

HEALTH EFFECTS OF AIR POLLUTION

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AIR POLLUTION

Outdoor

Indoor

Vehicular

**Industrial
Thermal power Stations**

Pesticides

Biomass burning

NO_x, SO_x, CO,
PM, VOCs, PAHs,
trace metals

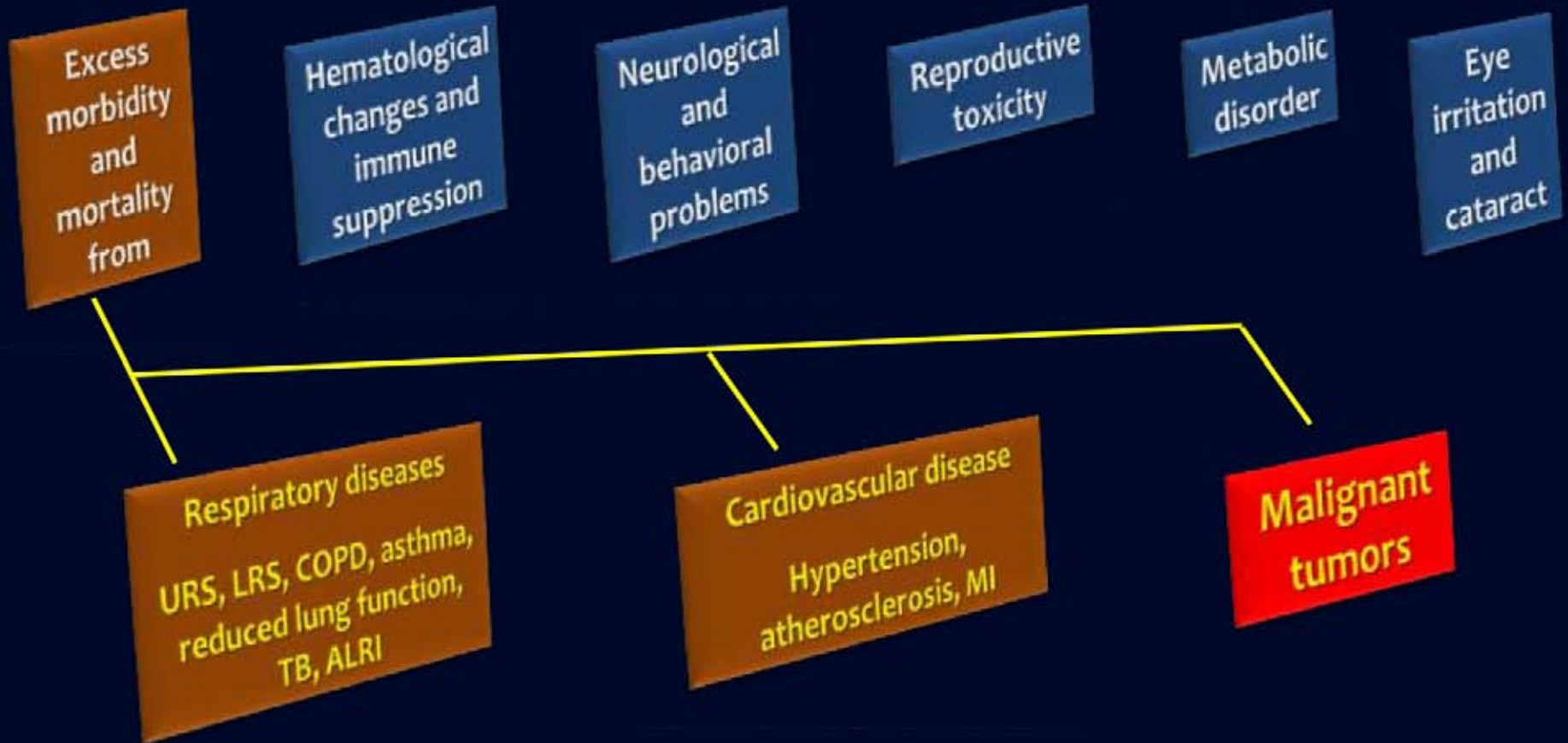
CO, SO_x, NO_x,
PM,
trace metals

OC, OP, C

NO_x, SO_x, CO, PM,
VOCs, PAHs,
trace metals



Health effects of air pollution



Particulate Matter (PM)

the prime concerned pollutant

PM₁₀ : diameter < 10 microns

PM_{2.5} : diameter < 2.5 microns

Ultra Fine Particles(UFPs) : diameter < 0.1 microns

Smaller the size, greater the health risk

PM deposition in lungs and the airways

Naso-oropharangeal region

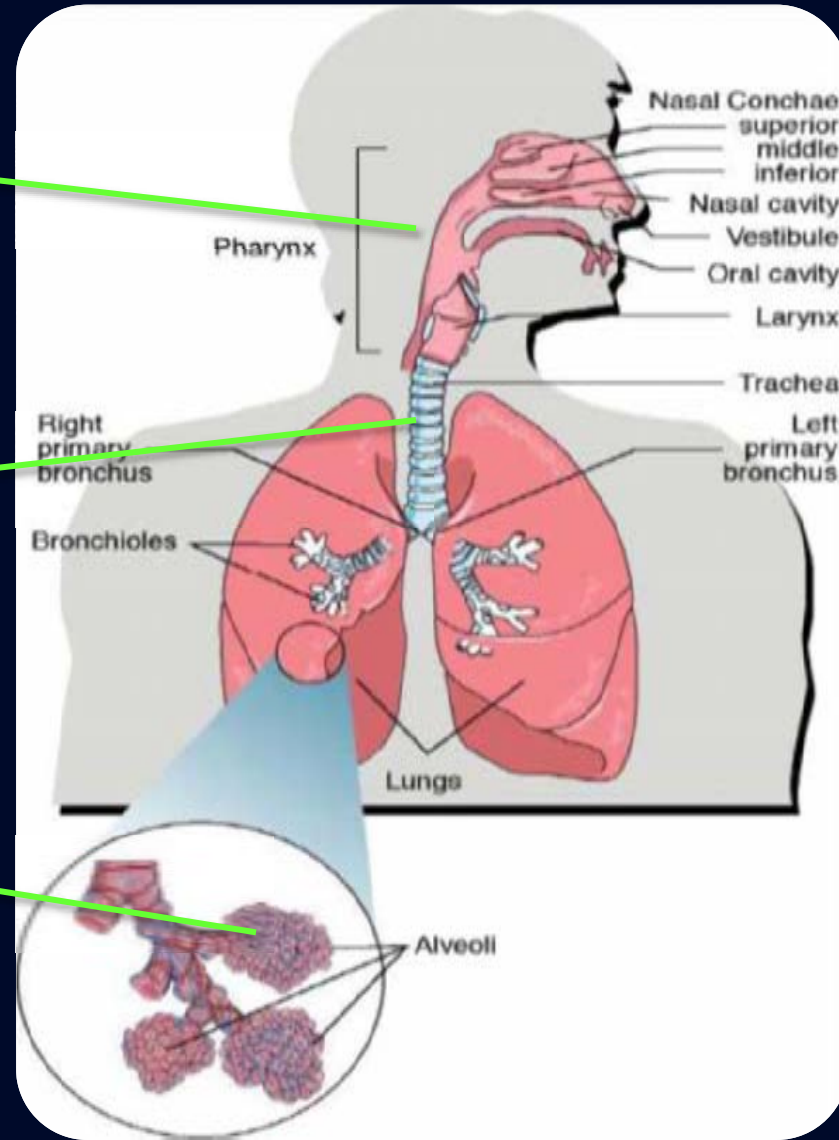
Large and water-soluble PMs are removed

Tracheo-bronchial region

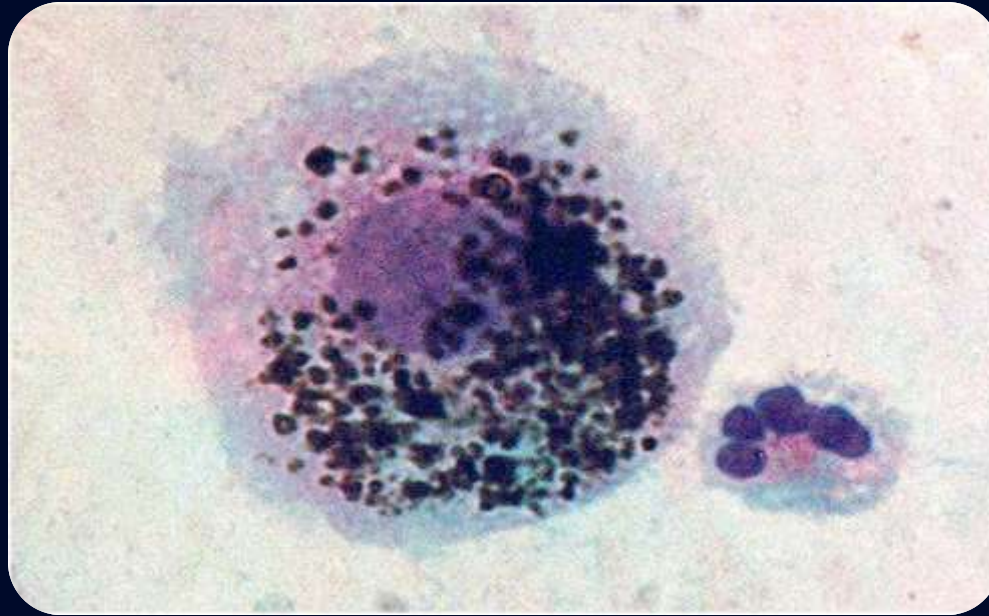
Smaller percentages of PM_{10} and $PM_{2.5}$ are deposited

Alveolar region

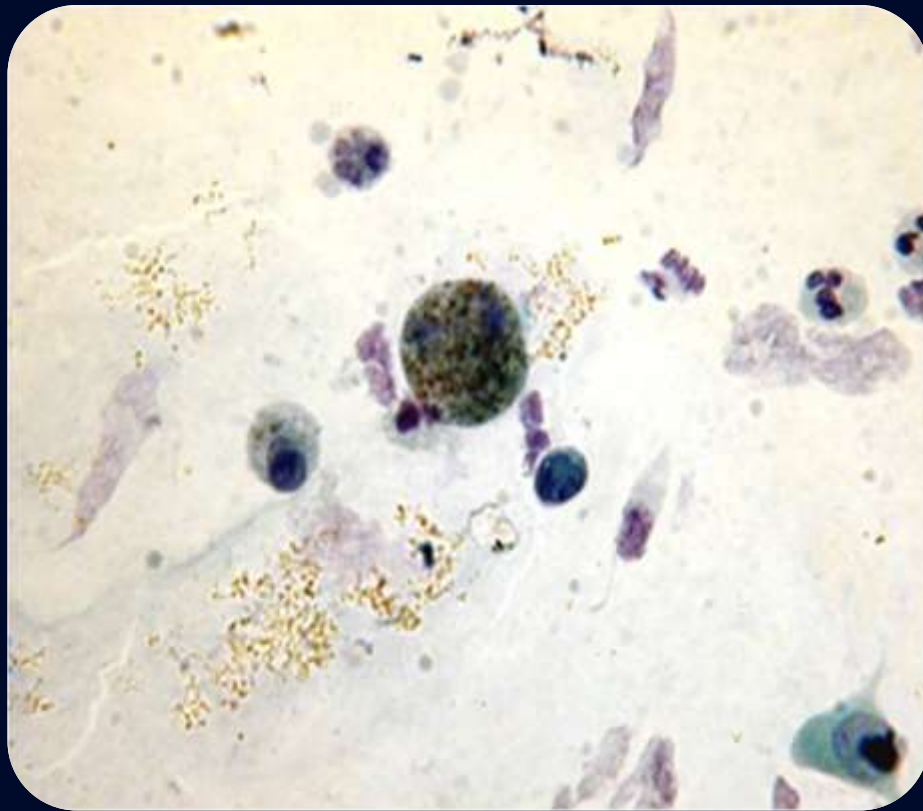
PM_{10} , $PM_{2.5}$ and UFPs are deposited; a fraction of UFPs migrate to circulation



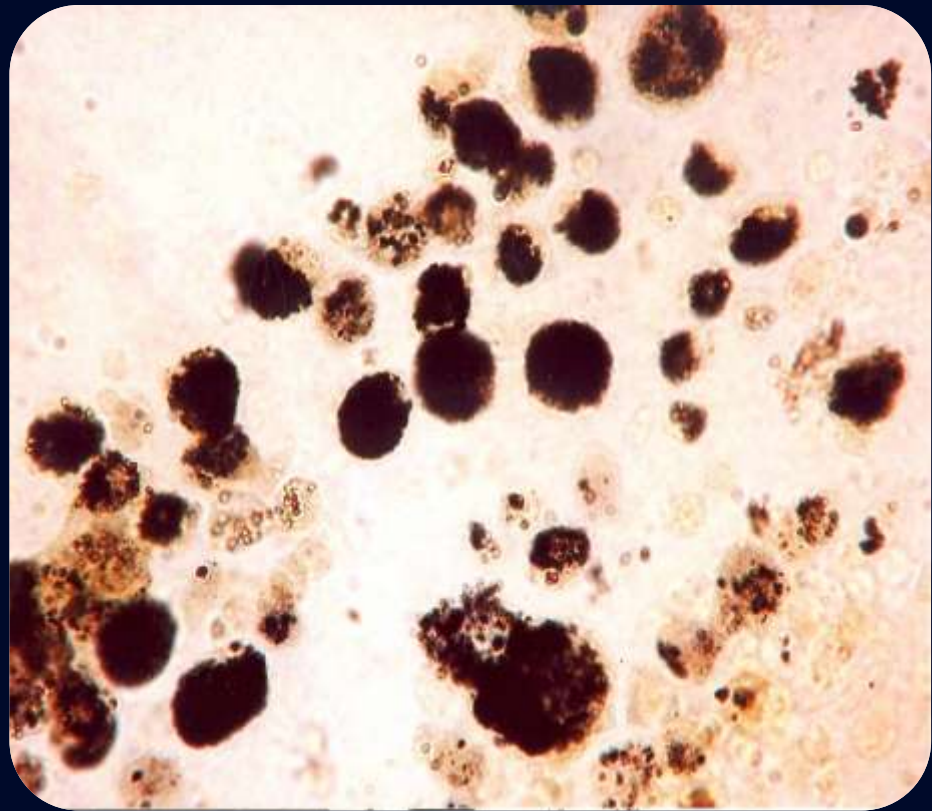
Alveolar macrophage biomarker of pollution exposure



