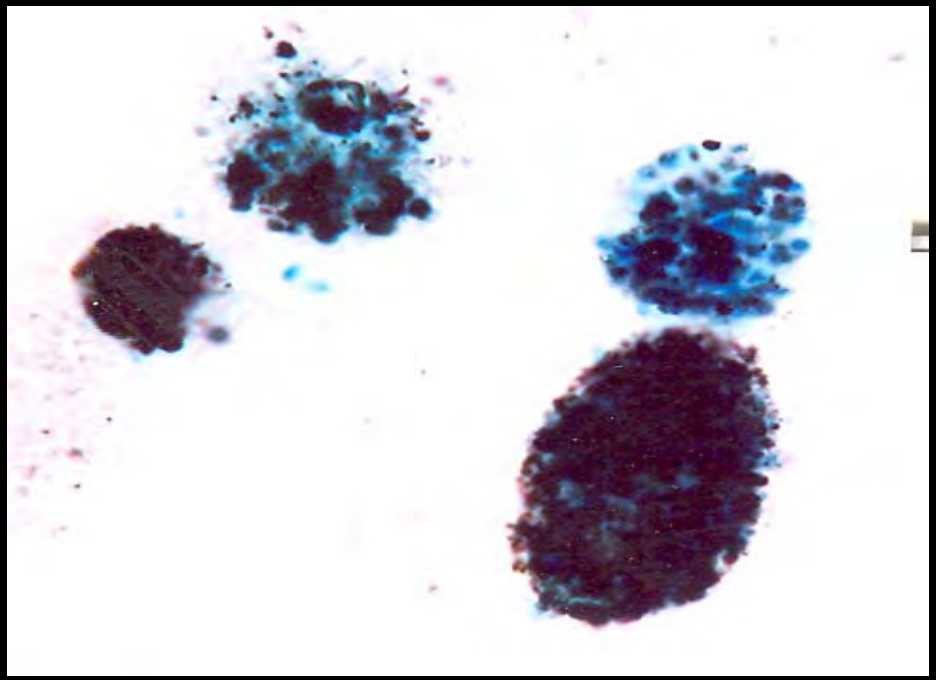


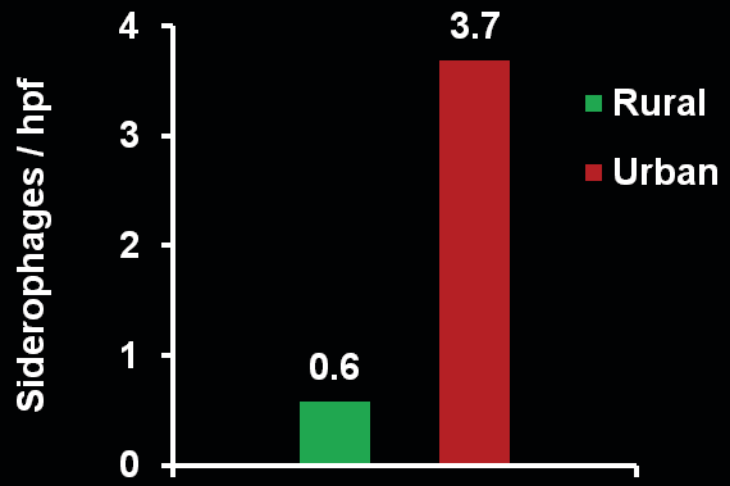

1. Interleukin-6, 2. Interleukin-8, 3. Interleukin-10, 4. Interleukin-12, 5. TNF-alpha

# Iron in AM



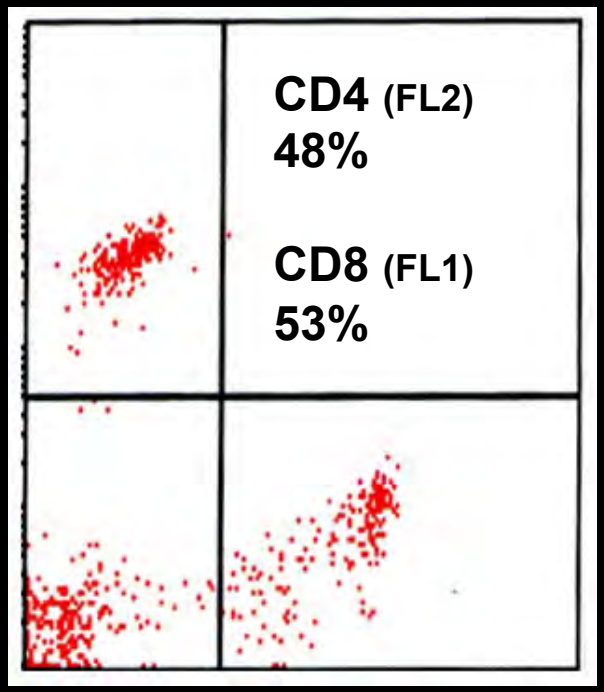




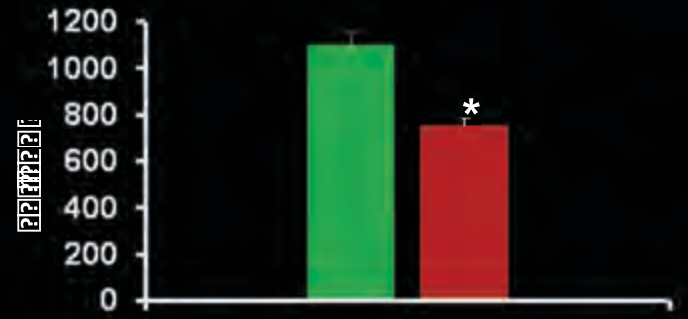


**Does air pollution affect the immunity?**

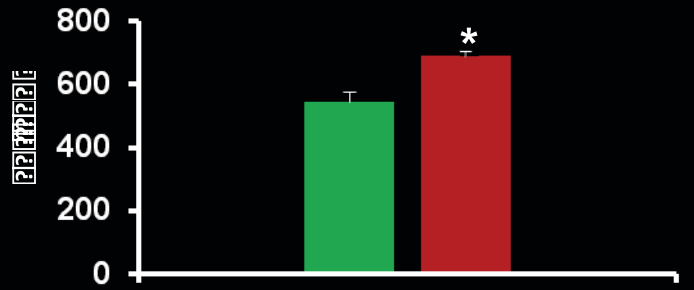
# Immune alterations



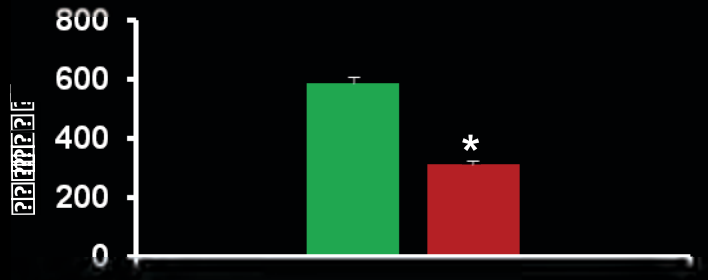

CD4+ cells



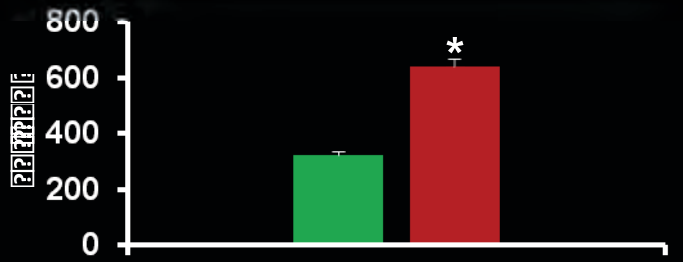

CD8+ cells




CD19+ cells

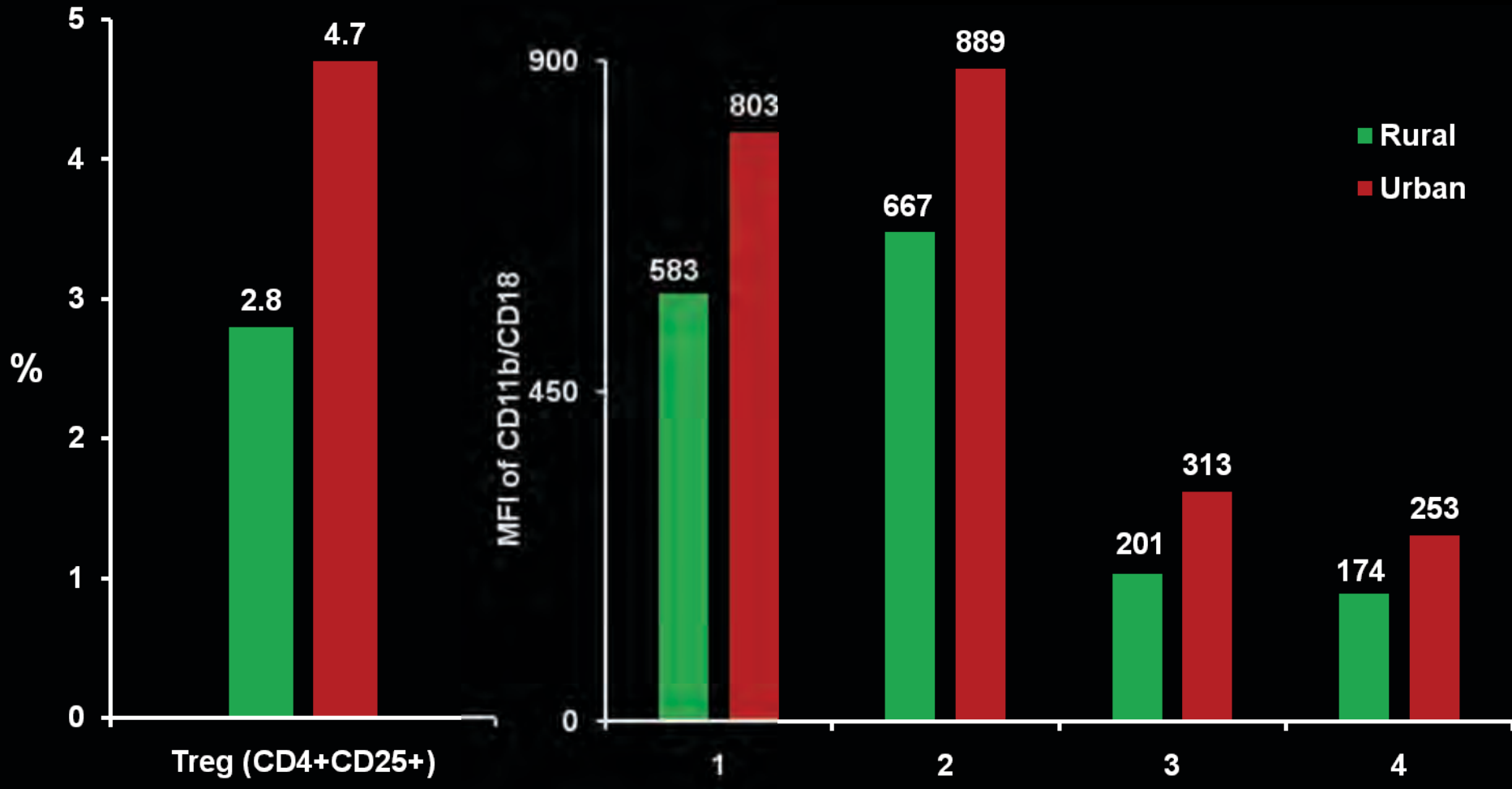



CD16+56+ cells




Rural Urban

# Immune alterations …




1. CD11b neutrophil, 2. CD11b monocyte, 3. CD18 neutrophil, 4. CD18 monocyte

# Does air pollution affect the cardiovascular system?

# Air pollution increases heart diseases

Lungs
1

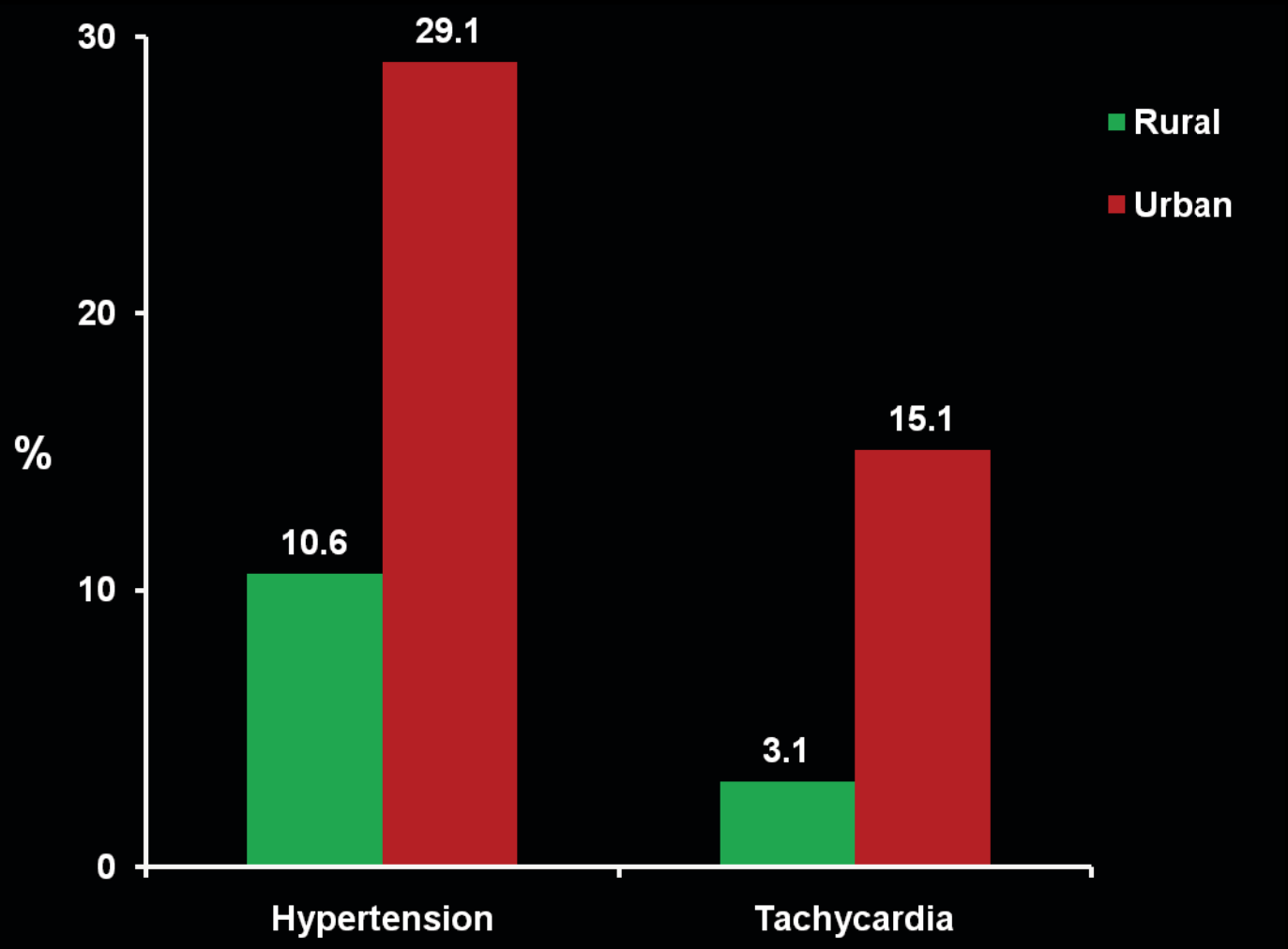
:

Heart
1

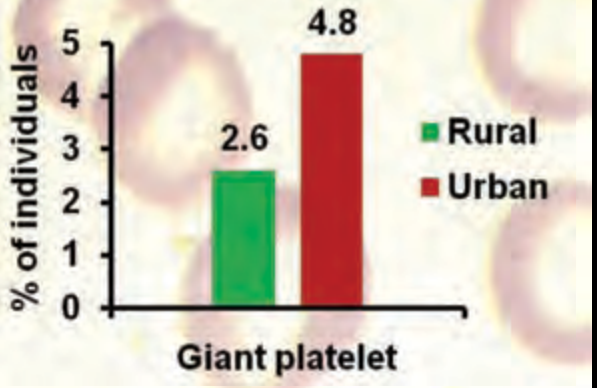
"It is not just the lungs and lower respiratory tract, the cardiovascular system is also affected by air pollution"

**Dr. Alfred Munzer**
**Former President, American Lung Association**

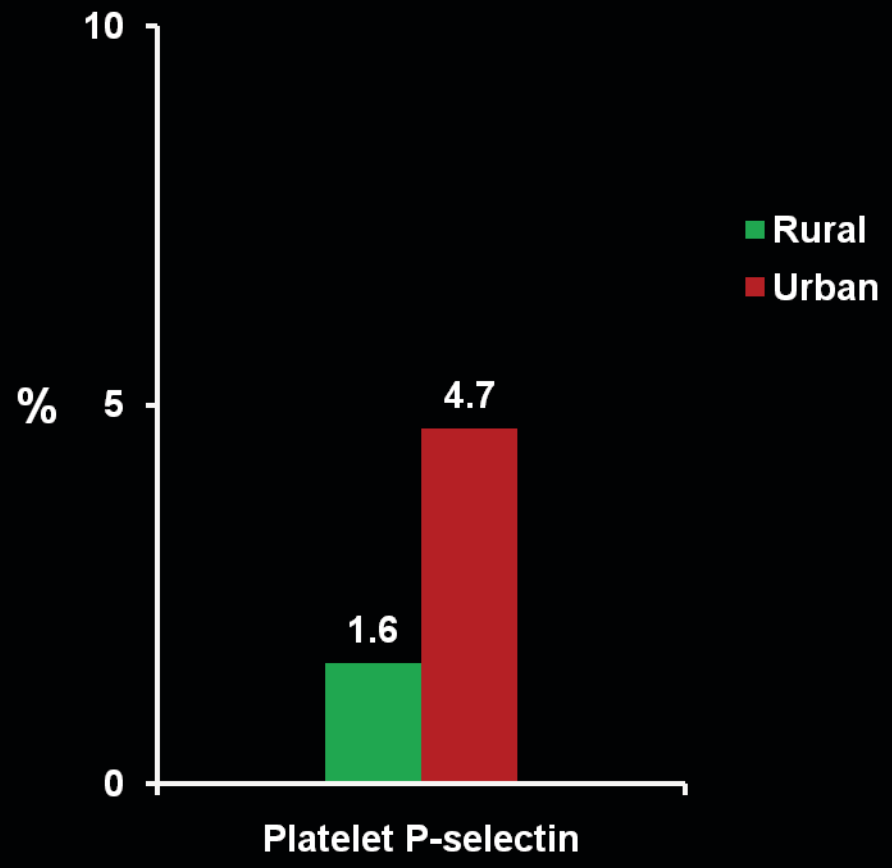
# Air pollution increases prevalence of hypertension