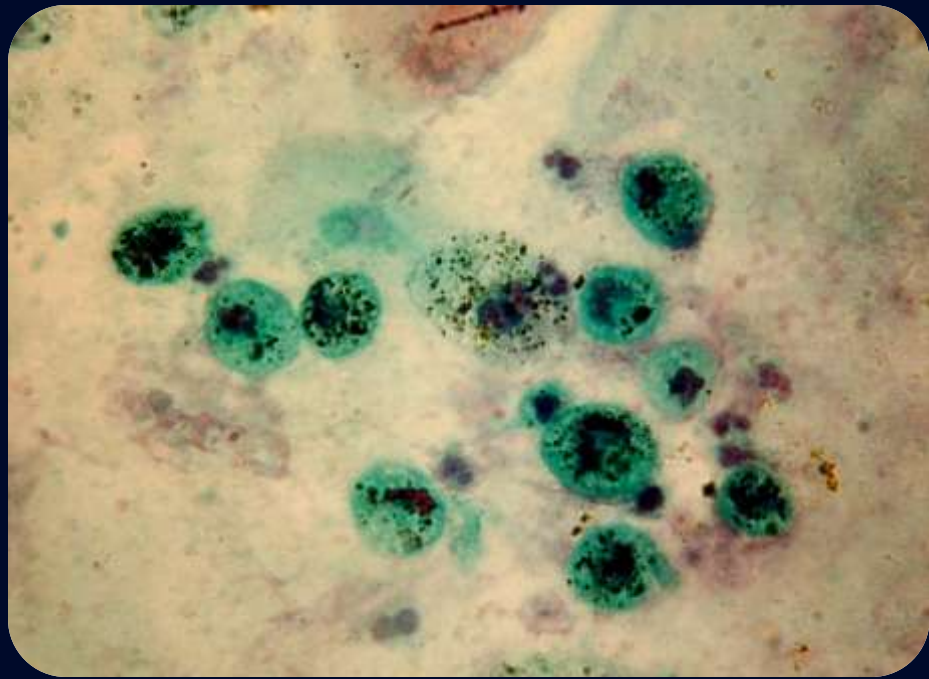
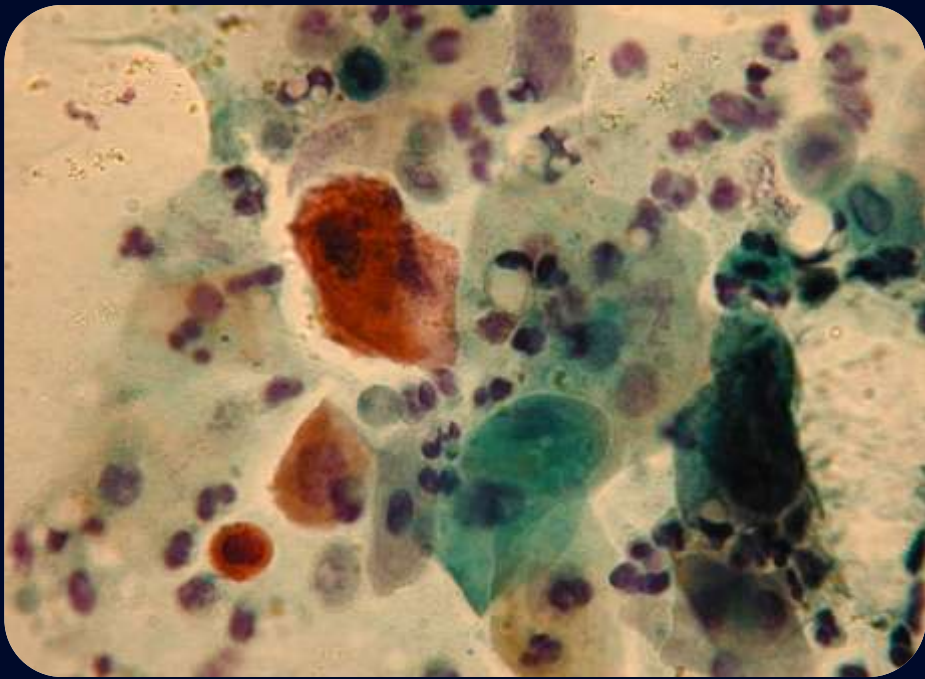
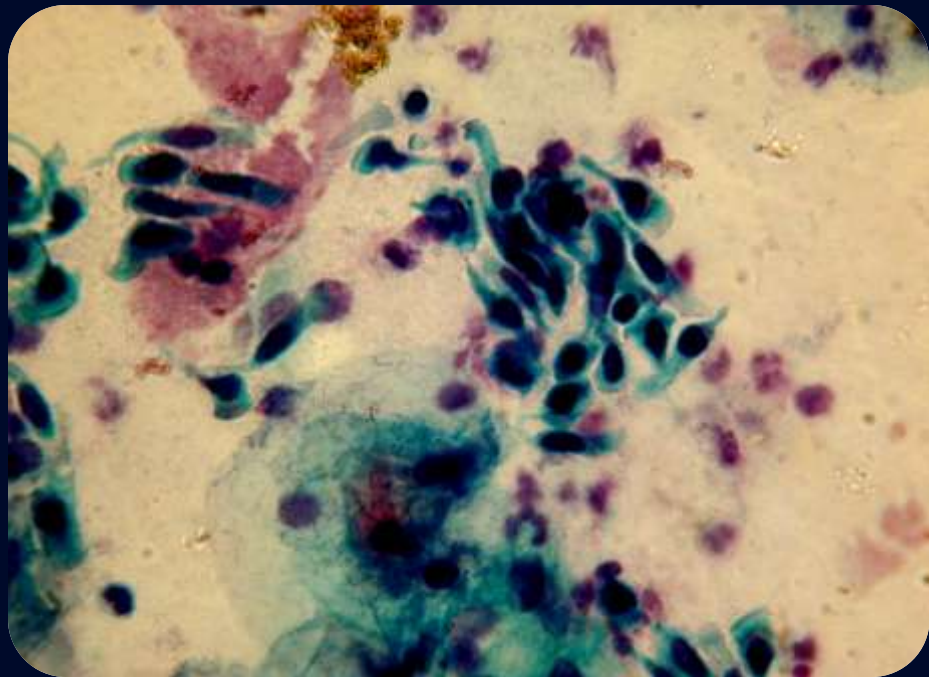
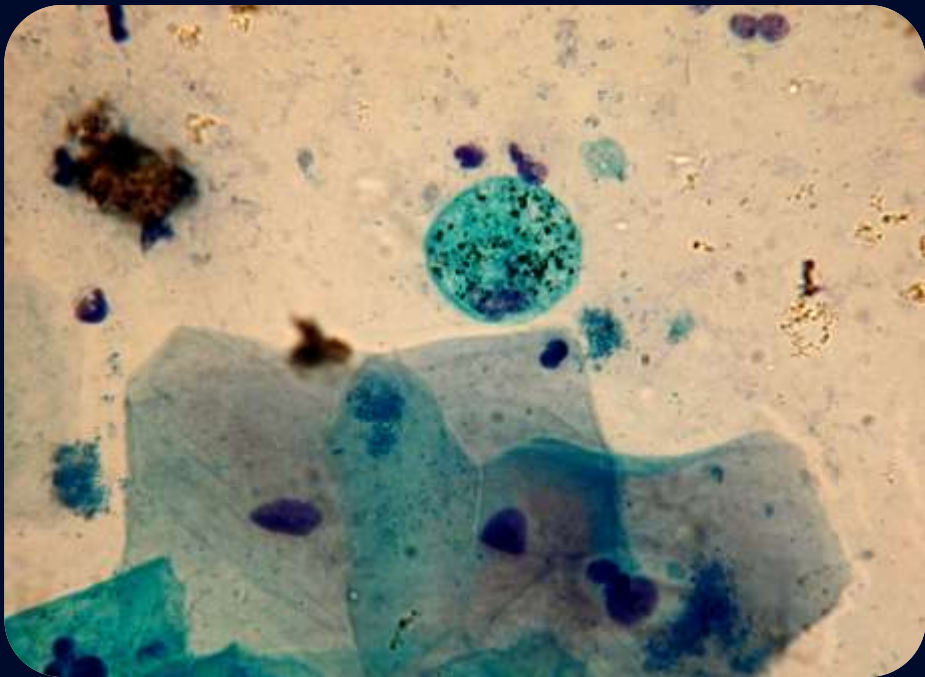
Alveolar macrophages (AM) engulf inhaled pollutants



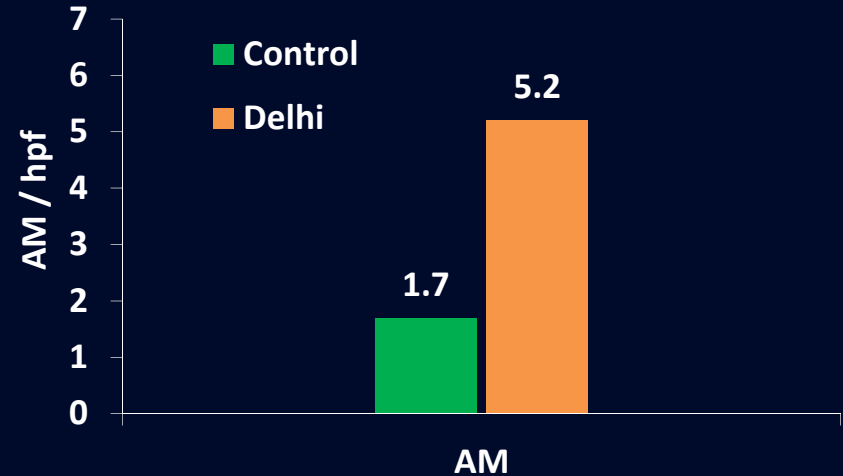
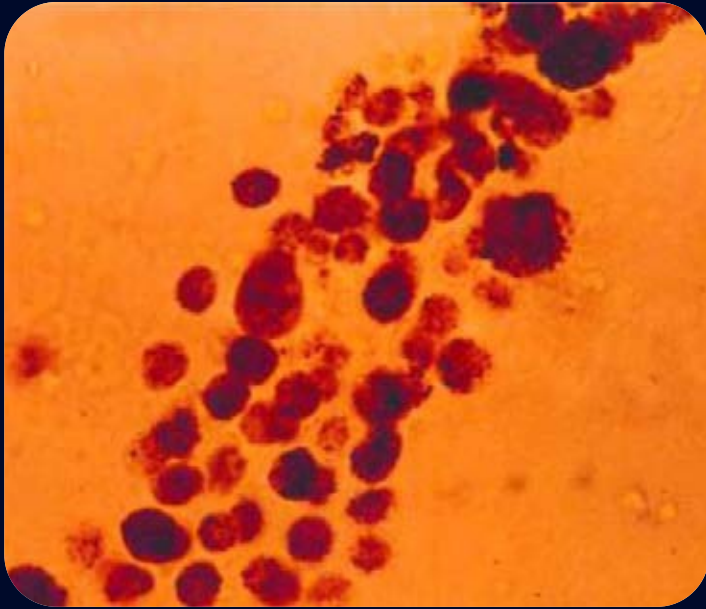
Control



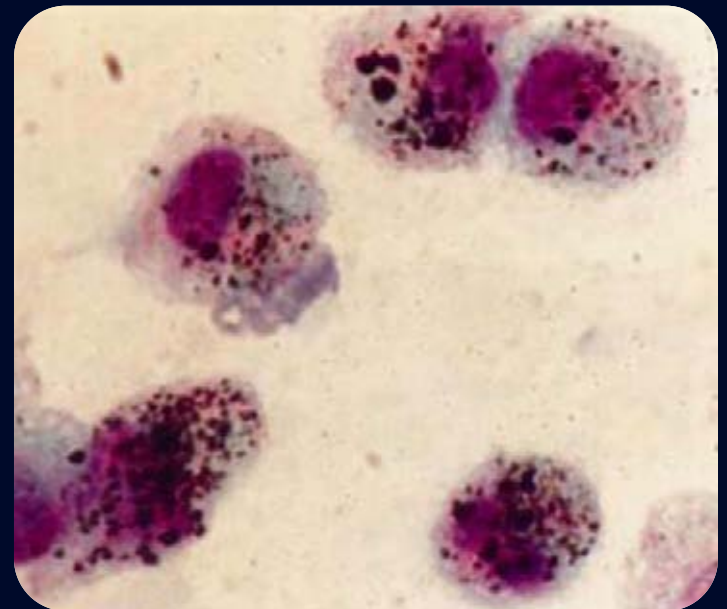
Exposed



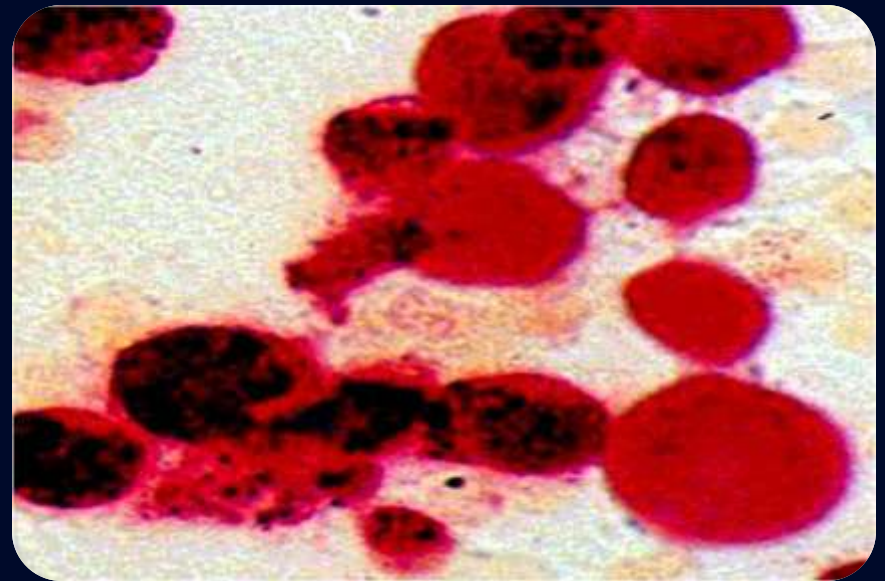
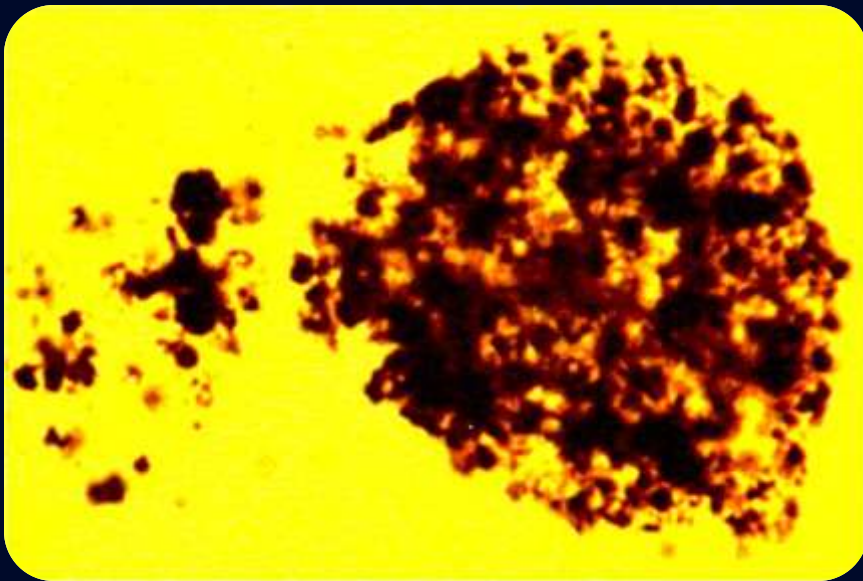
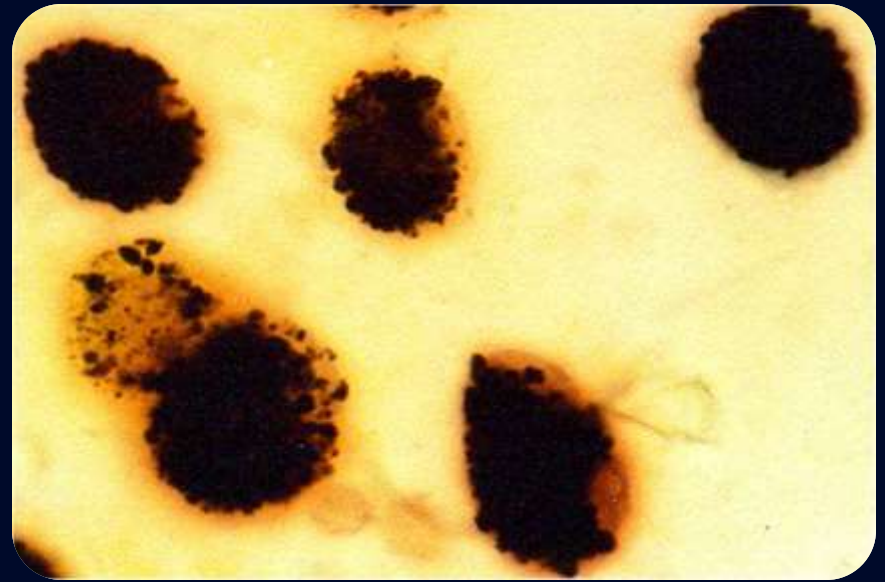
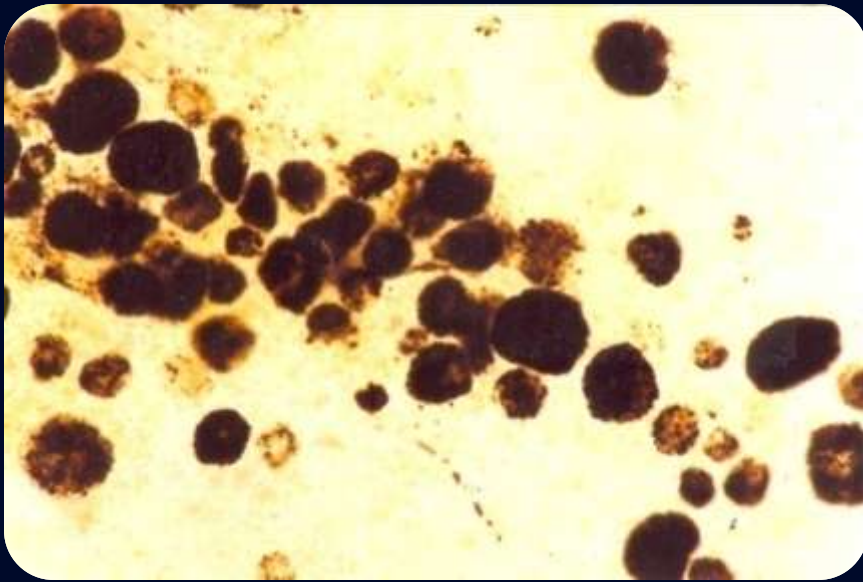
Alveolar macrophage: the biomarker of air pollution