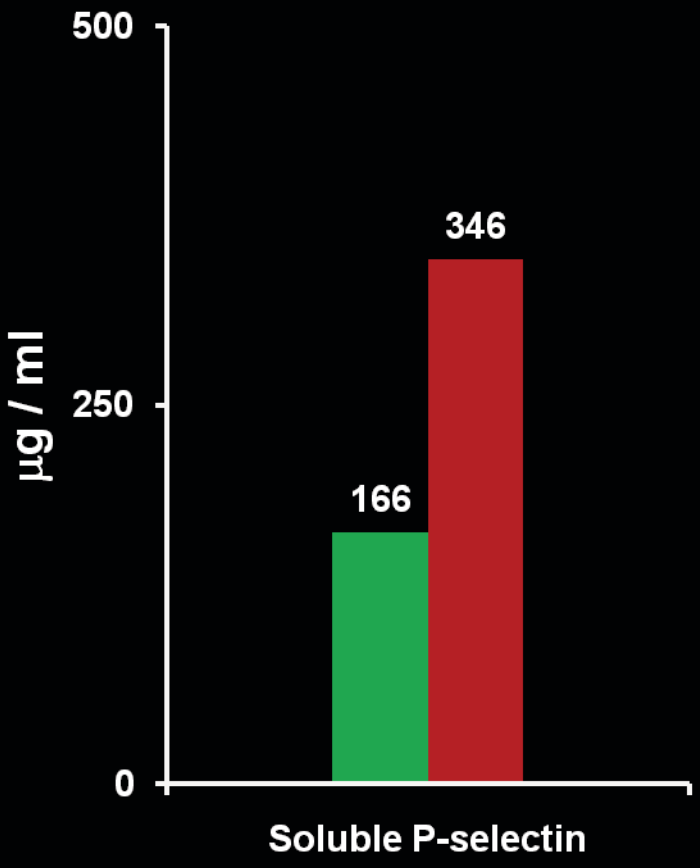


# Giant platelets



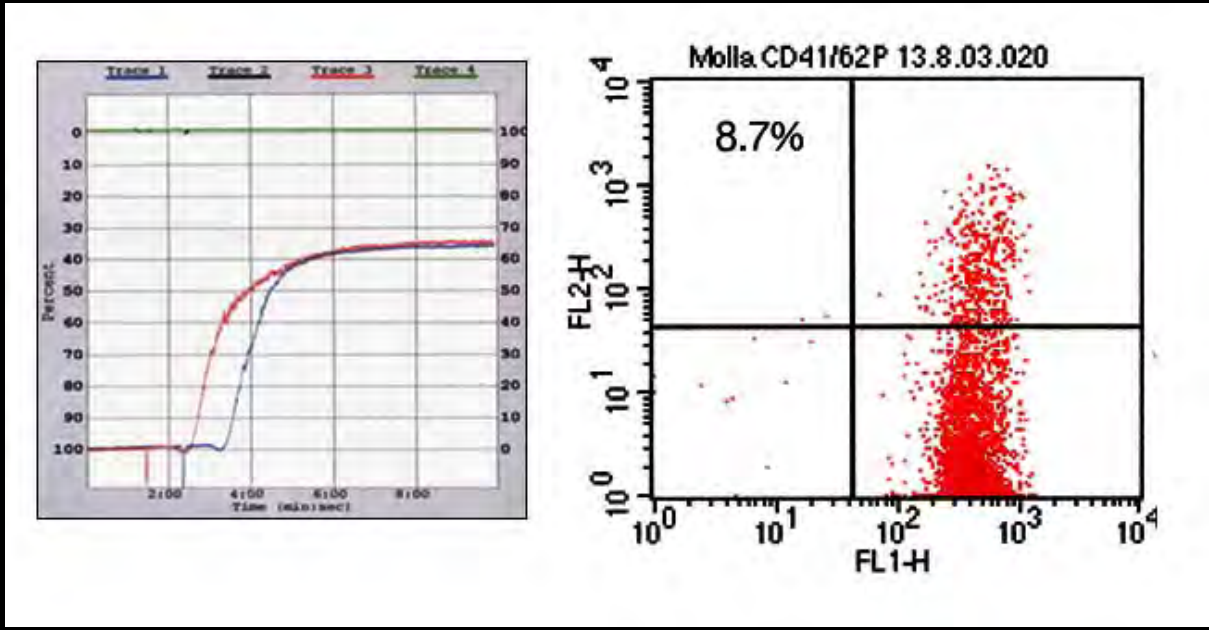
# Air pollution activates blood platelets



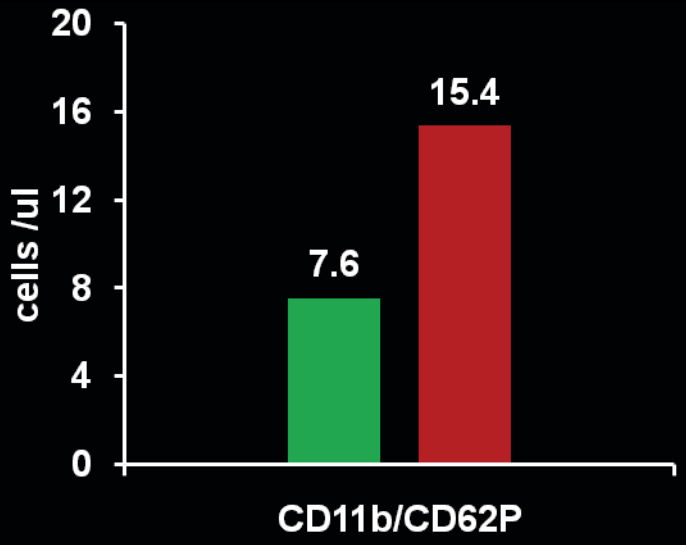



# Platelet activation – cardiovascular risk

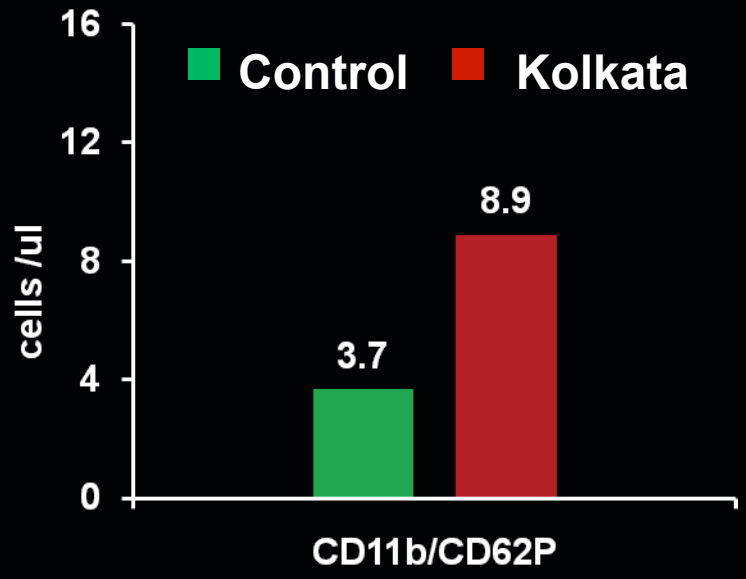
- 2-fold rise in aggregation & ATP-release



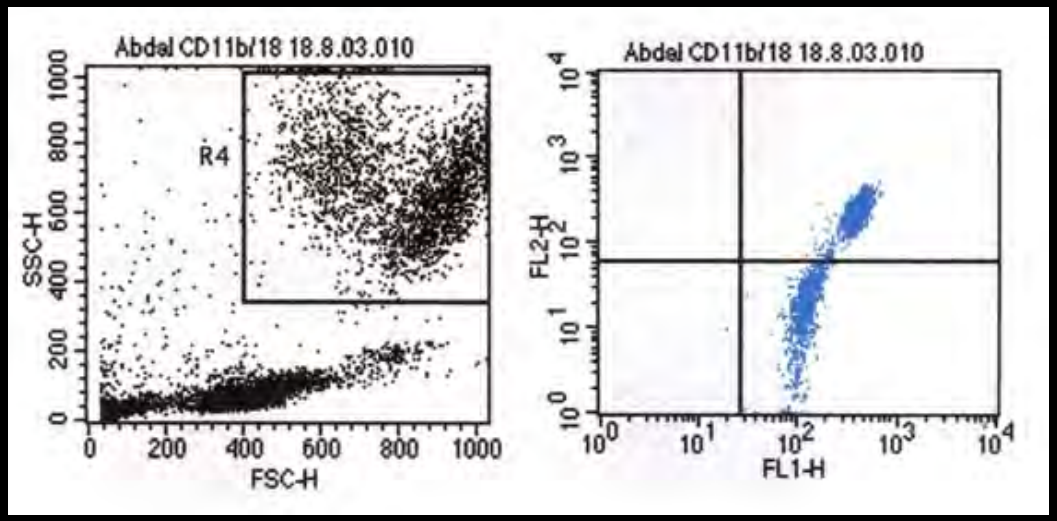
# Platelet- leukocyte aggregates cardiovascular risk