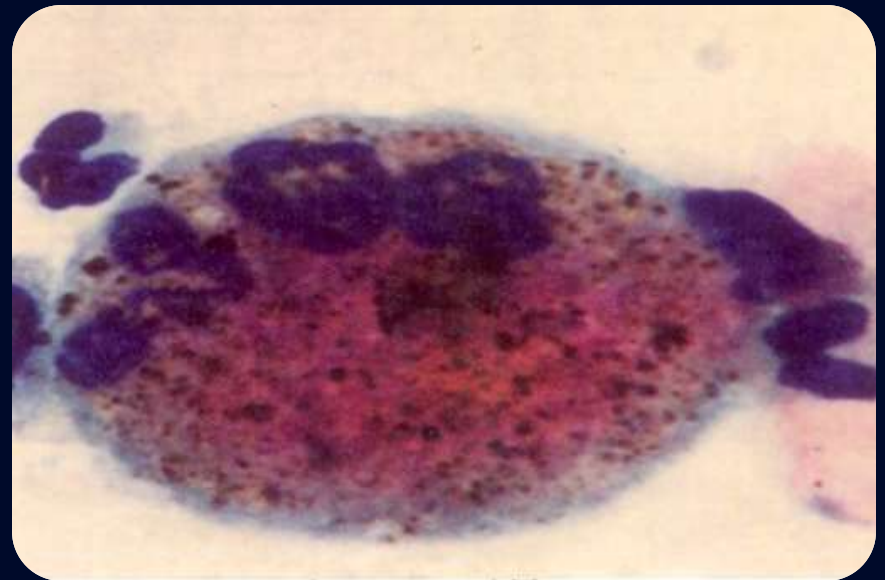
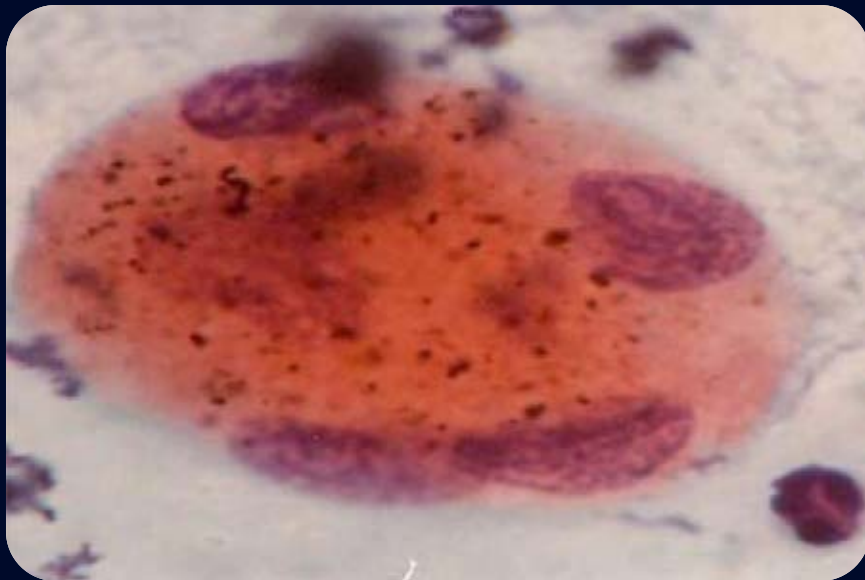
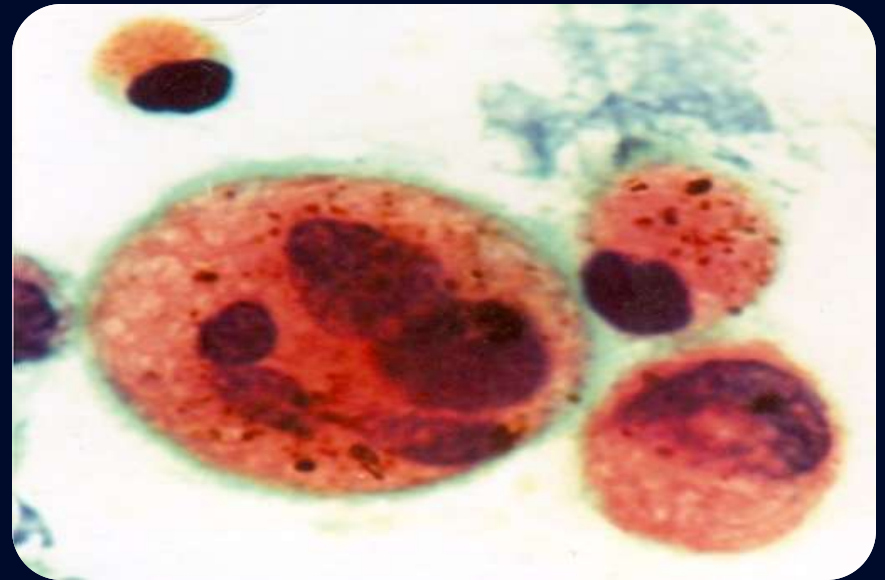
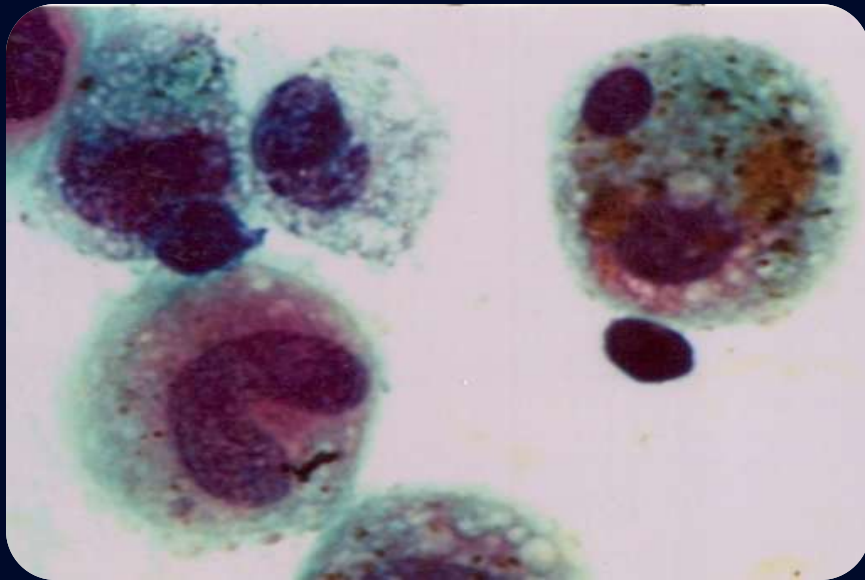
Sputum cytology of a 14-year old girl, showing abundance of particle laden AM



Alveolar Macrophage Response

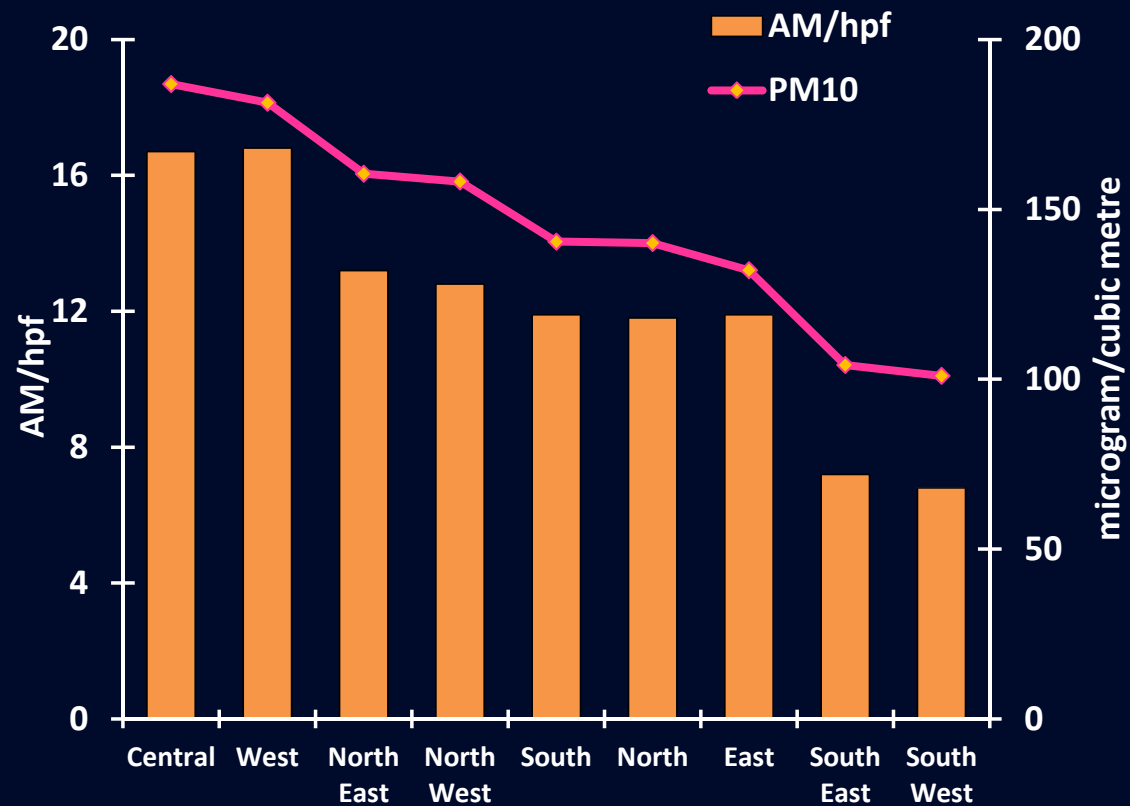
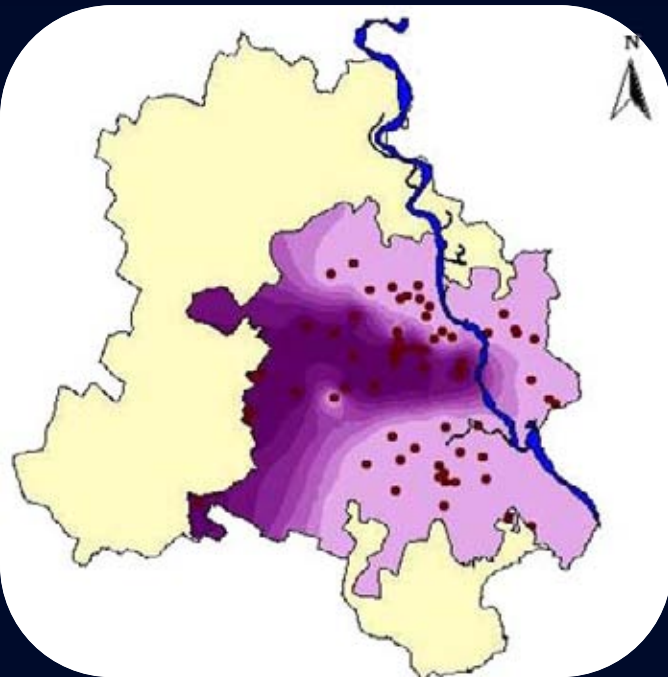
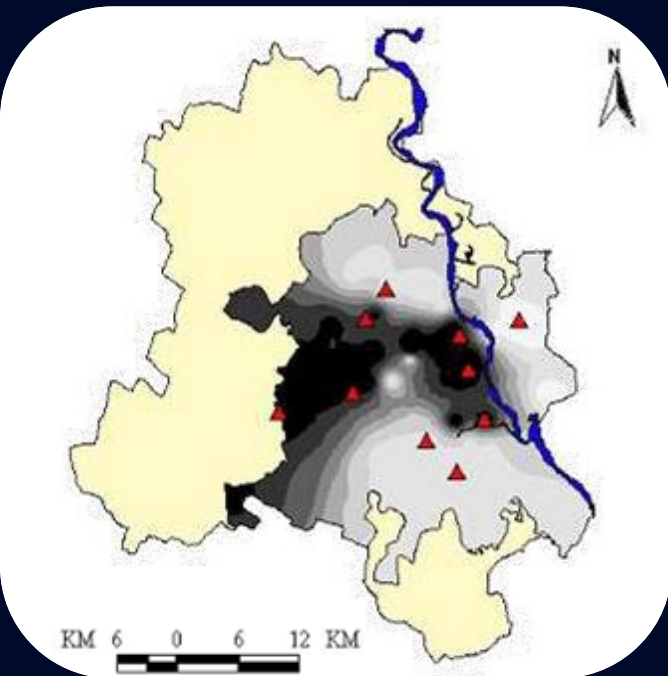


Nuclear heterogeneity of AM

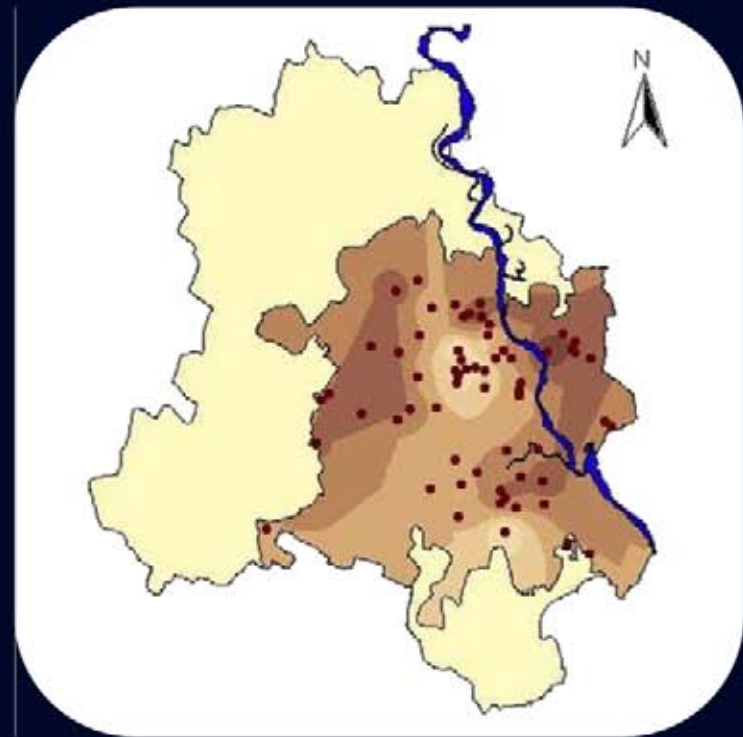
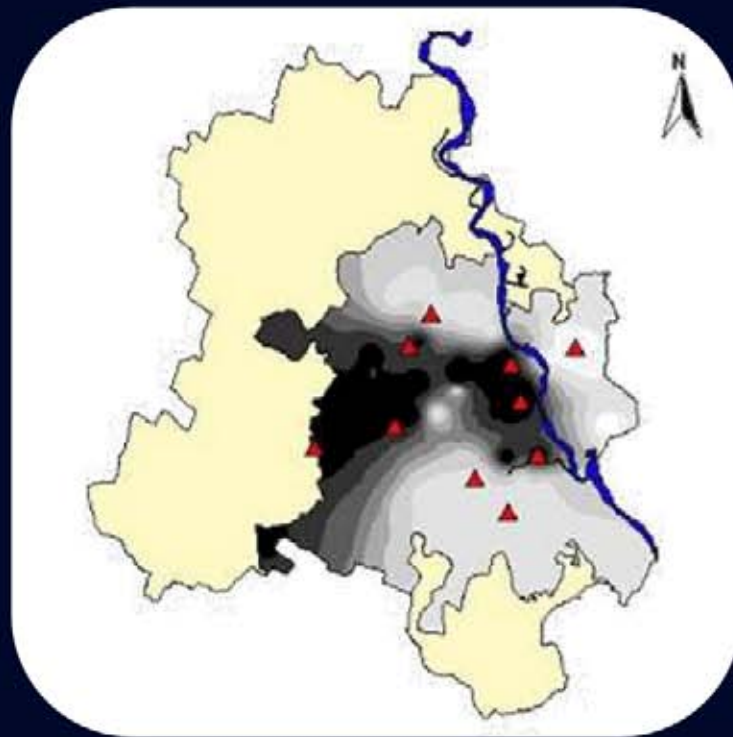


PM₁₀ and AM count

AM count correlated positively with PM₁₀ level
(rho=0.581, p<0.001)