Neutrophil-platelet aggregates




Monocyte-platelet aggregates




**MFI of CD11b/CD18 on leukocytes increased by 48%**

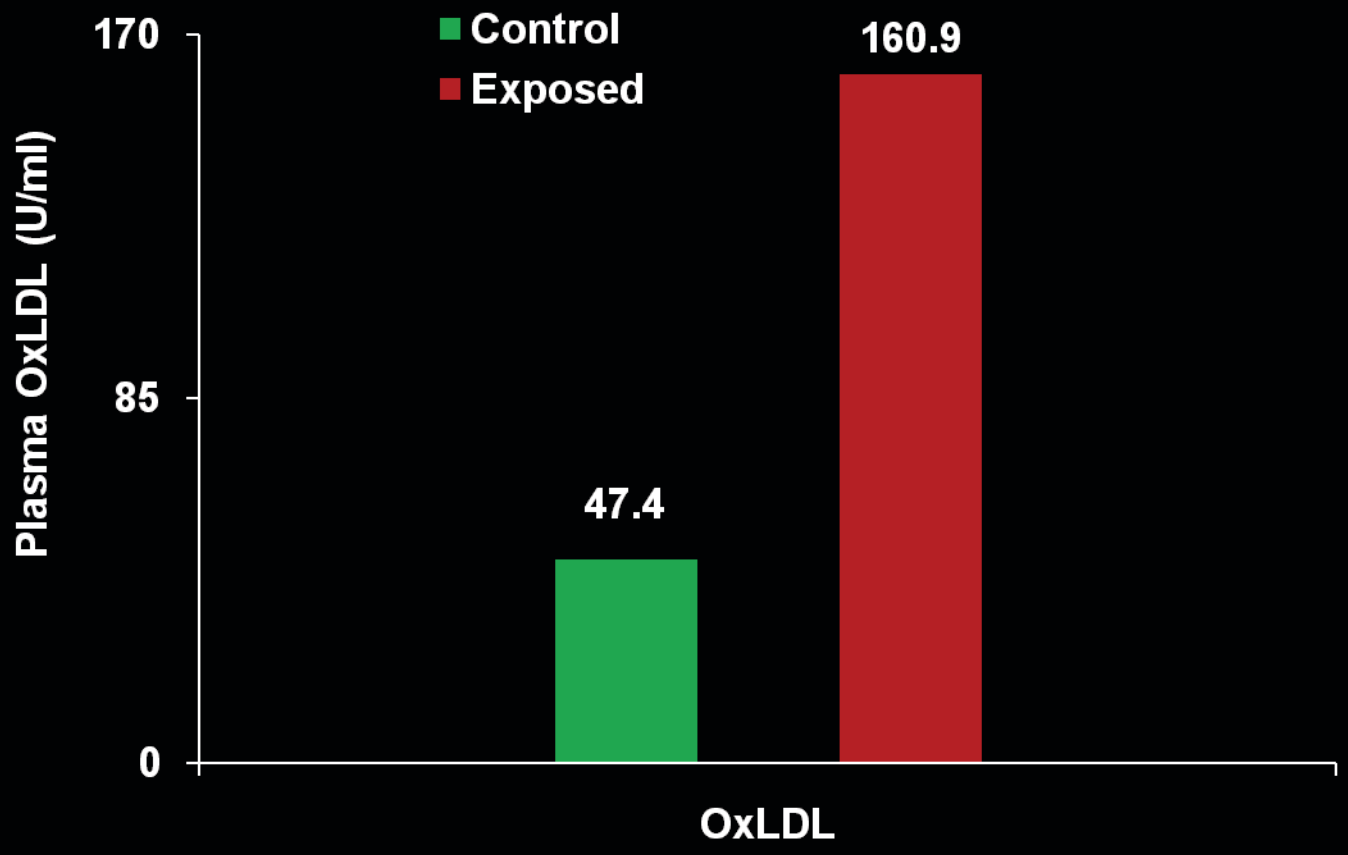
☞ Inflammation and activation of coagulation cascade

**Increased formation of leukocyte-platelet aggregates**

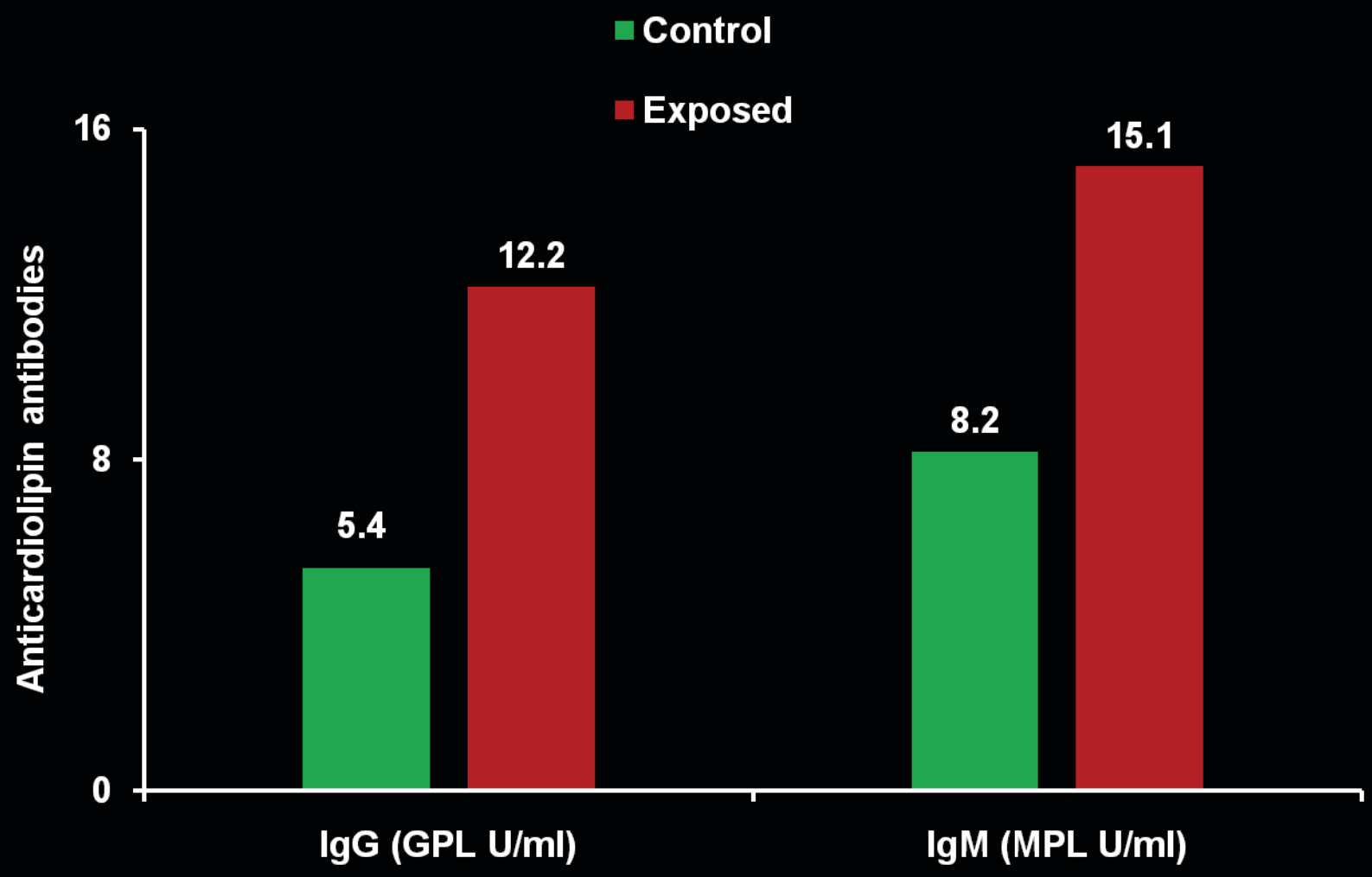
☞ Thrombotic disorders

CVD

# Oxidized low-density lipoprotein in blood



# Anti-cardiolipin antibodies in serum



# Air pollution and the heart

$PM_{2.5}$, UFP

ROS

$_{ox}$LDL

Foam cell

Plaque formation

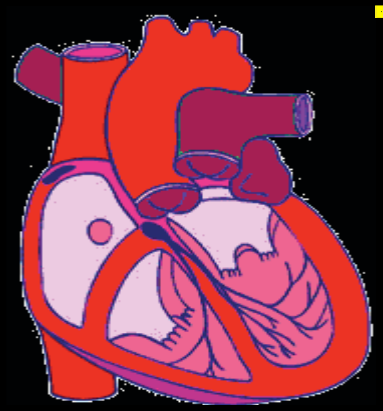
Rupture

Liver

Coagulation factor, CRP, IL-6

Platelet activation

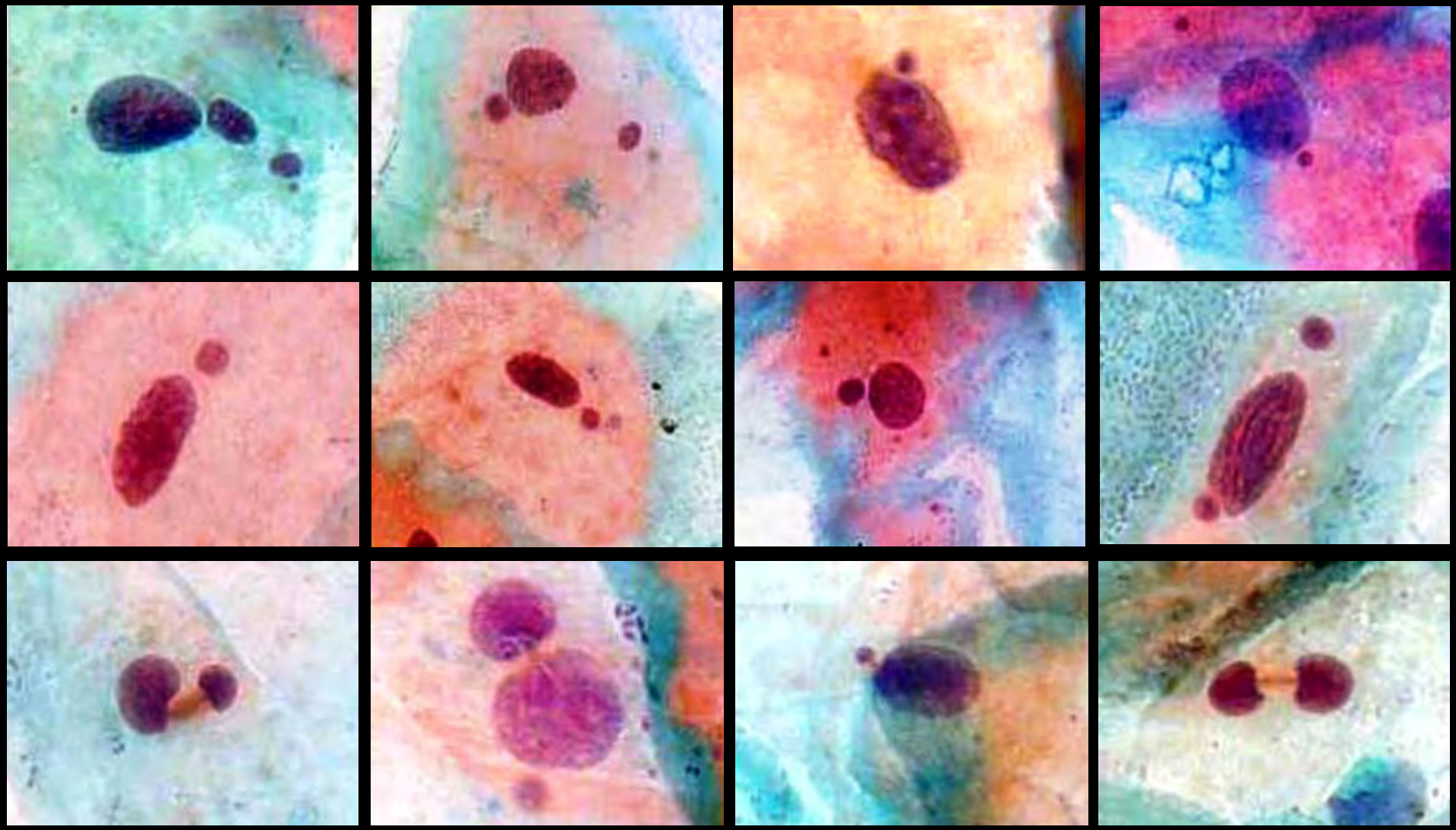
Thrombosis



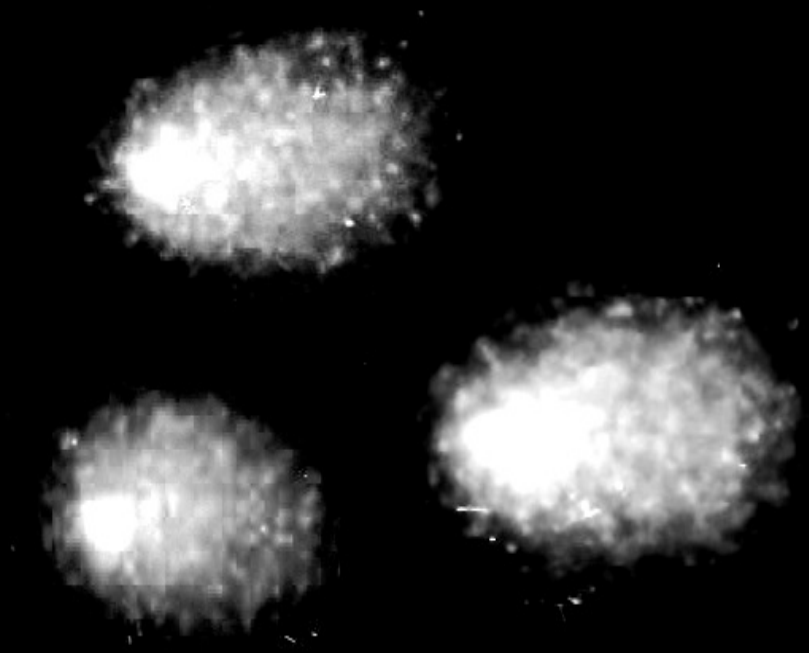
CVD

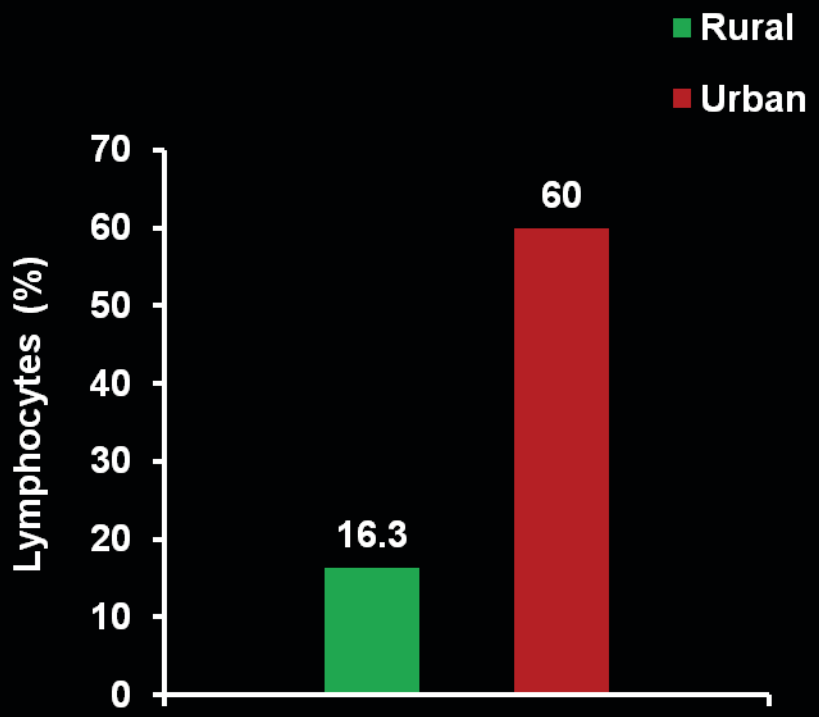
**Does air pollution damage the chromosomes and the DNA?**