PM₁₀ and respiratory symptoms



KM 6 0 6 12 KM

PM 10

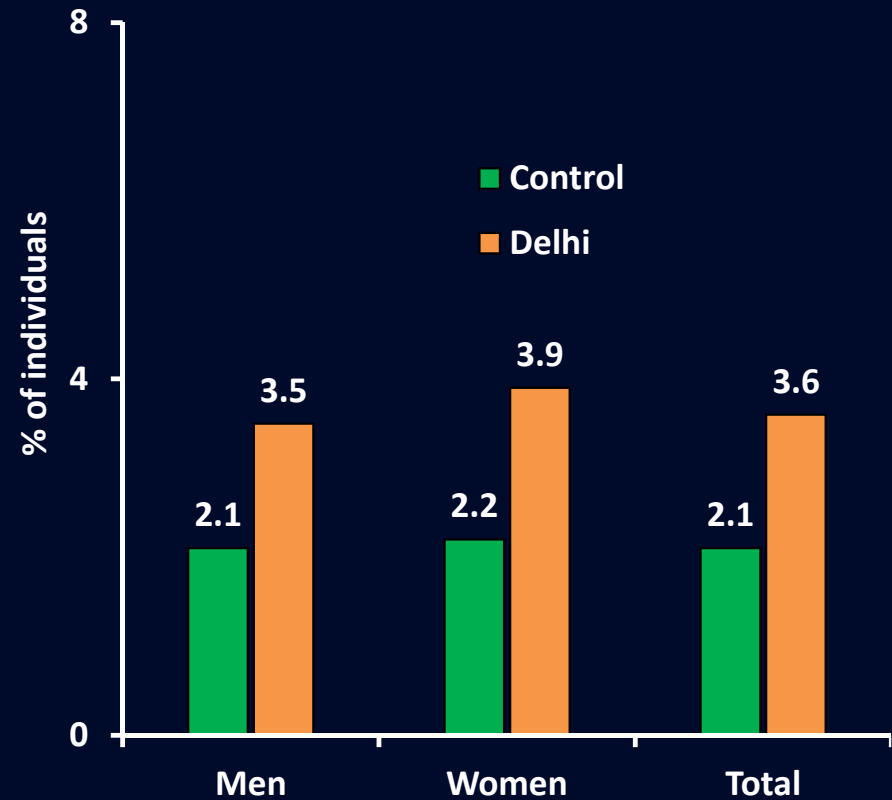
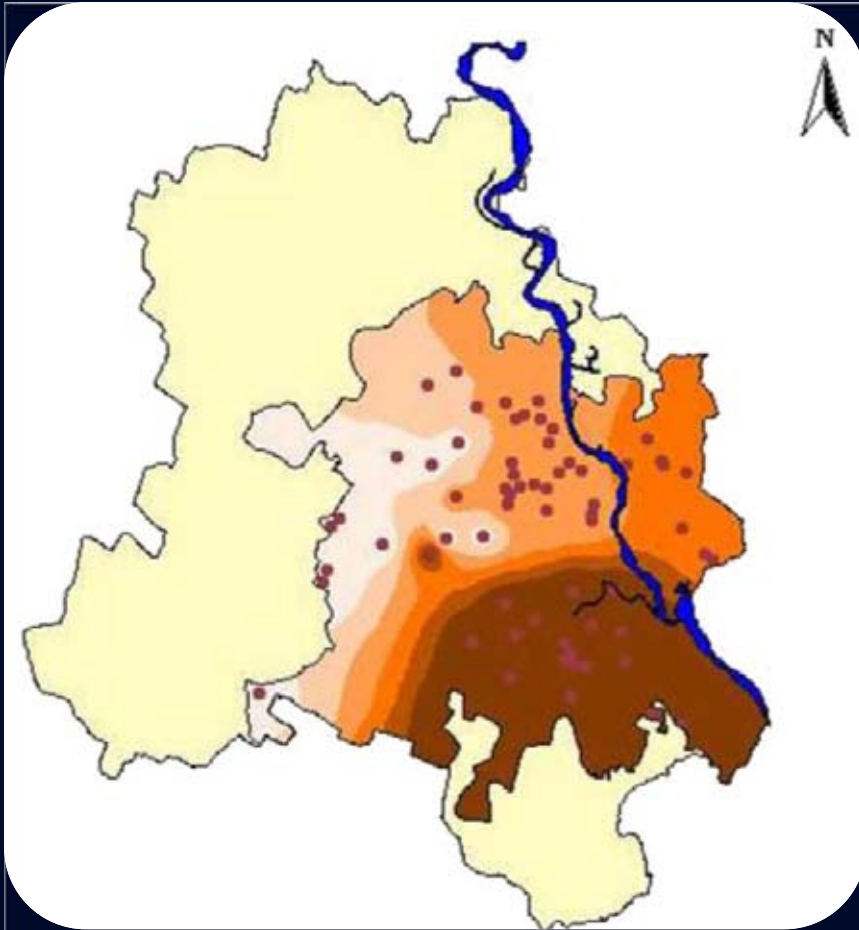
130 - 137	158 - 165
137 - 144	165 - 172
144 - 151	172 - 179
151 - 158	179 - 186

- ▲ MONITORING SITES
- CAMP SITES
- R. YAMUNA
- GREATER DELHI

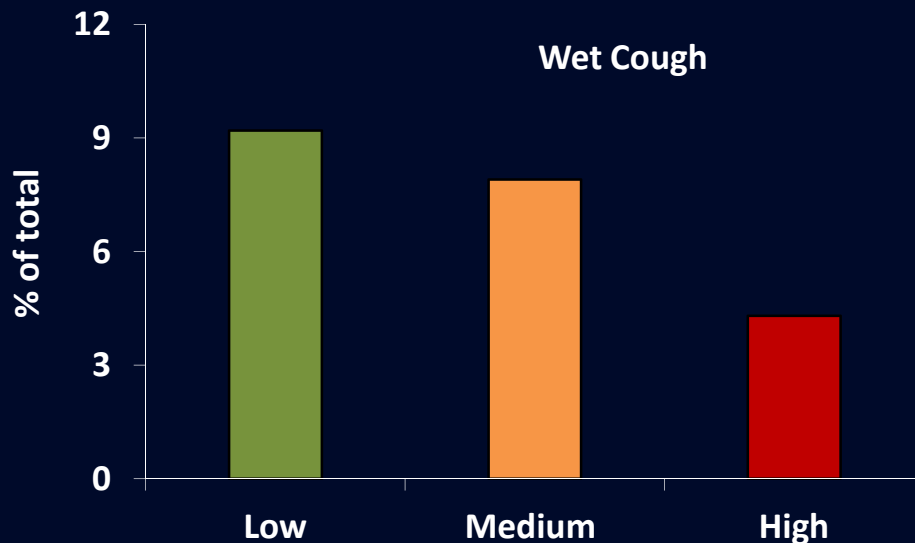
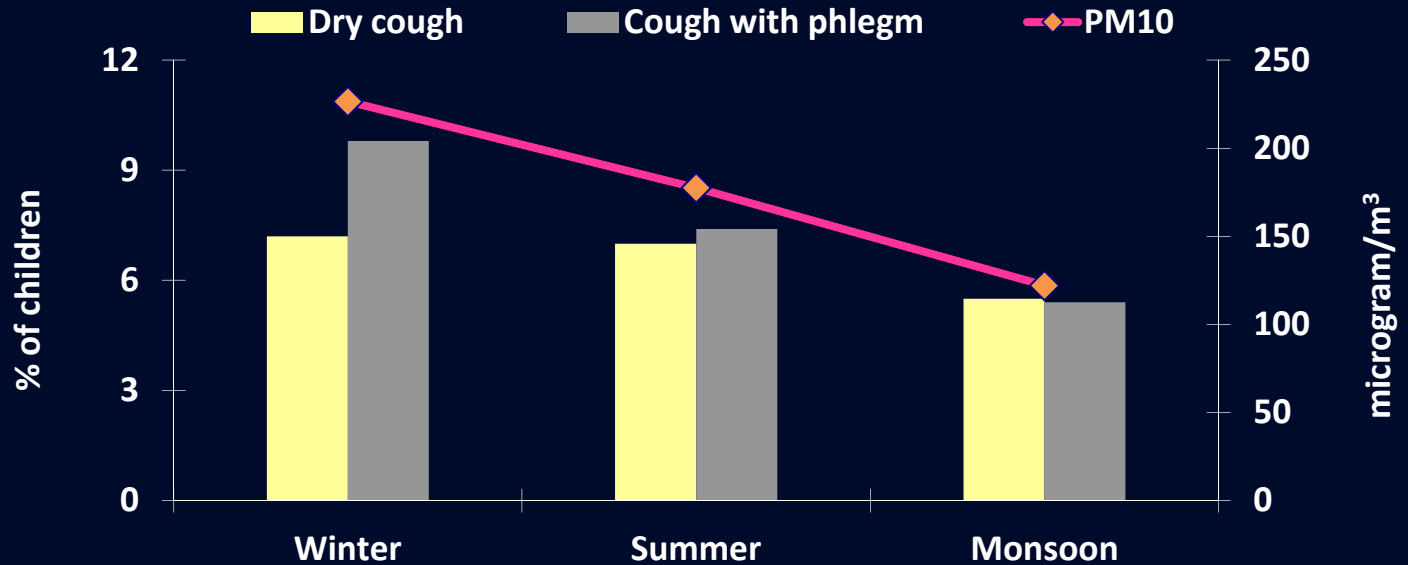
RSC

5 - 9	21 - 25
9 - 13	25 - 29
13 - 17	29 - 33
17 - 21	33 - 37

Prevalence of bronchial asthma



Lower Respiratory Symptoms



Inverse relation with SES

SES	Dry cough	Wet cough
High	1	1
Medium	2.31* (1.96-2.73)	1.72* (1.48-2.01)
Low	3.34* (2.83-3.95)	2.20* (1.89-2.57)

Strong positive association between PM₁₀ level and prevalence of LRS

PM ₁₀ (µg/m ³)	Dry cough	Wet cough	Wheeze	Breathless- ness	Chest discomfort	Disturbed Sleep
50-75	1	1	1	1	1	1
76-100	1.22* (1.04-1.47)	1.06 (0.84-1.29)	0.97 (0.76-1.14)	1.12* (1.02-1.44)	1.13* (1.02-1.34)	1.26* (1.10-1.48)
101-125	1.86* (1.54-2.24)	1.29* (1.06-1.57)	1.04 (0.72-1.38)	1.34* (1.14-1.83)	1.66* (1.27-2.14)	1.64* (1.25-2.13)
126-150	2.20* (1.81-2.68)	1.30* (1.09-1.56)	1.43* (1.12-1.77)	1.51* (1.22-1.78)	1.94* (1.53-2.44)	1.78* (1.33-2.27)
>150	3.12* (2.36-3.75)	3.03* (2.53-3.62)	1.67* (1.19-2.36)	2.84* (2.31-3.47)	2.65* (2.09-3.37)	2.73* (1.89-4.32)

*The results are expressed as odds ratio with 95% CI in parentheses; *, p<0.05*

Pulmonary function test



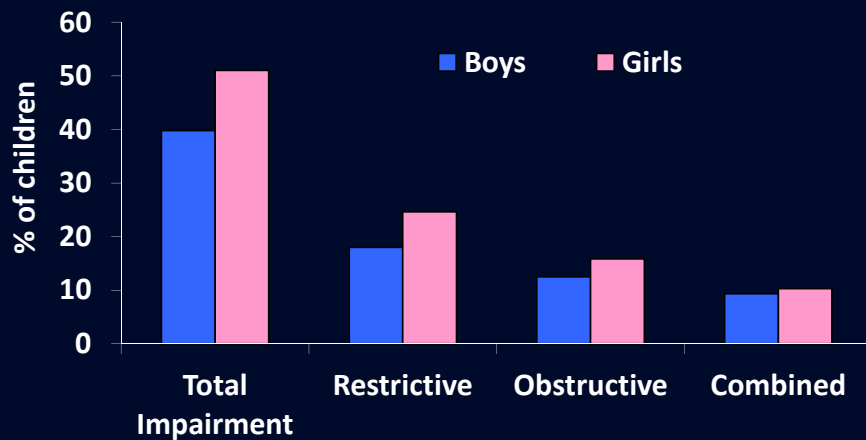
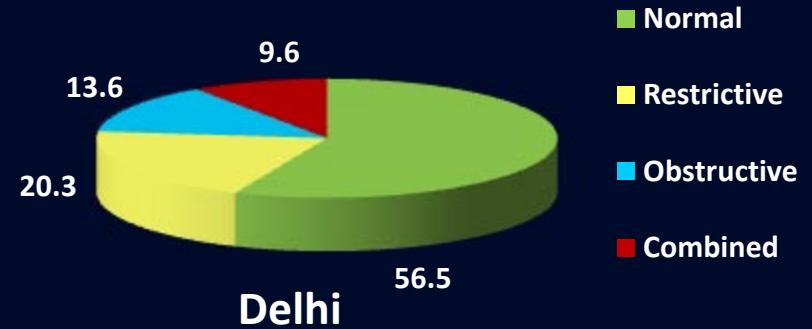
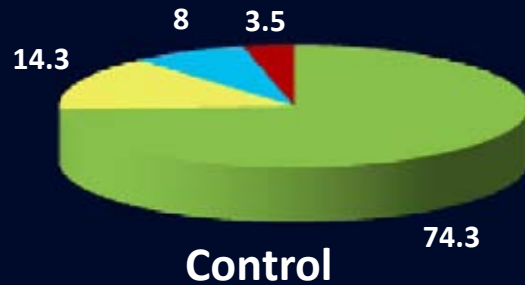
Assessed by spirometry using portable spirometer (Spirovit SP1, Schiller, Switzerland)



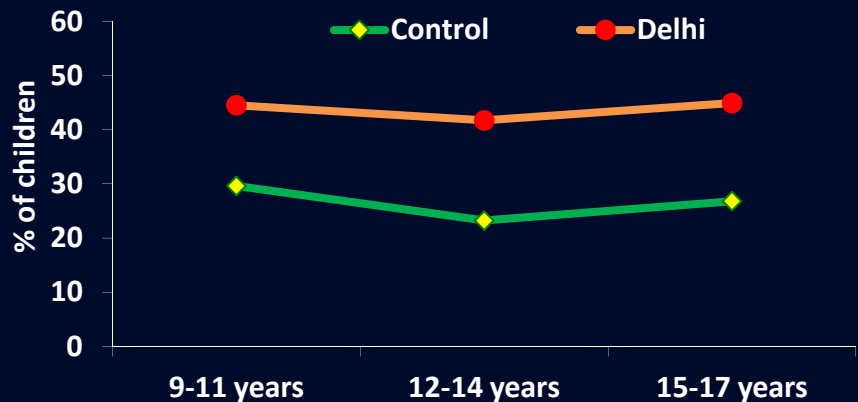
Parameters assessed : FVC, FEV₁, PEFR, FEF_{25-75%}

Lung function impairment categorized as restrictive, obstructive and combined defects & degree of impairment was ascertained

Overall prevalence of lung function deficits

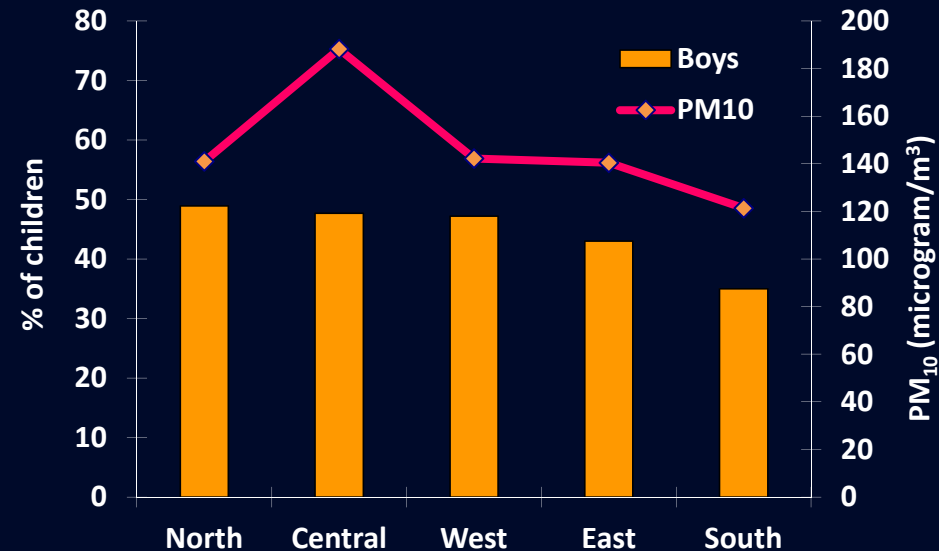
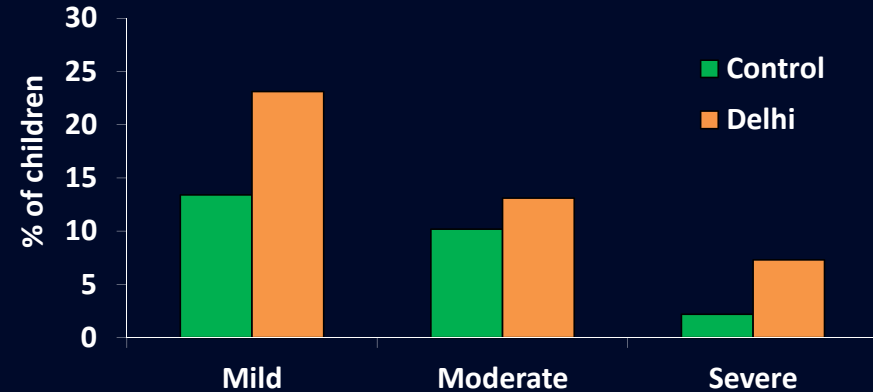
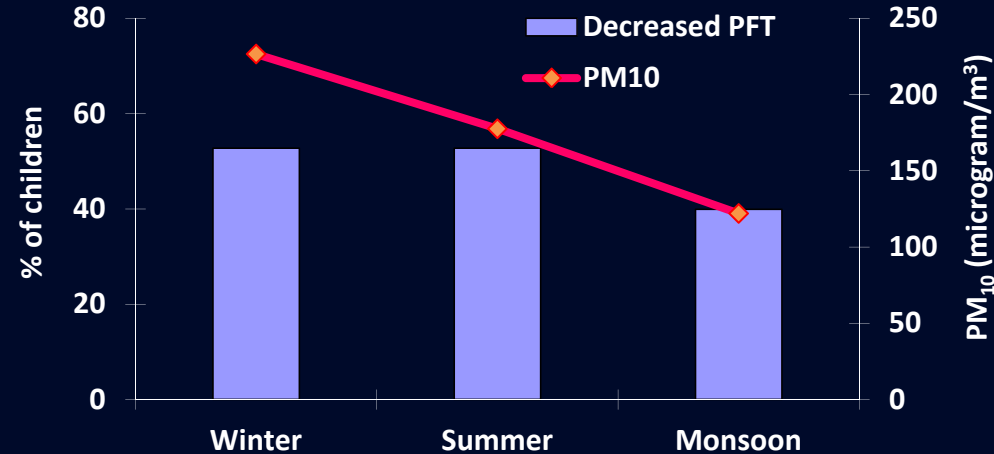