# Micronucleus formation



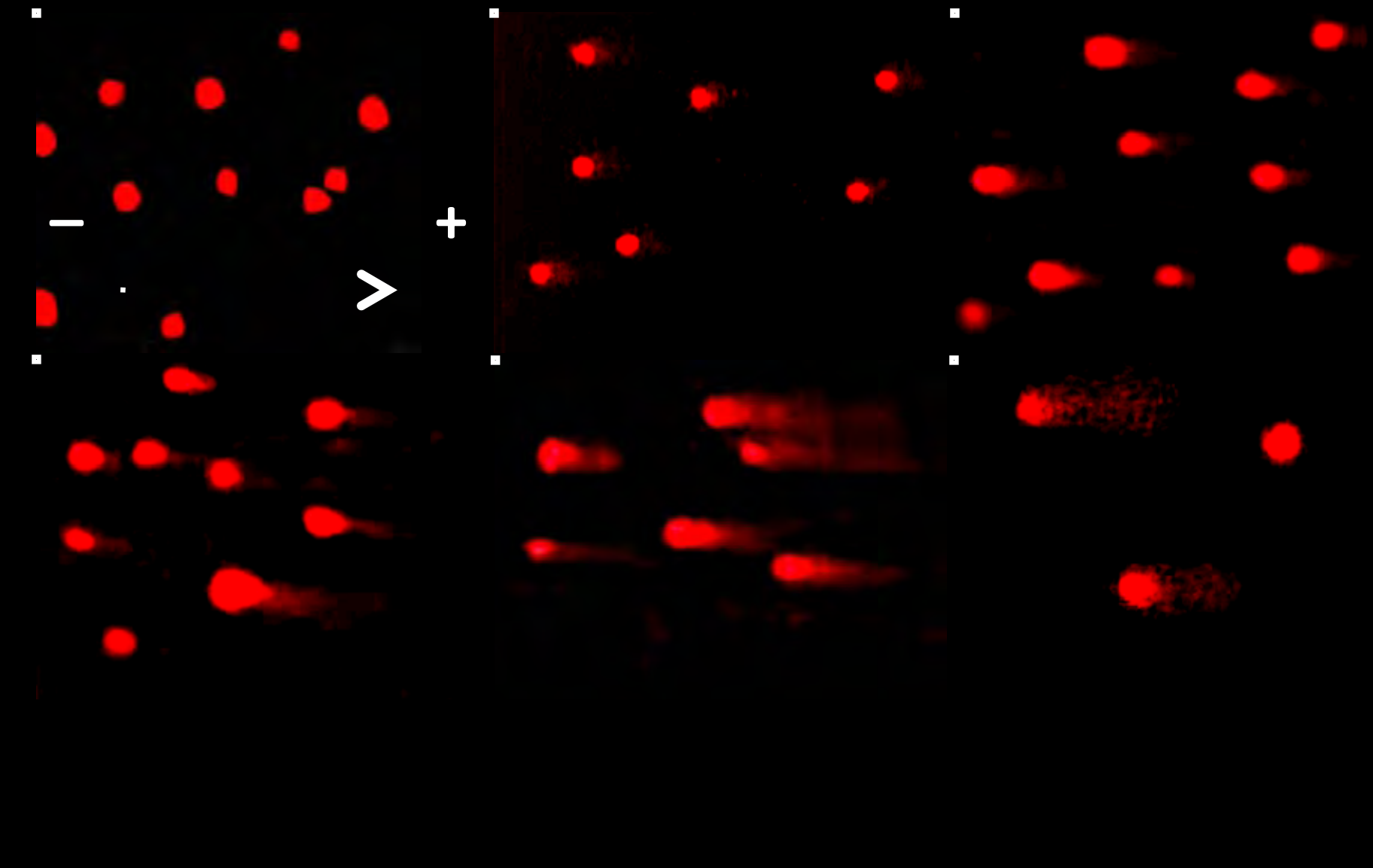
# DNA damage, comet assay



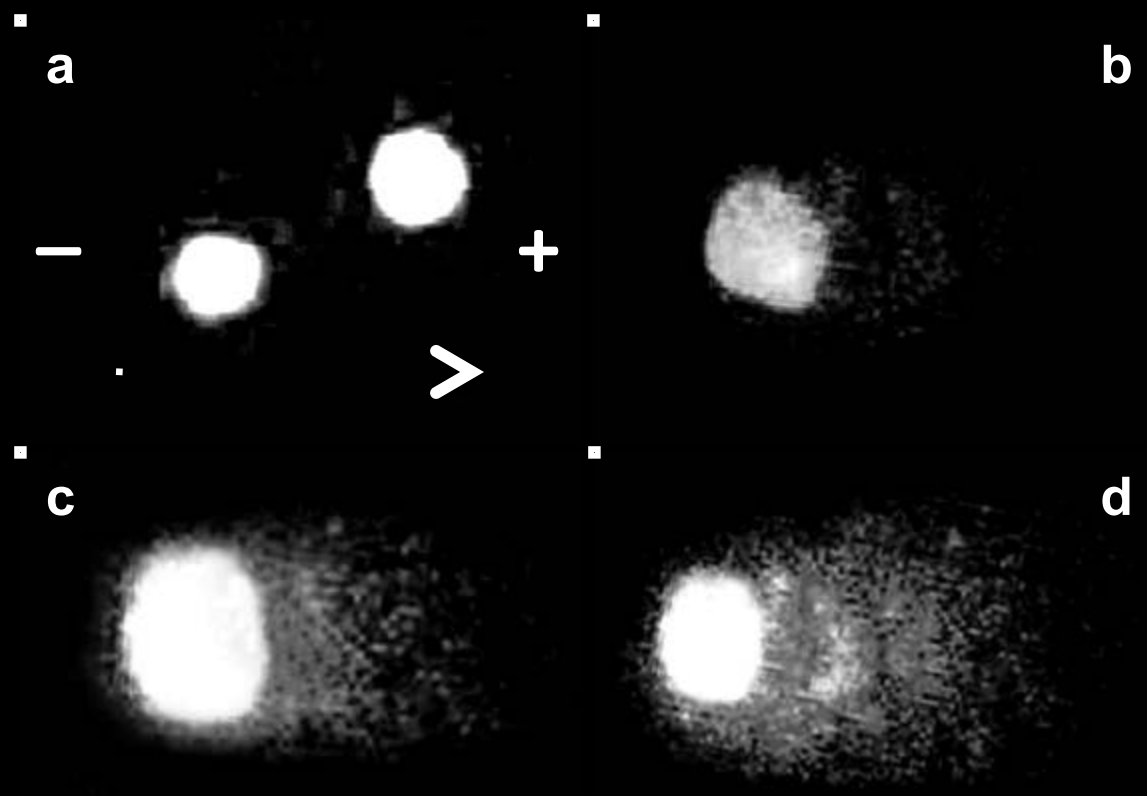



Excess comet formation suggests increase in DNA damage

# Comet assay in PBL

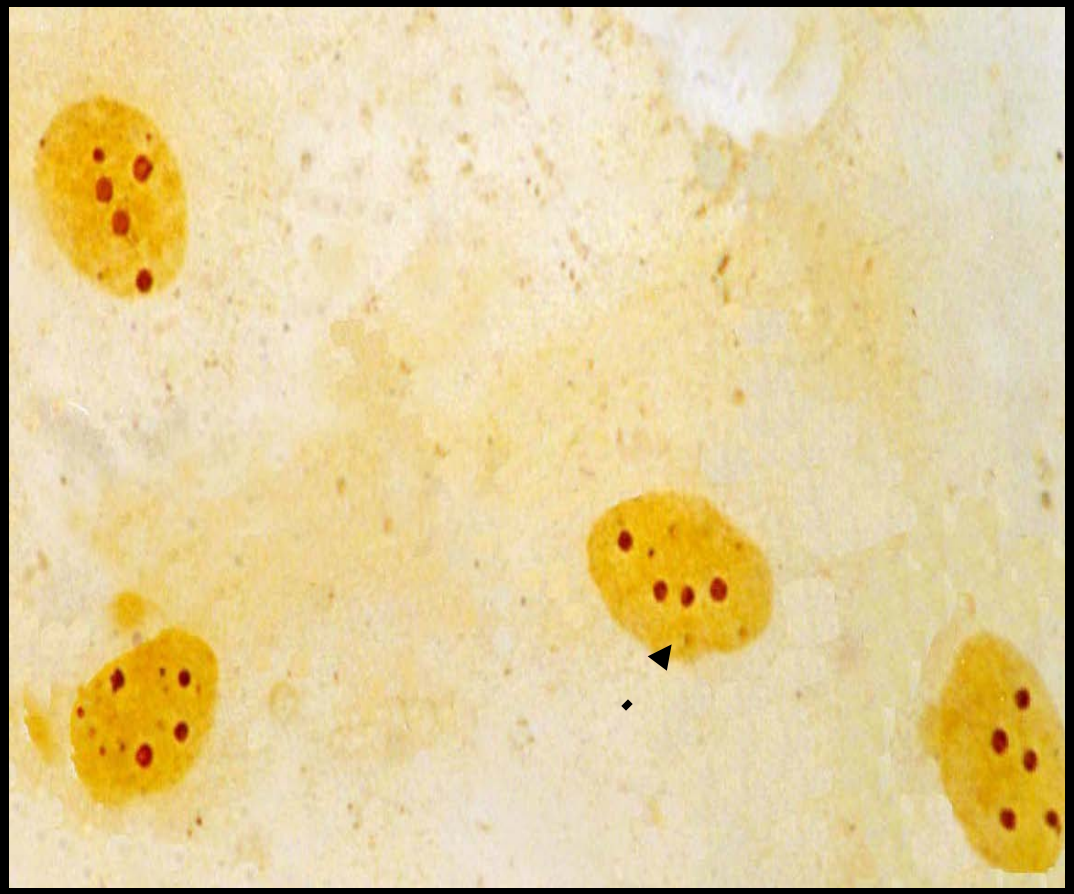


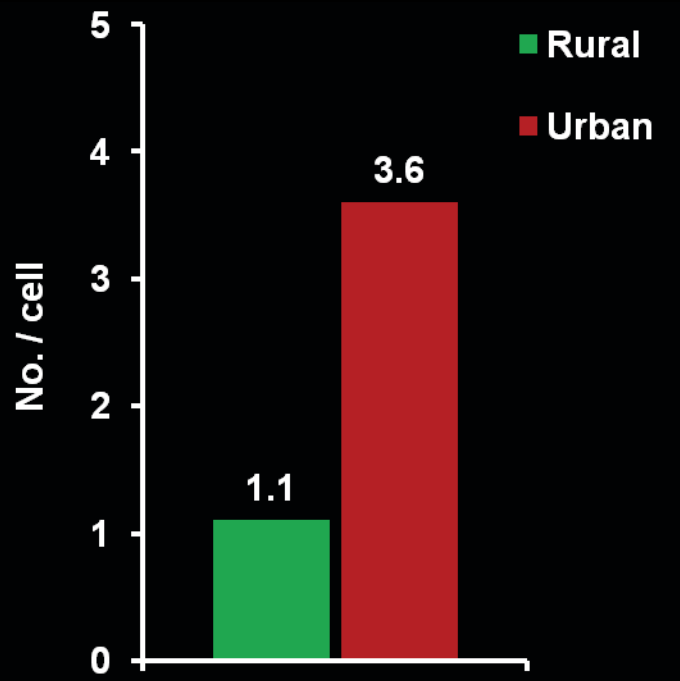
# Comet assay in epithelial cells



# Air pollution
# and
# risk of lung cancer

# AgNOR, ribosome biosynthesis

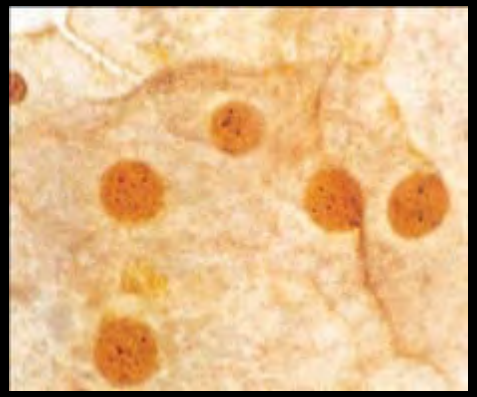




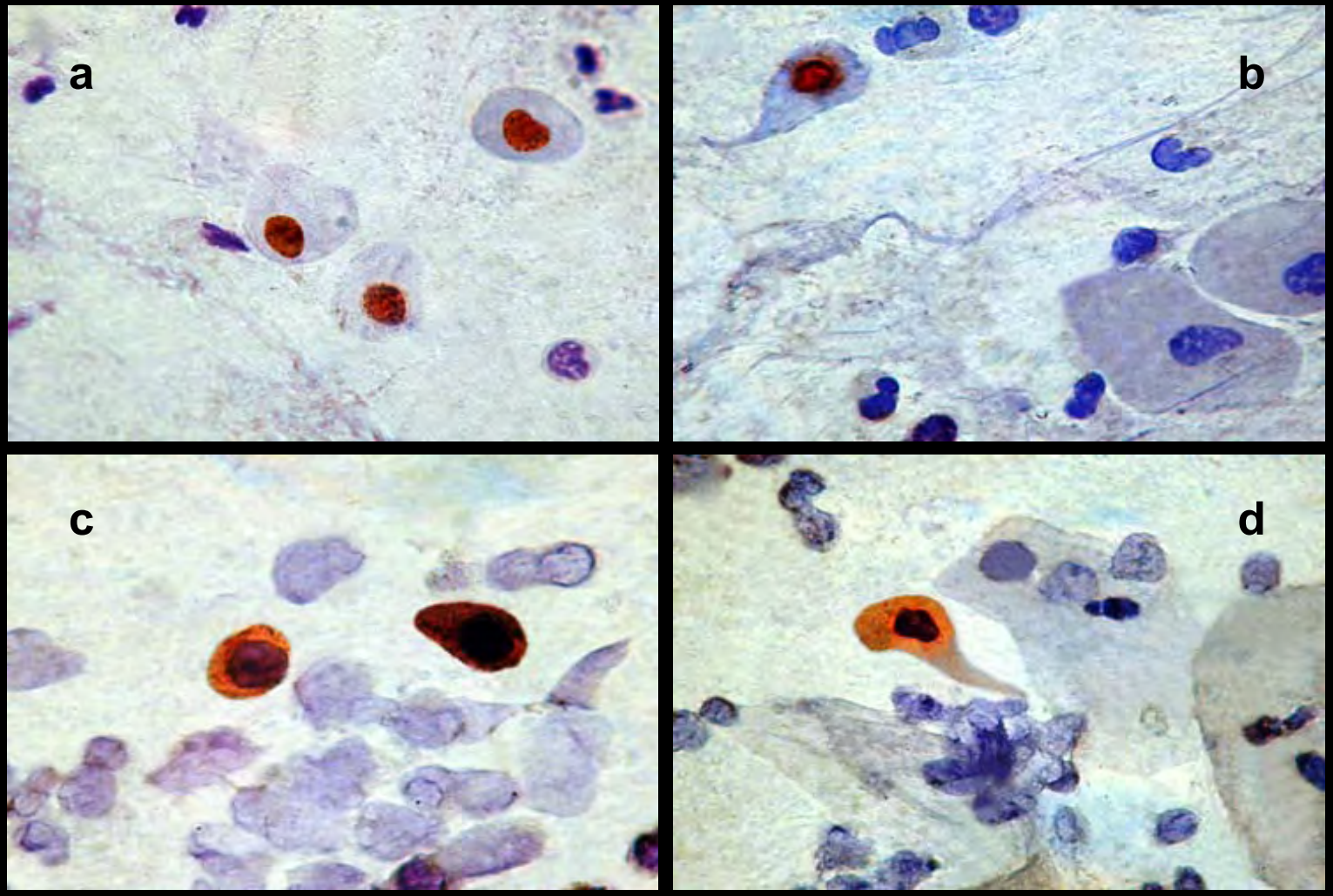

Excess AgNOR in buccal epithelial cells

indicates

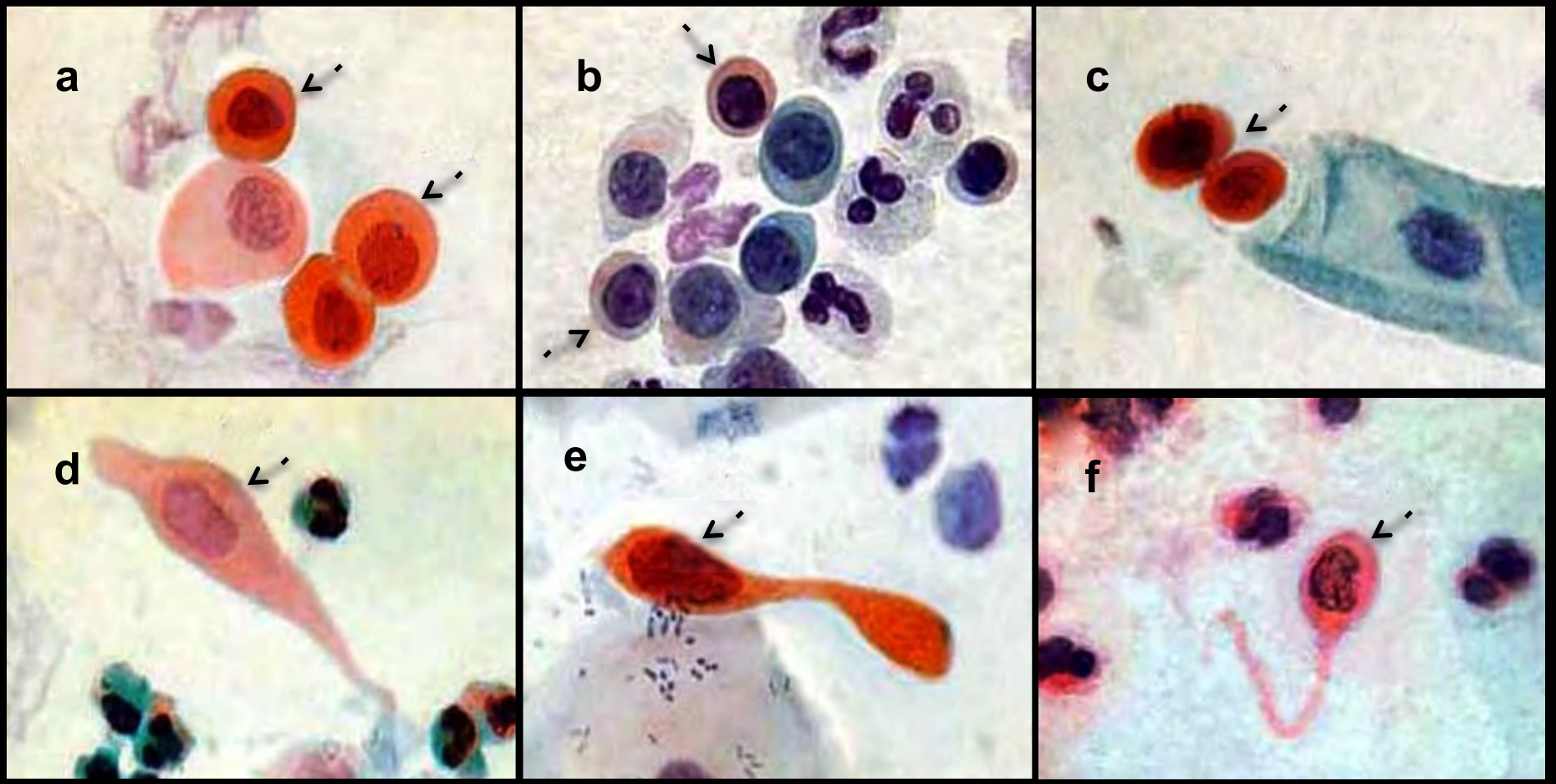
increase in ribosome biosynthesis



# Up-regulation of Akt signal transduction



# Metaplasia, dysplasia, cancer risk

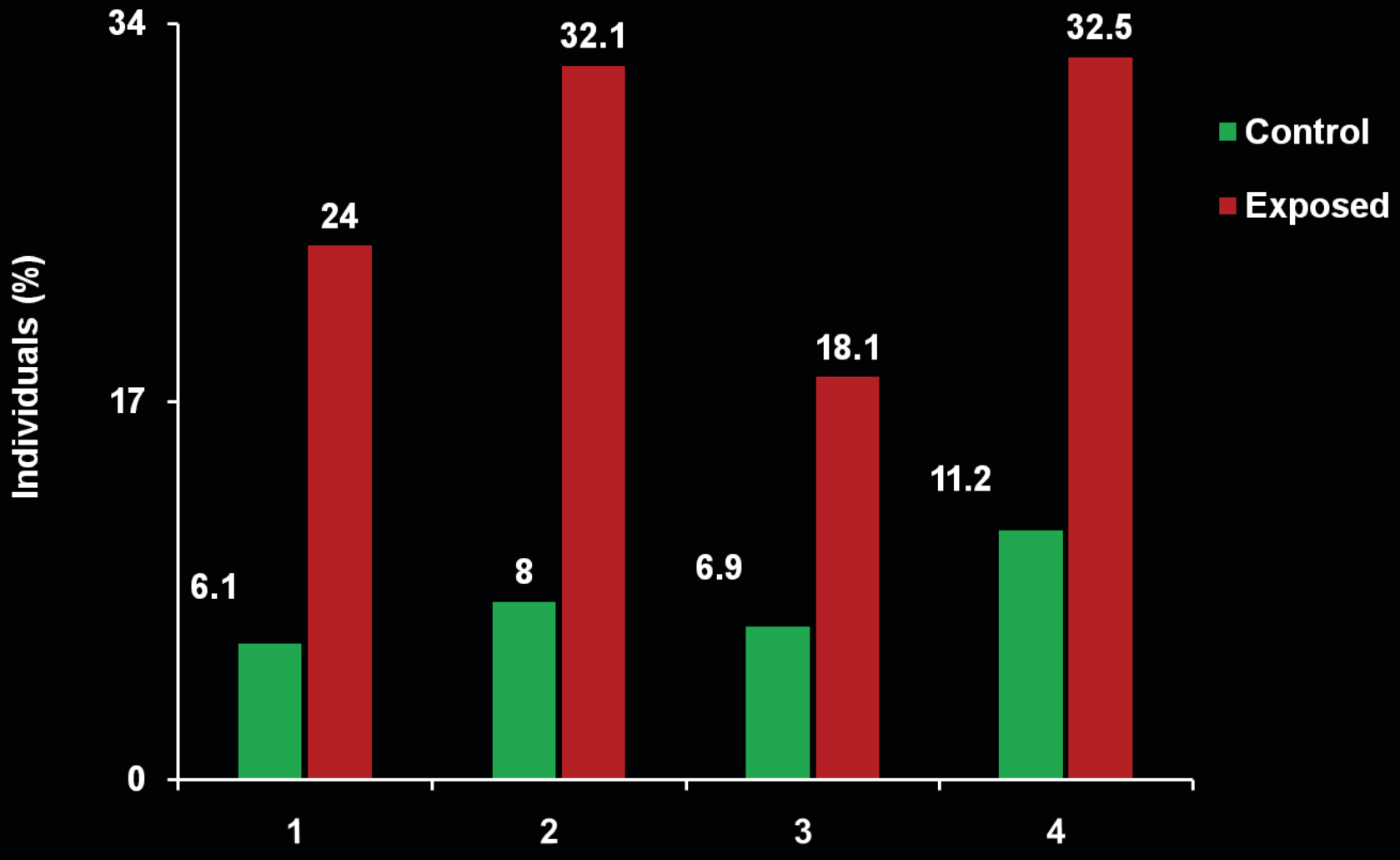


# Mechanism of air pollution induced health impairment : oxidative stress

# Generation of oxidative stress

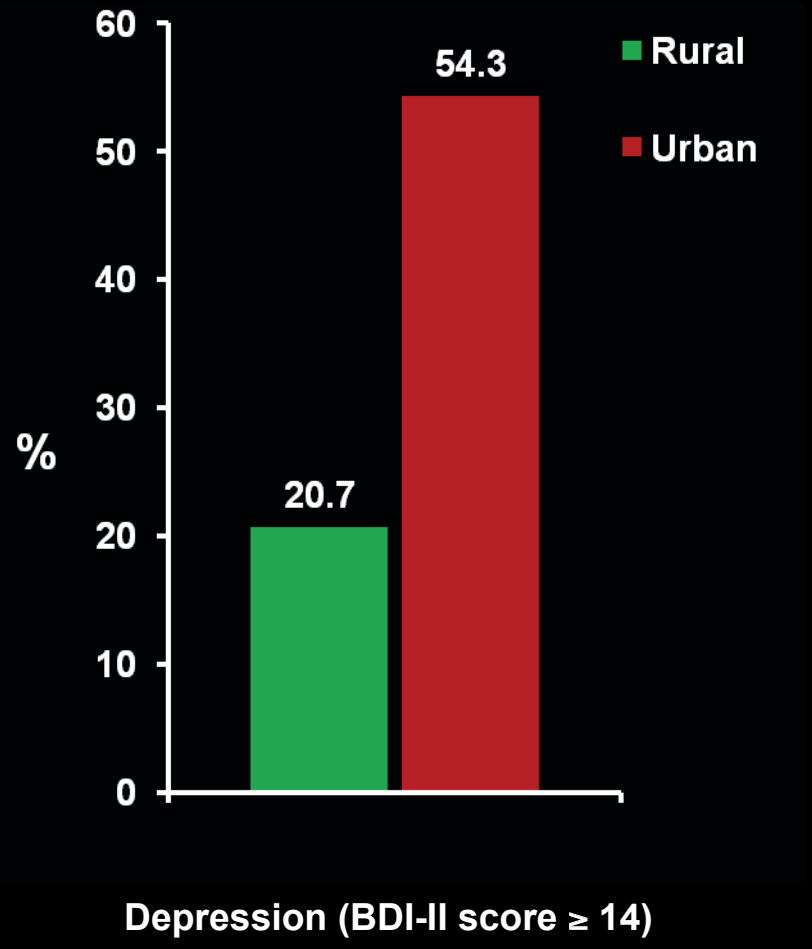
# Does air pollution affect mental health?

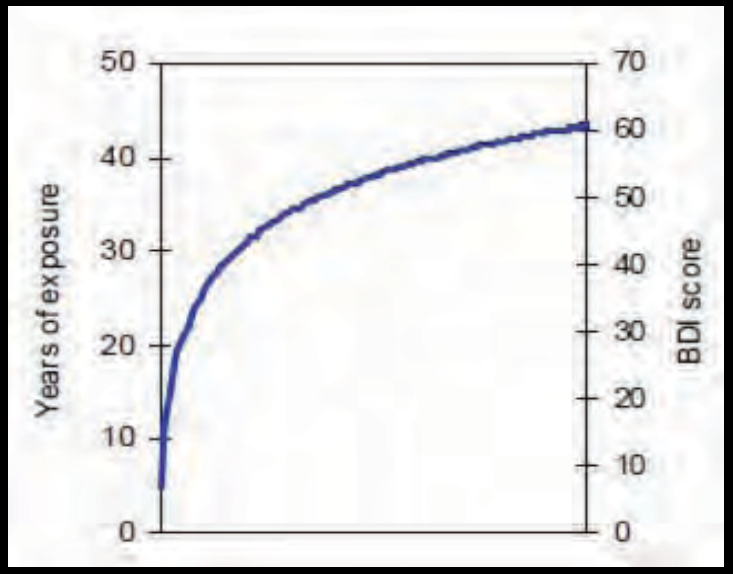
# Neurobehavioral symptoms

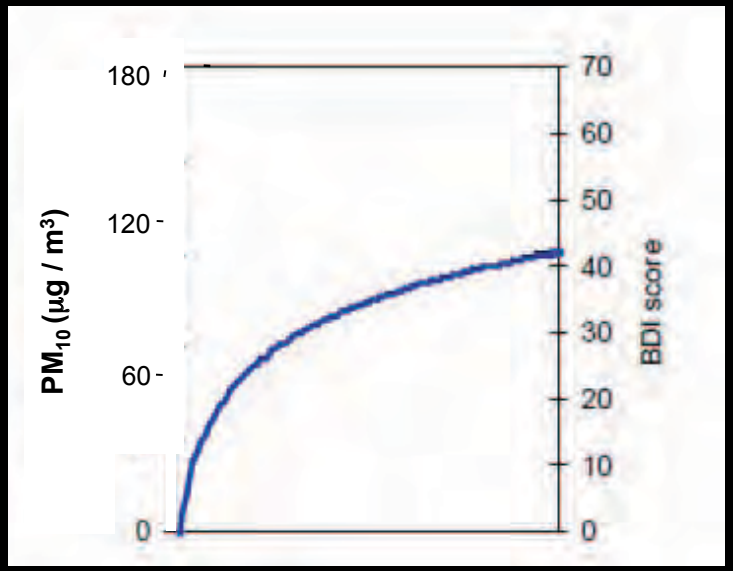



1. Burning sensation in extremities, 2. Blurred vision, 3. Drunken feeling, 4. Forgetfulness

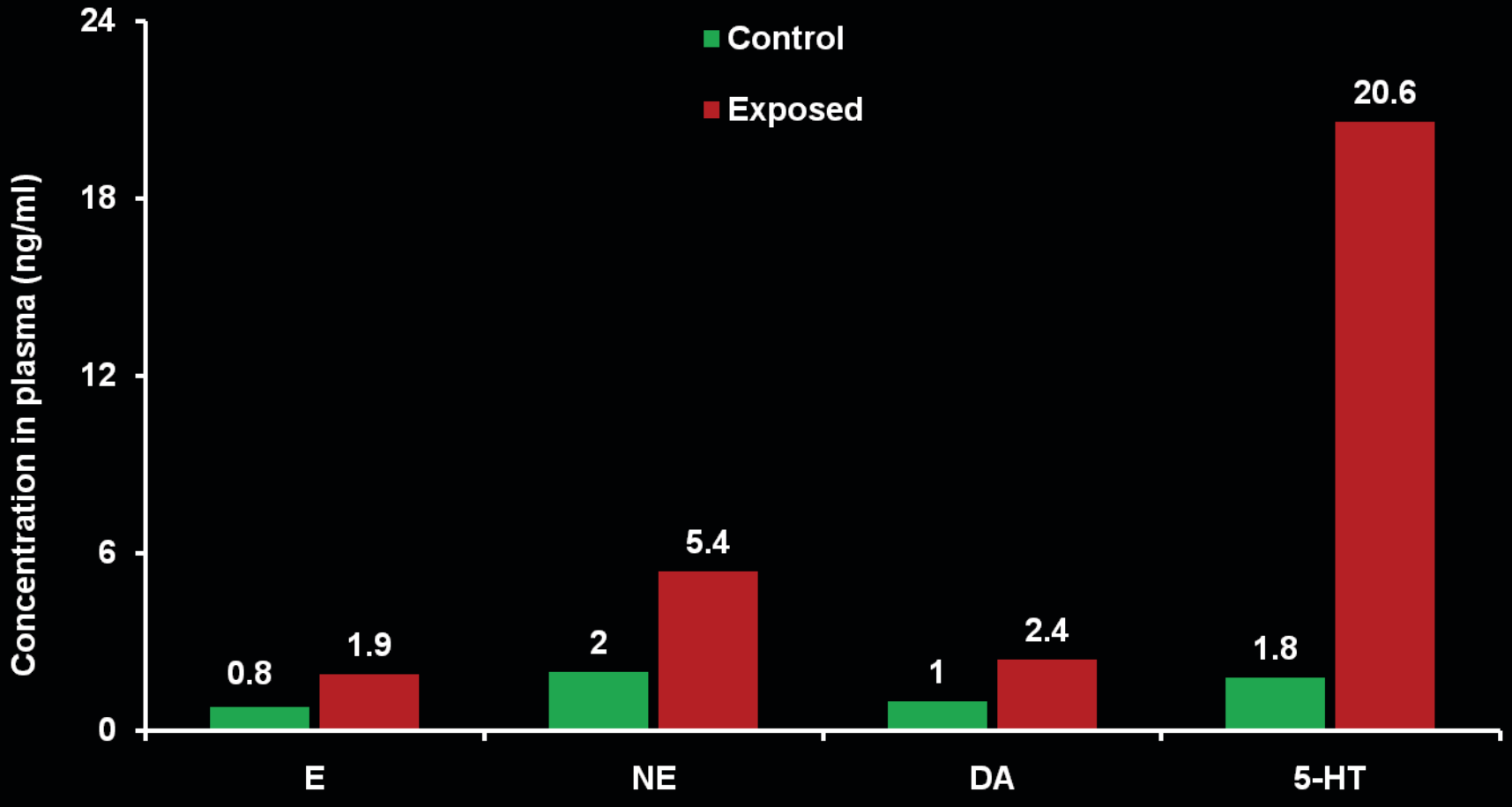
# Depression


60
50
40
30
20
10
0
%
54.3
20.7
Rural
Urban
Depression (BDI-II score ≥ 14)


50
40
30
20
10
0
Years of exposure
70
60
50
40
30
20
10
0
BDI score


180
120
60
0
PM10 (µg / m3)
70
60
50
40
30
20
10
0
BDI score

# Air pollution alters blood neurotransmitter levels




E: Epinephrine; NE: Nor-epinephrine; DA: Dopamine; 5-HT: Serotonin

# Summary

- Chronic exposure to urban air pollution affects lung function, increases the risk of CVD and lung cancer, alters immunity, induces DNA and chromosomal damage and increases the prevalence of depression and neurobehavioral symptoms
- The changes were positively associated with $PM_{10}$ and $PM_{2.5}$ in ambient air after controlling potential confounders by multivariate logistic regression analysis
- PM perhaps mediated these changes via generation of ROS and depletion of antioxidant defense

**Let us join hands**
**To curb Air Pollution**
**For a Better Tomorrow**


CNCI
The Study Team