Lung function reduction was more prevalent in girls



Lung function reduction was highest (44.9%) in the age group of 15 – 17 years

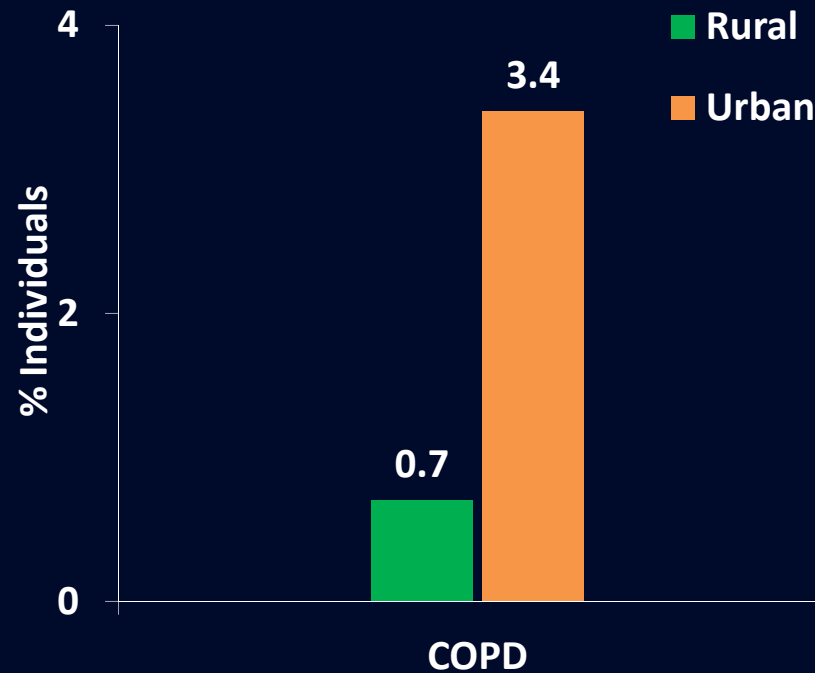
Reduced lung function



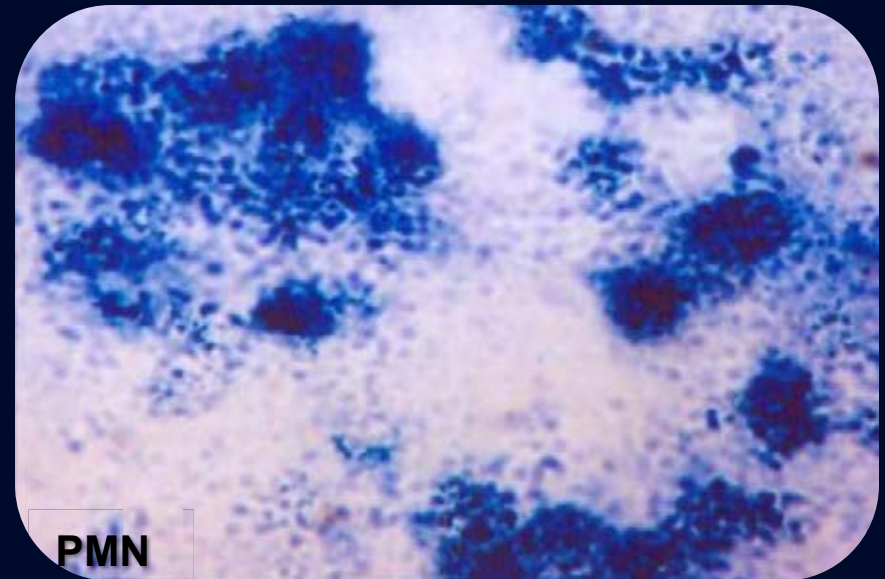
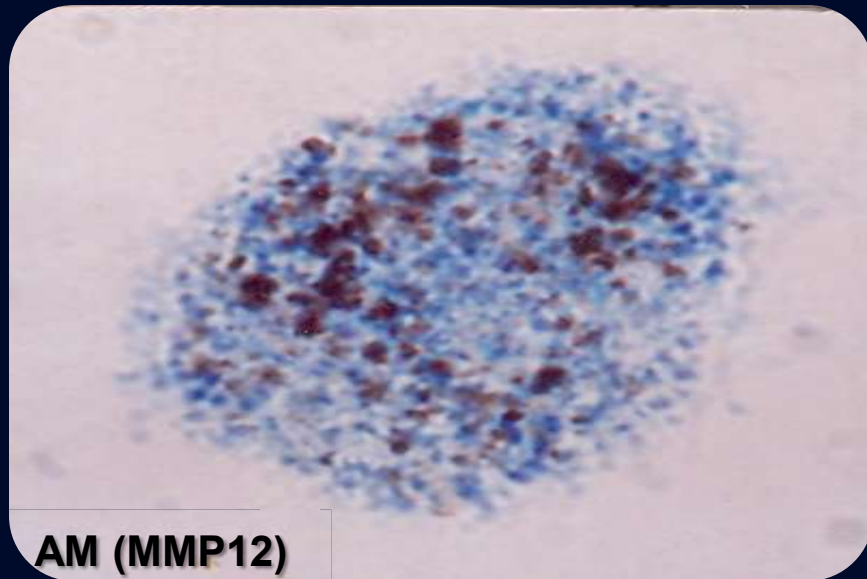
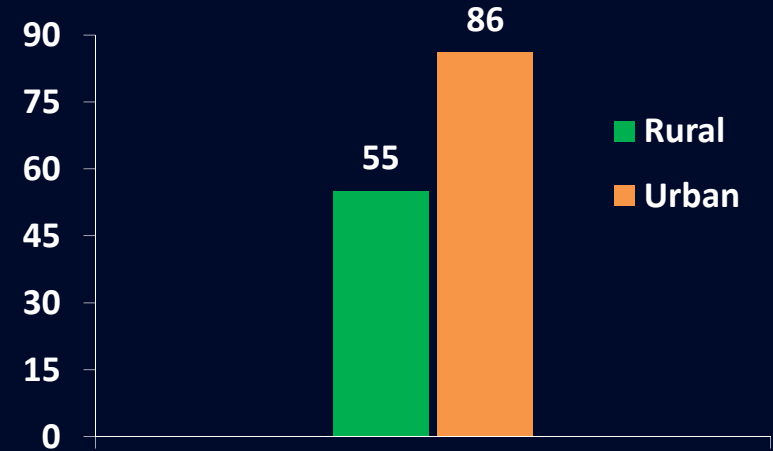
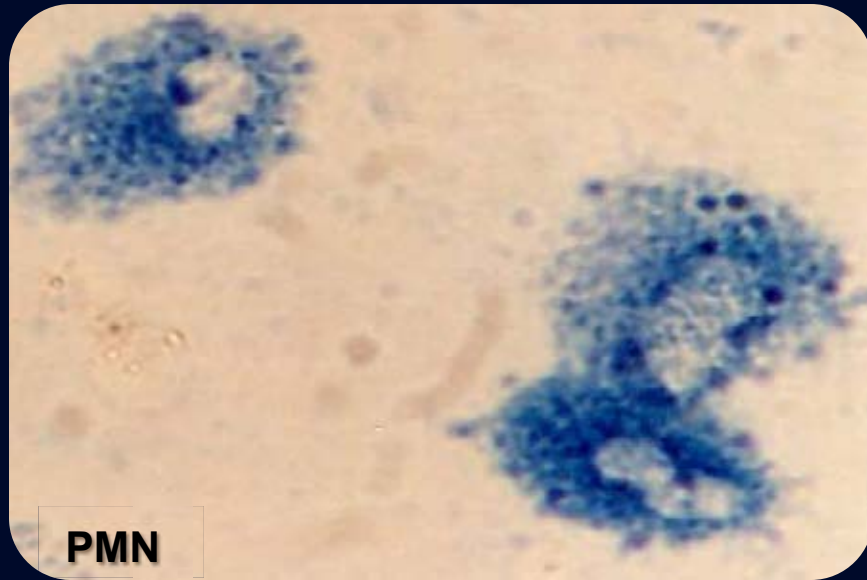
7.3% of children of Delhi had severe lung function deficits

Lung function decrement was highest in North Delhi (48.5%), and lowest in South Delhi (34.3%)

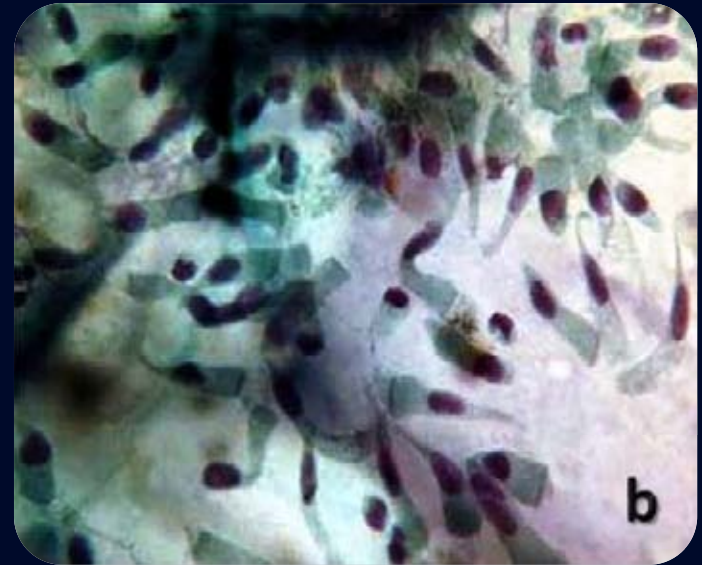
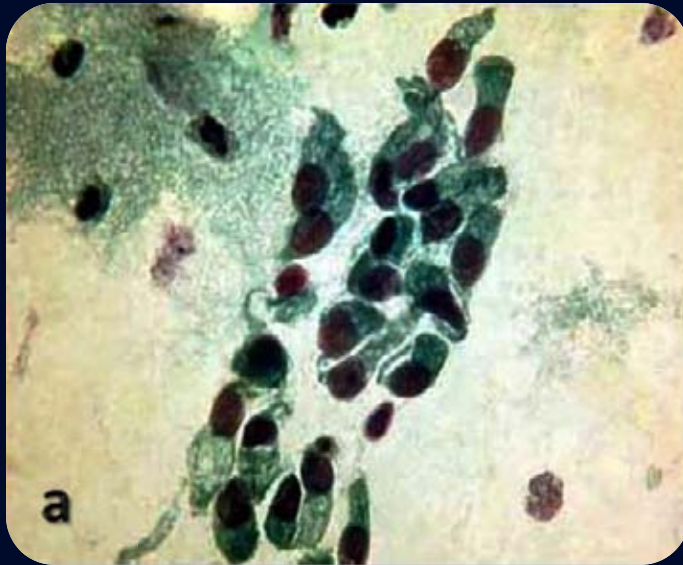
Air pollution and COPD among never-smokers

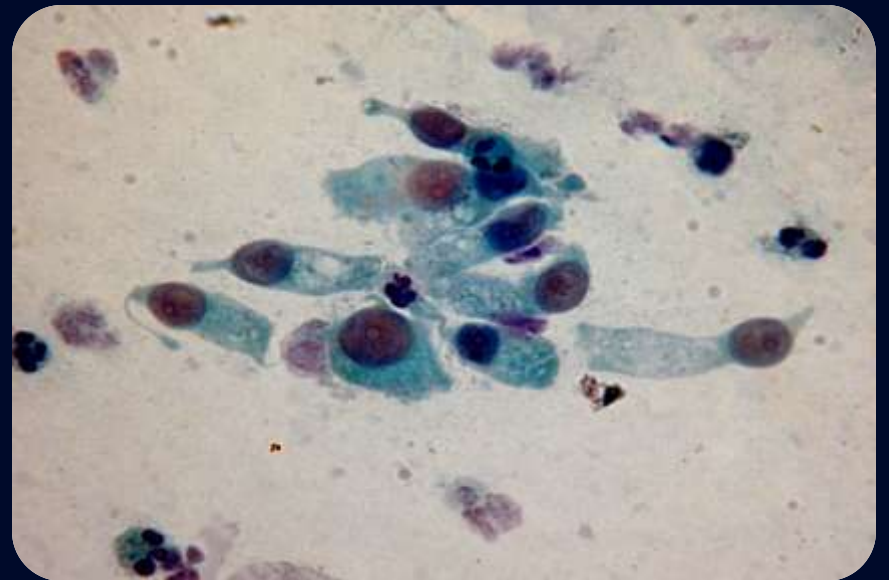
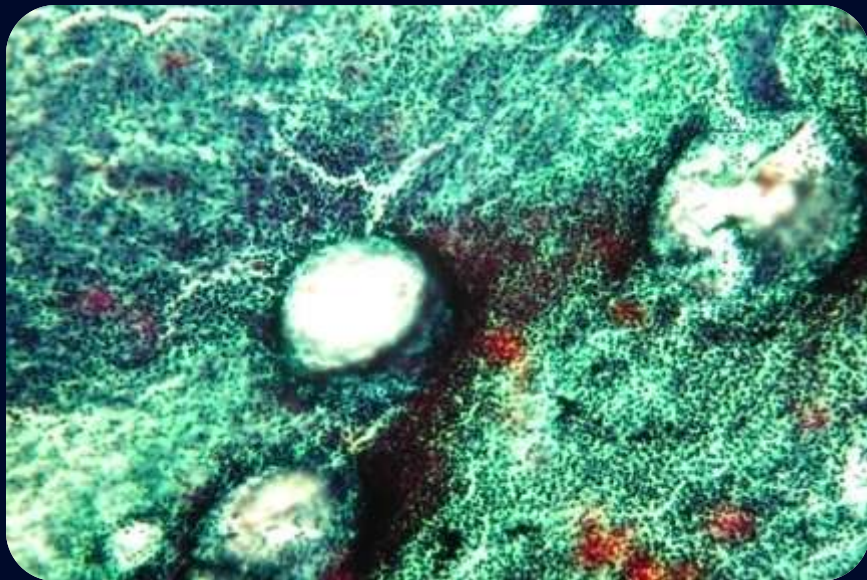
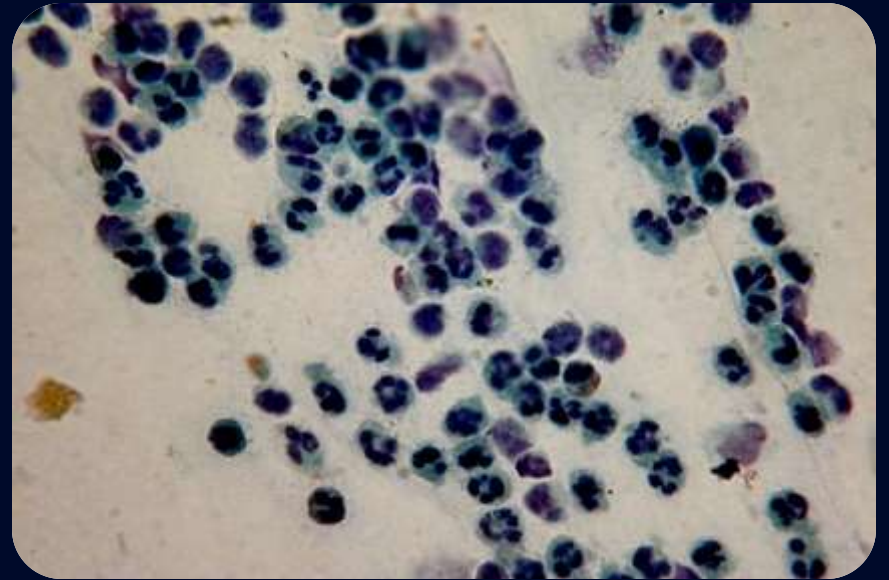
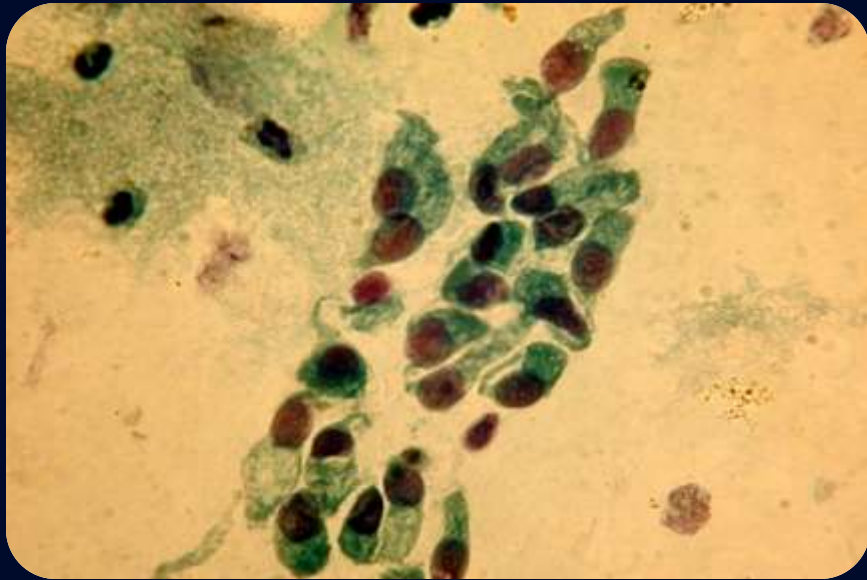


Elastase

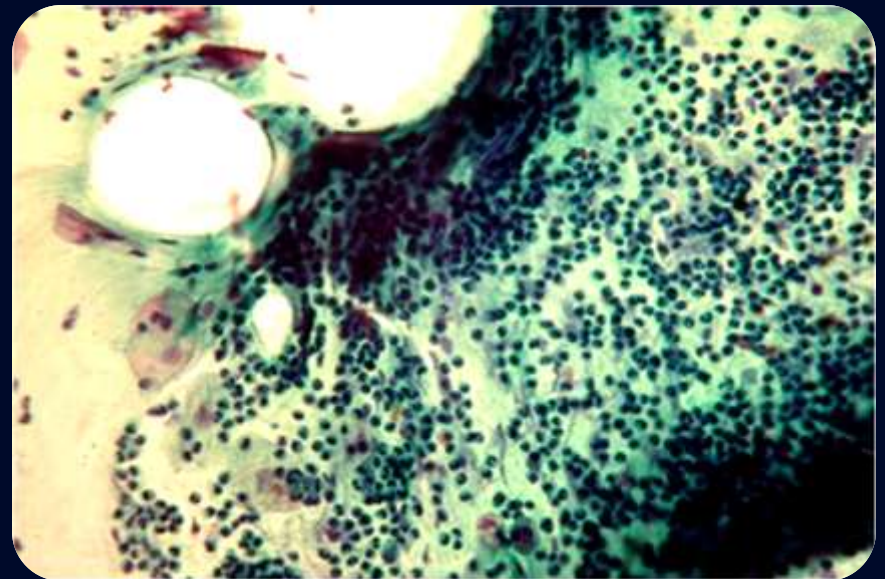
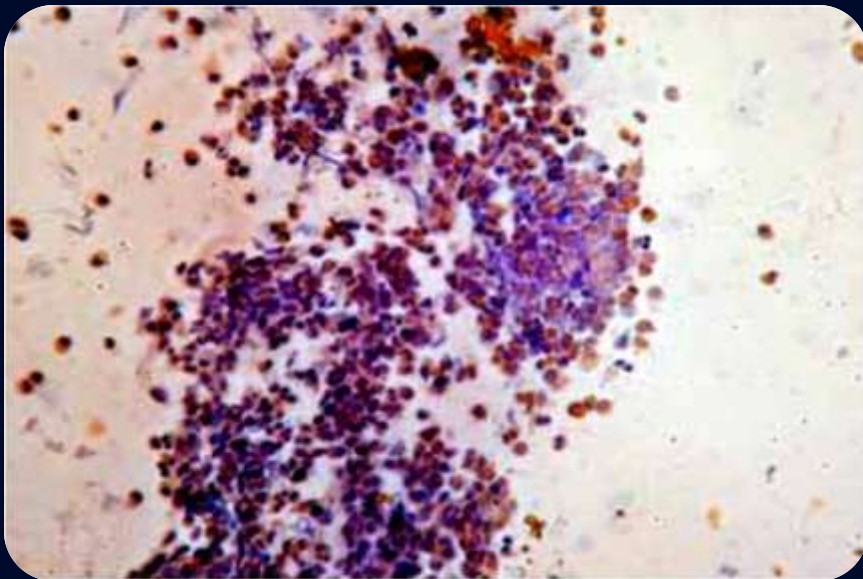
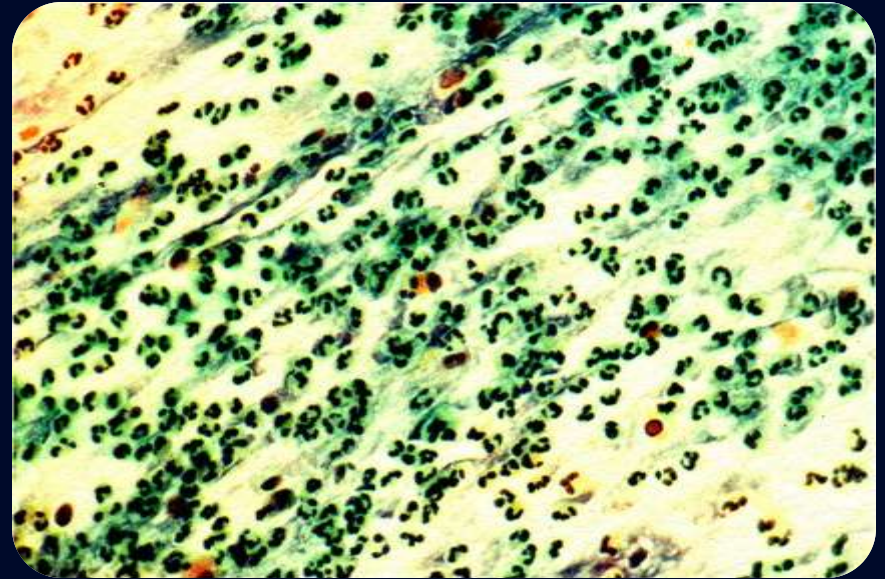
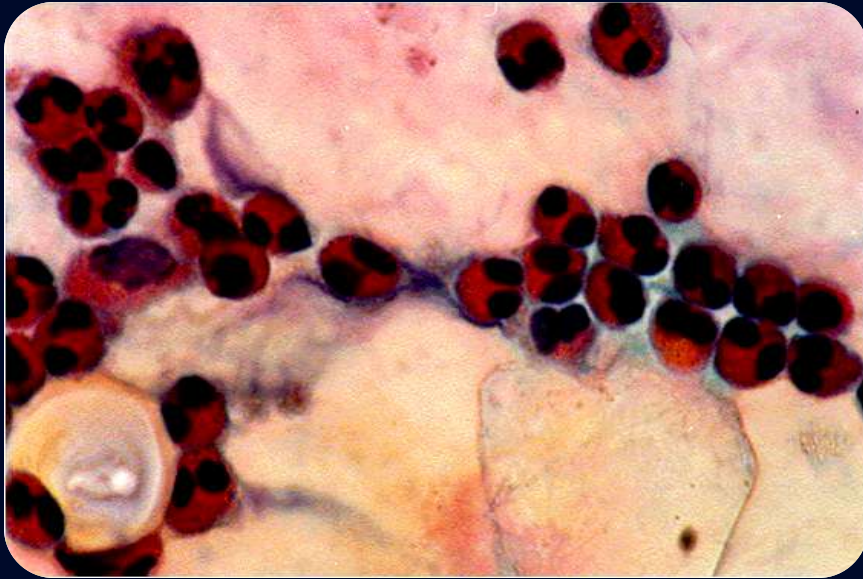


Adverse cellular lung reactions to chronic air pollution exposures

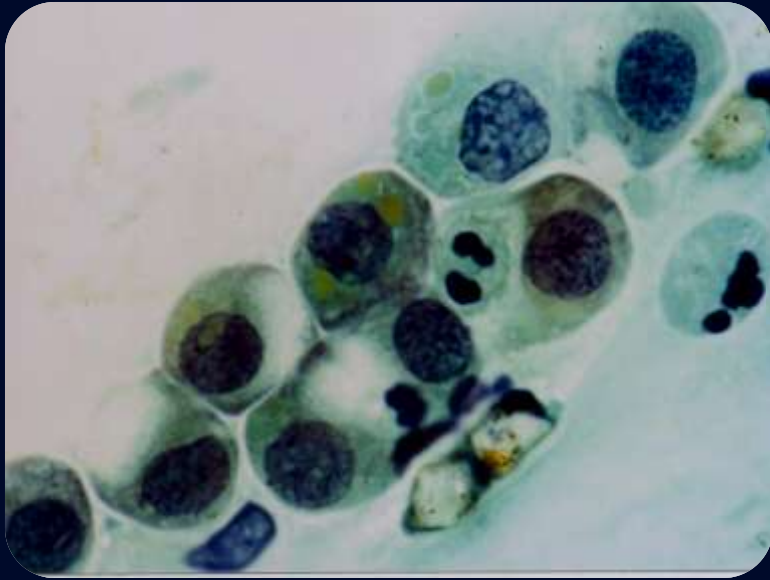




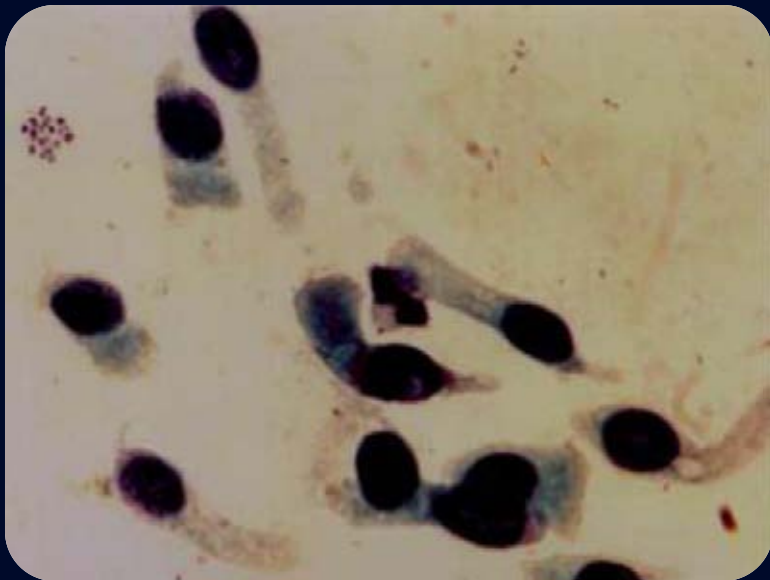
Airway Inflammation



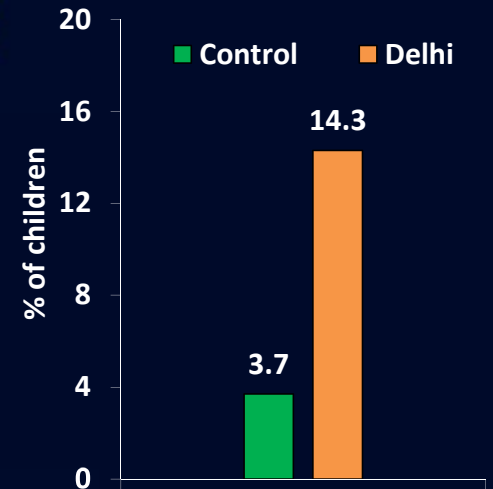
Changes in airway epithelial cells



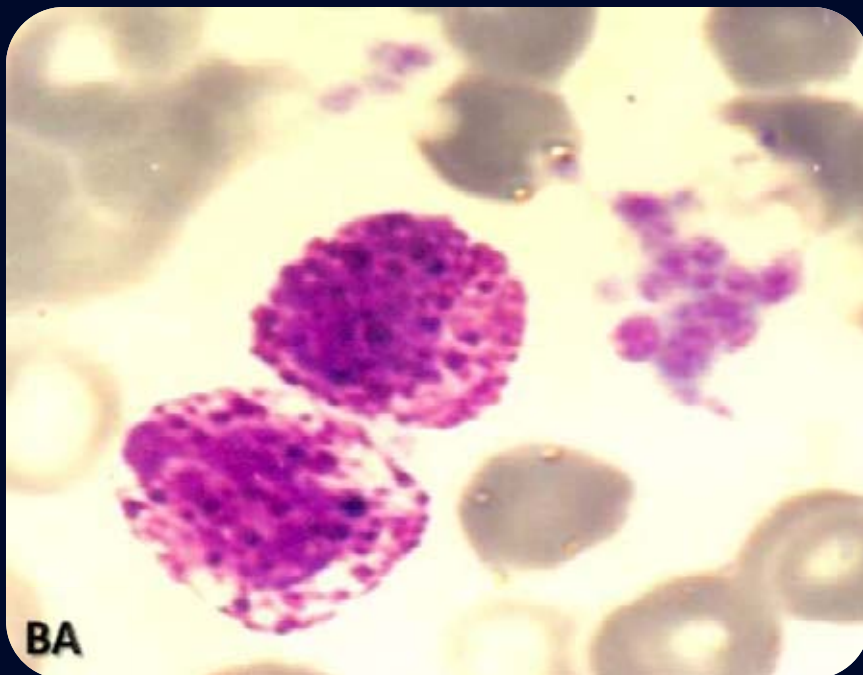
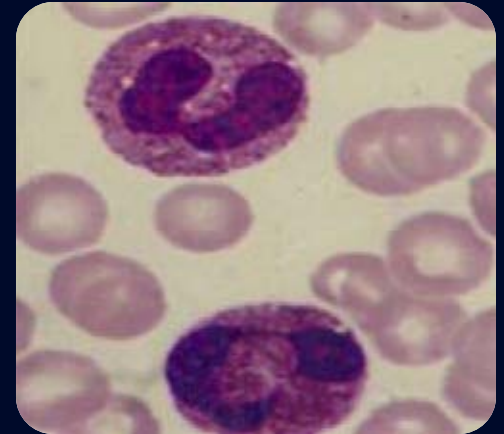
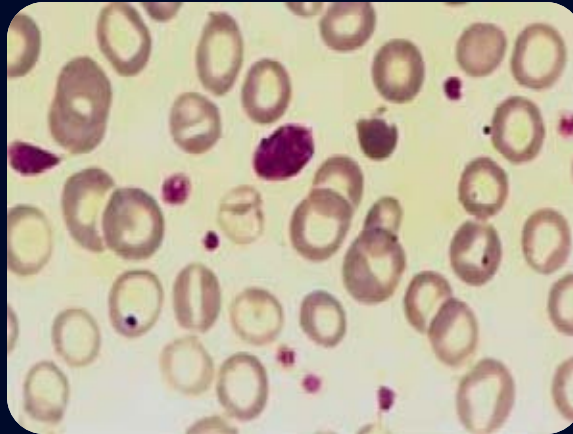
Goblet cell hyperplasia. The change indicates hypersecretion of mucous, a defence against pollutants



Aggregates of columnar epithelial cells, suggesting airway injury



Hematological changes



Alteration in immune status

increased susceptibility to disease

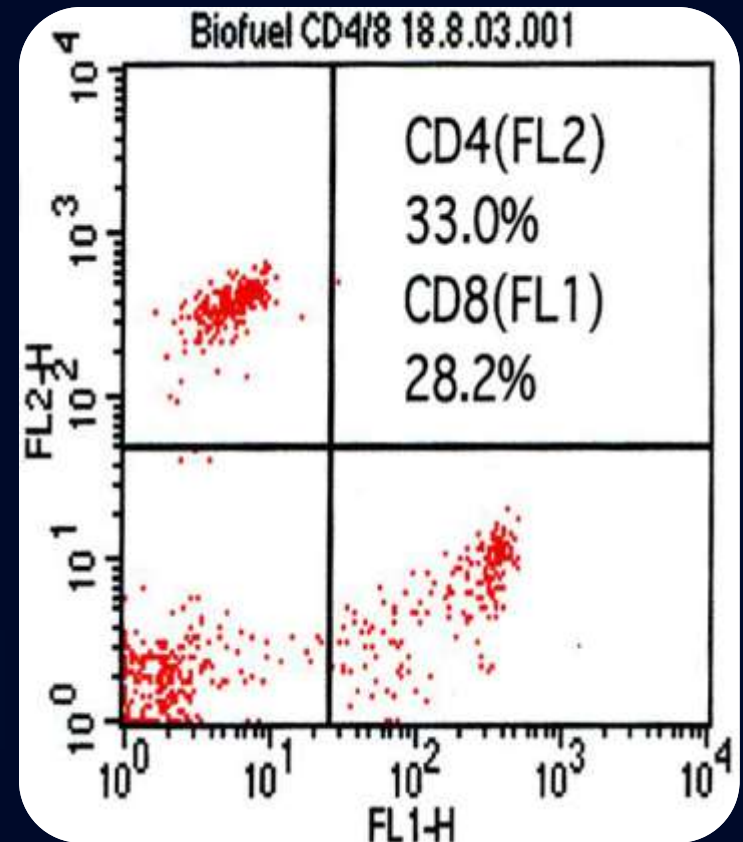
↓ suppression of CD4⁺ Th cells

↑ increase in CD 8⁺ Tc

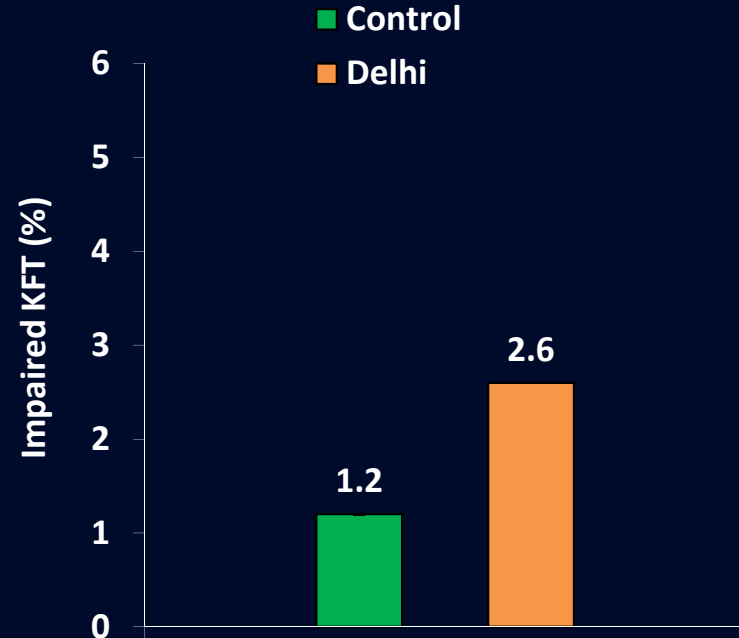
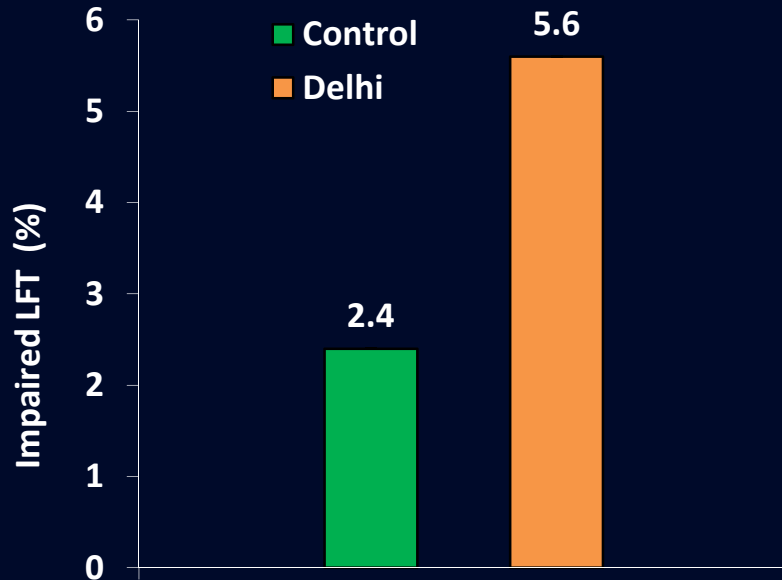
CD4:CD8 ratio 2:1 → 1:1

↓ decrease in CD19⁺ B cells

↑ increase in CD16⁺56⁺ NK cells

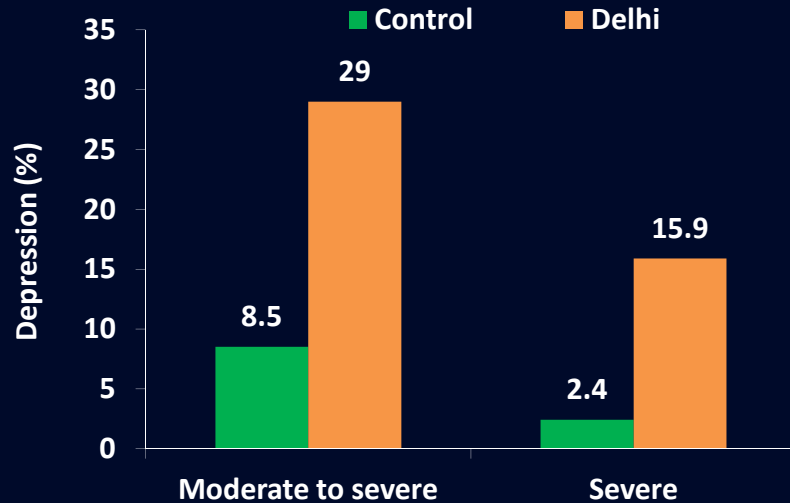


Liver and kidney function



- **2-fold rise in liver and kidney function impairments**
- **4-fold rise in diabetes: 7.4% in Delhi vs. 1.9% in control**

Neurobehavioral symptoms

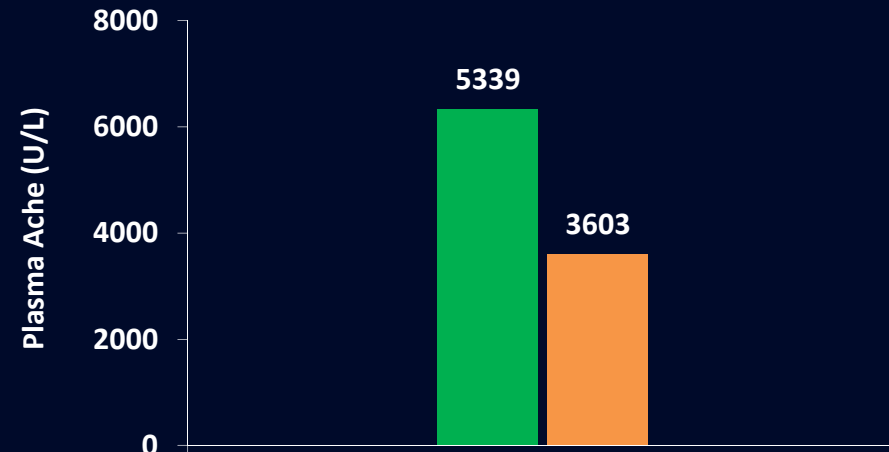
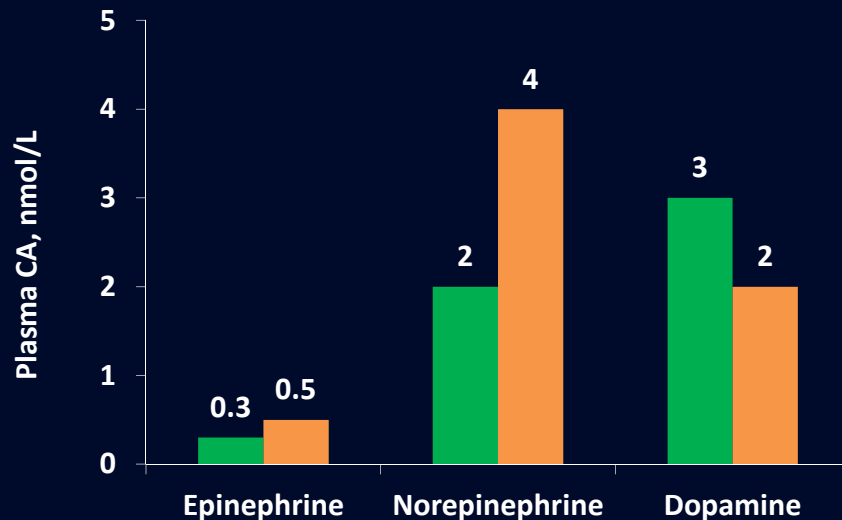


Depression: 2-times more in Delhi

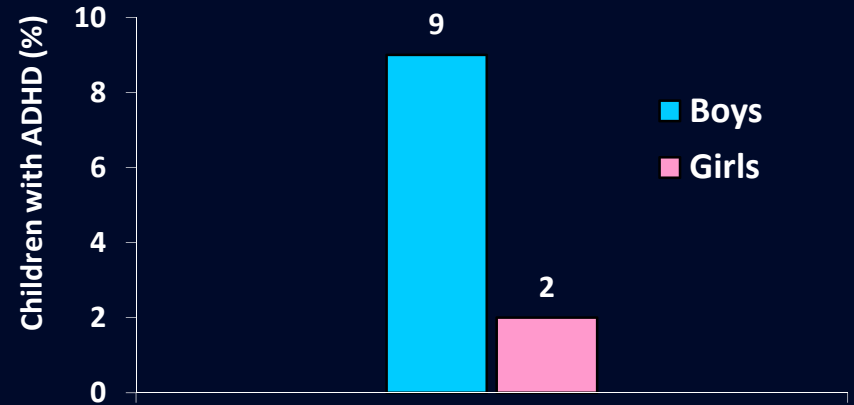
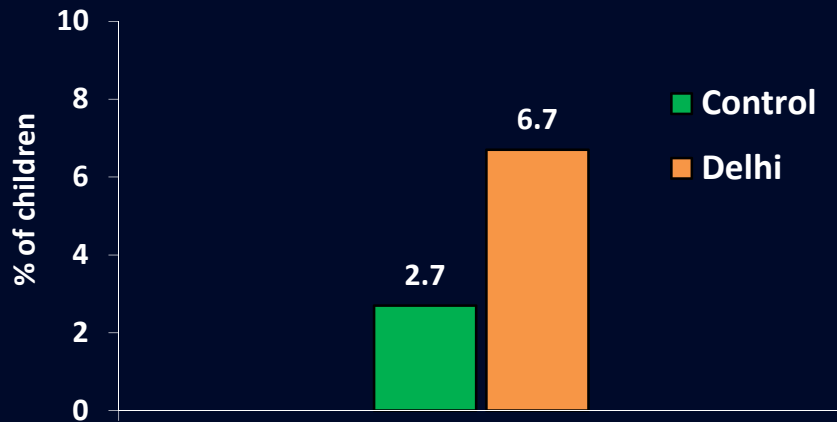
Significant alteration in plasma neurotransmitter level

Marked fall in plasma acetylcholinesterase activity

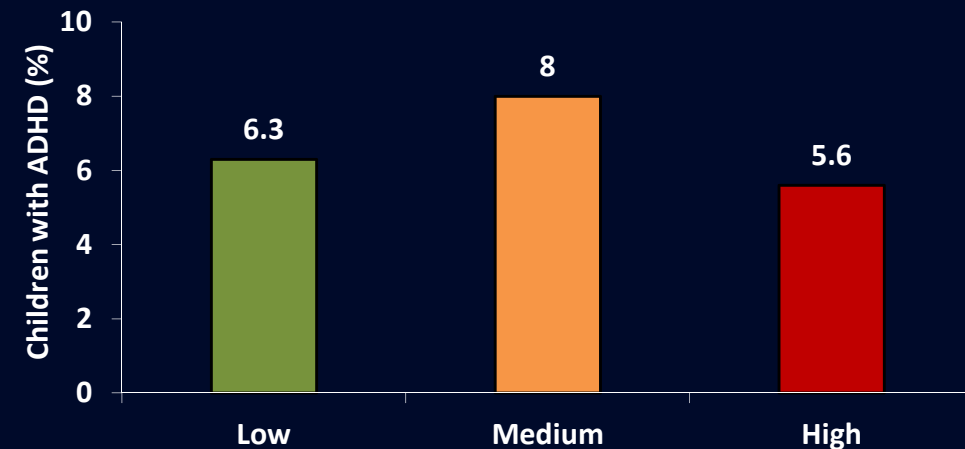
A positive association between PM₁₀ and depression (OR=1.83)



Attention Deficit Hyperactivity Disorder (ADHD)

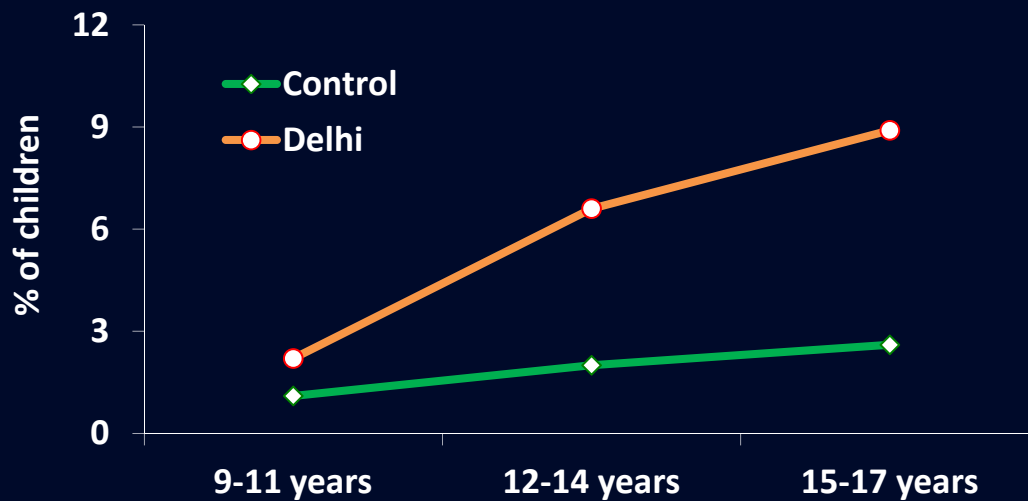
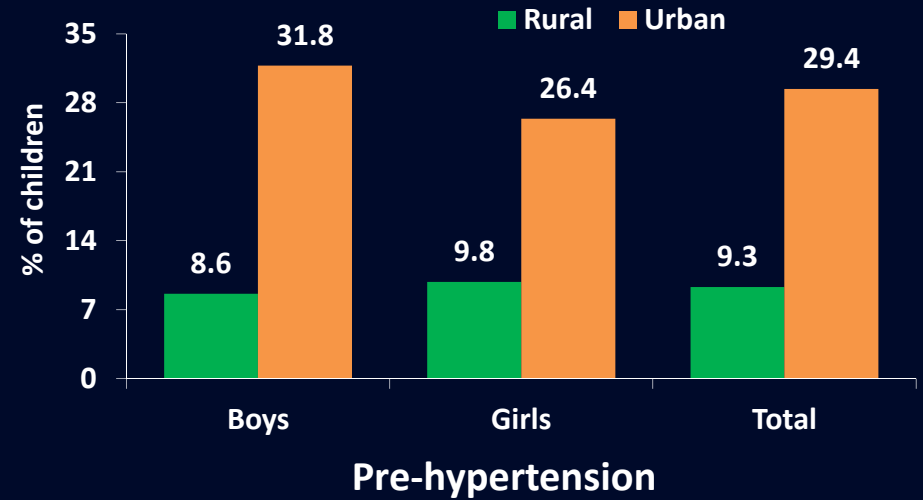
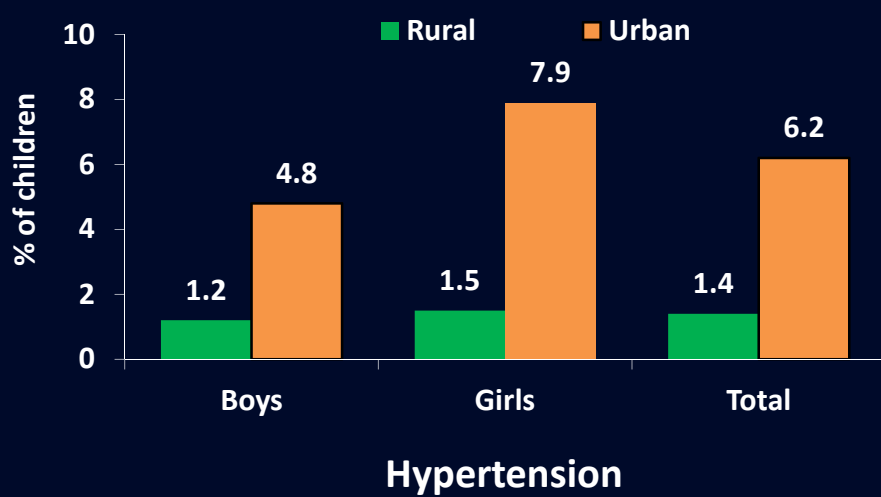


9% of the boys in Delhi had ADHD against 2% of the girls, giving a male:female ratio of 4.5:1



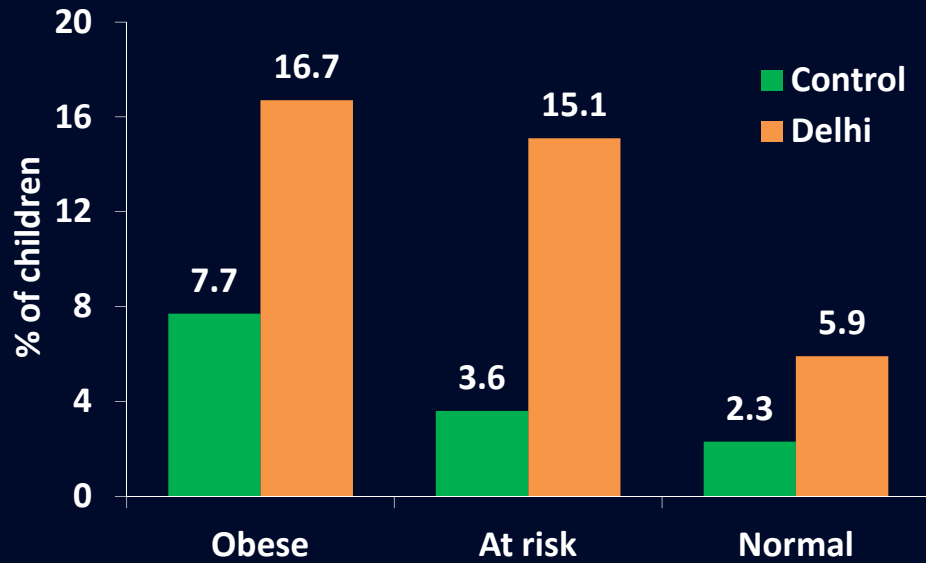
Children with ADHD are impulsive, forgetful, restless, prone to fail, unable to follow tasks, unpredictable and moody

Hypertension - I



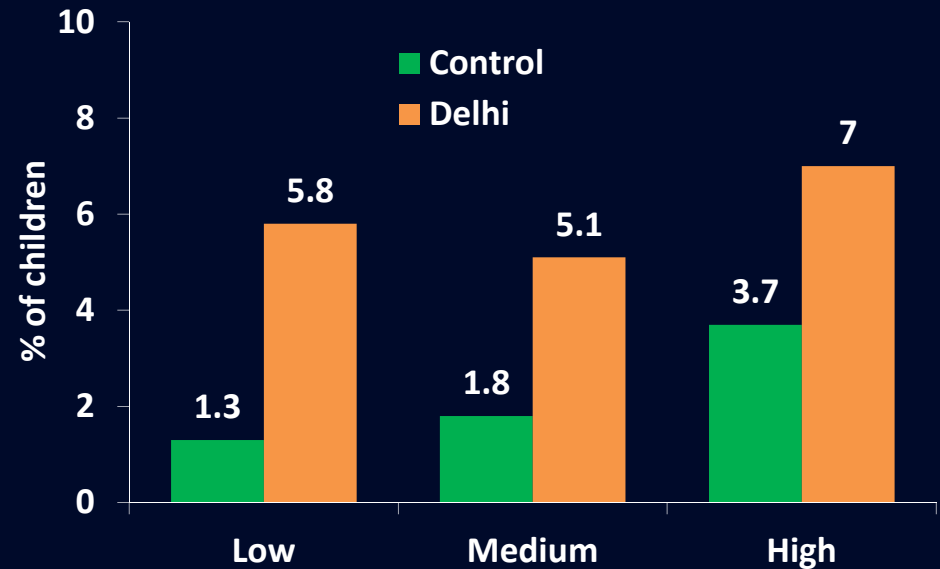
Prevalence of hypertension increased progressively with age

Hypertension - II

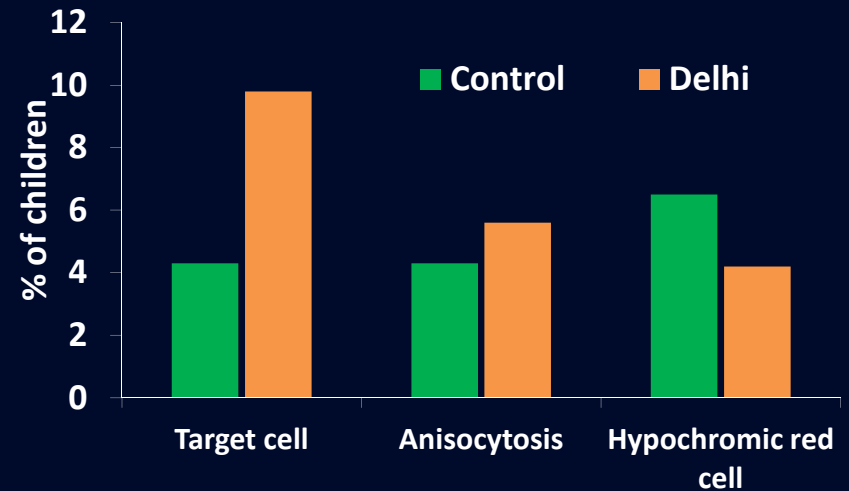
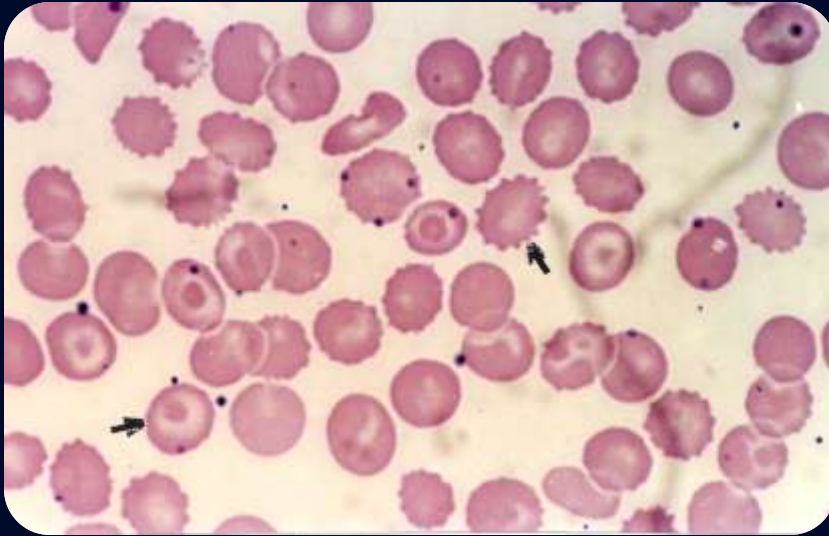


Prevalence of hypertension was least (1.8%) in underweight children and highest (16.7%) in obese group

Children from high SES had highest prevalence of hypertension



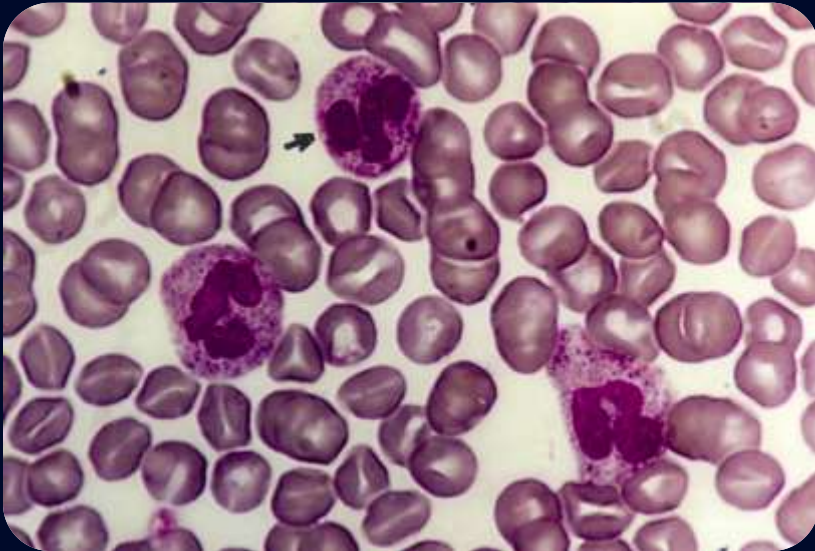
Hematological alterations- I



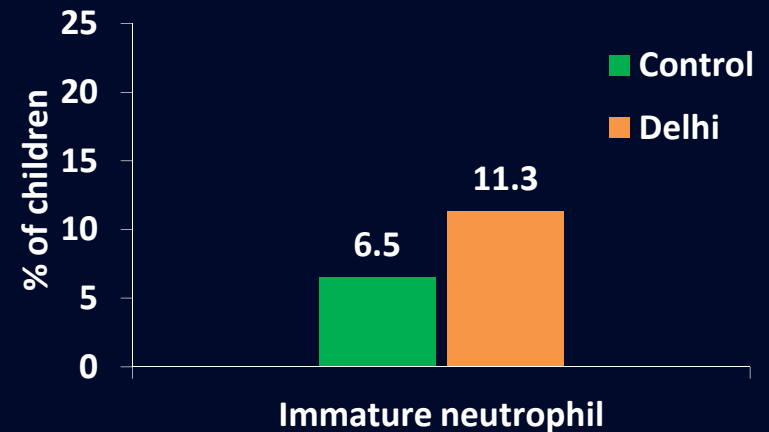
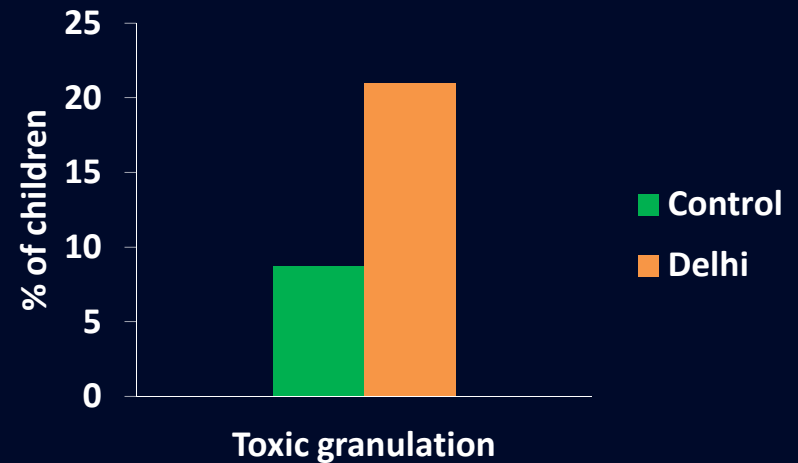
9.8% of Delhi's children had abundance of 'target' cells in their peripheral blood compared with 4.3% of controls ($p < 0.001$)

Their presence in circulation in excess signifies liver problem

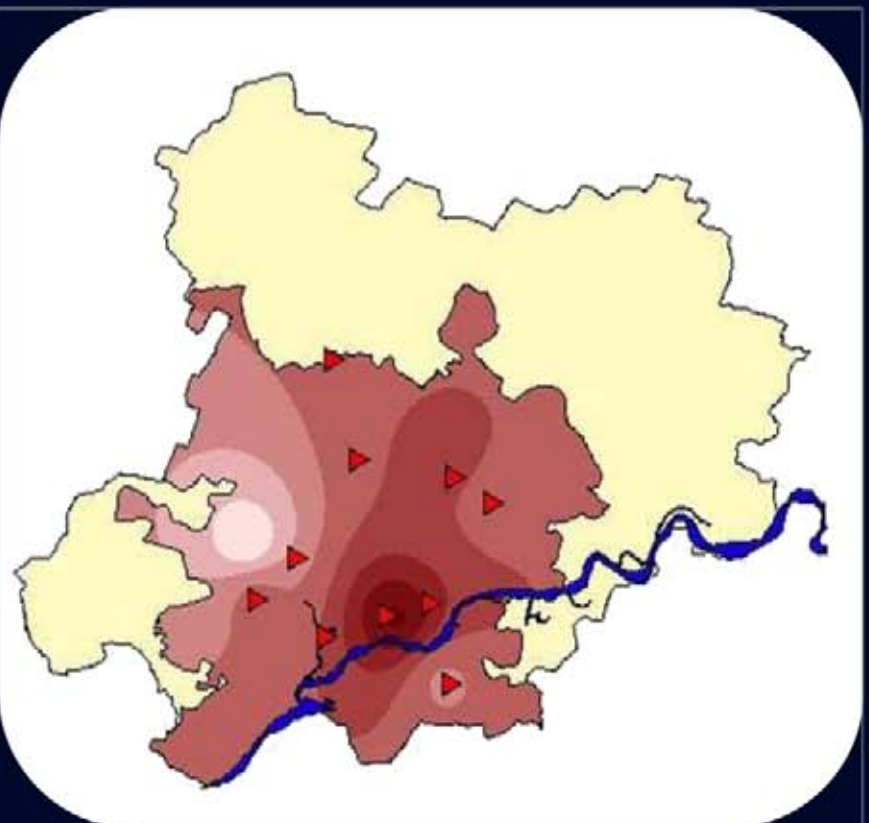
Hematological alterations- II



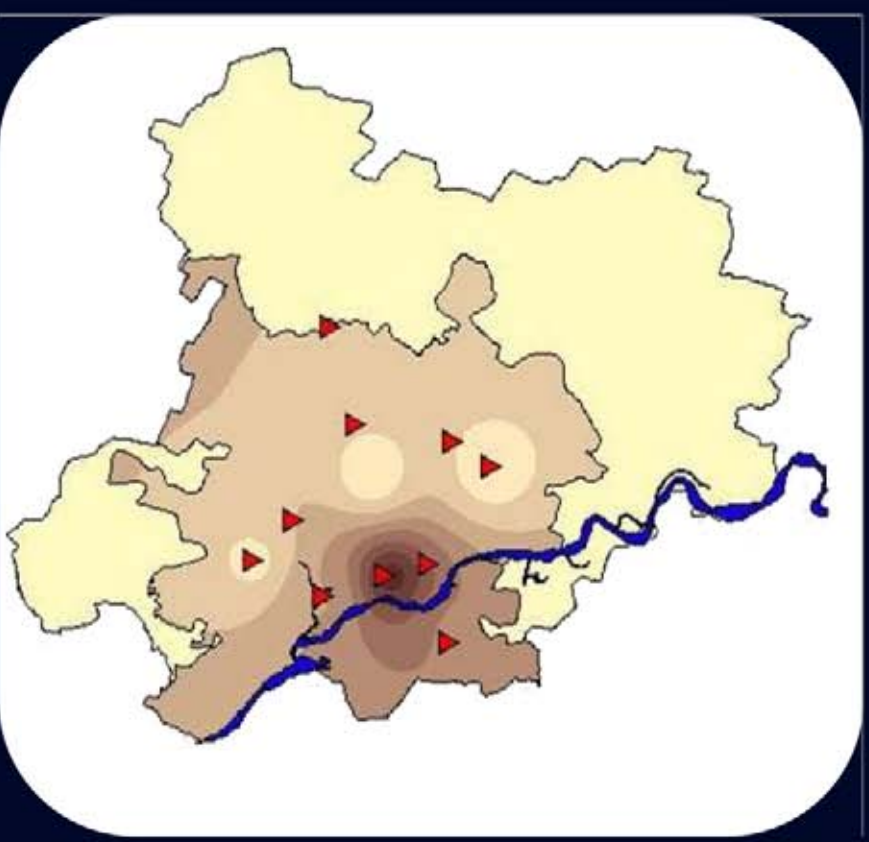
Higher prevalence of circulating immature neutrophil and toxic granulation in neutrophil in Delhi's school children suggests greater risk of infection and inflammation



Benzene and B[a]P distribution in Delhi



Benzene

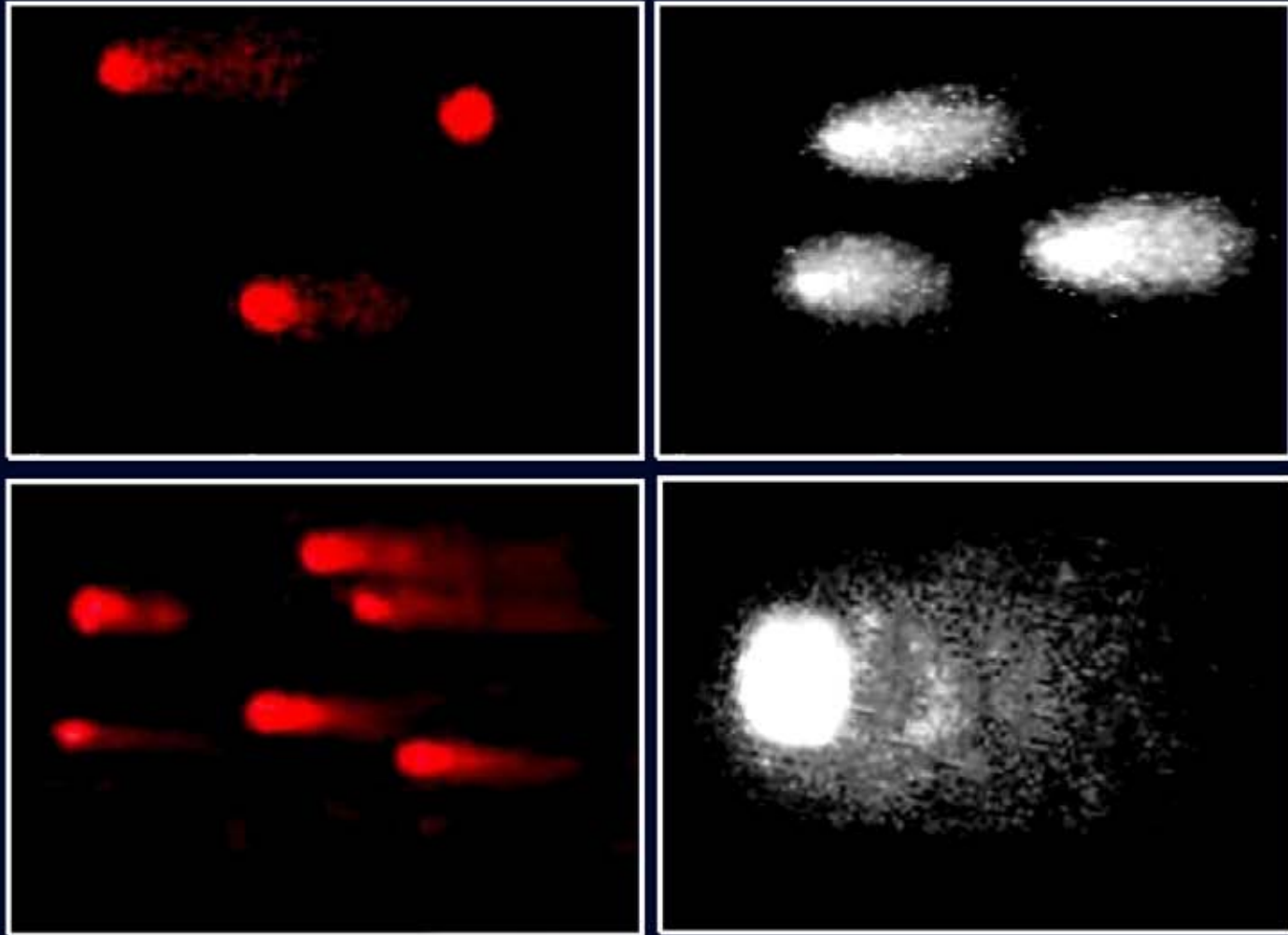


B[a]p

Mean concentrations of

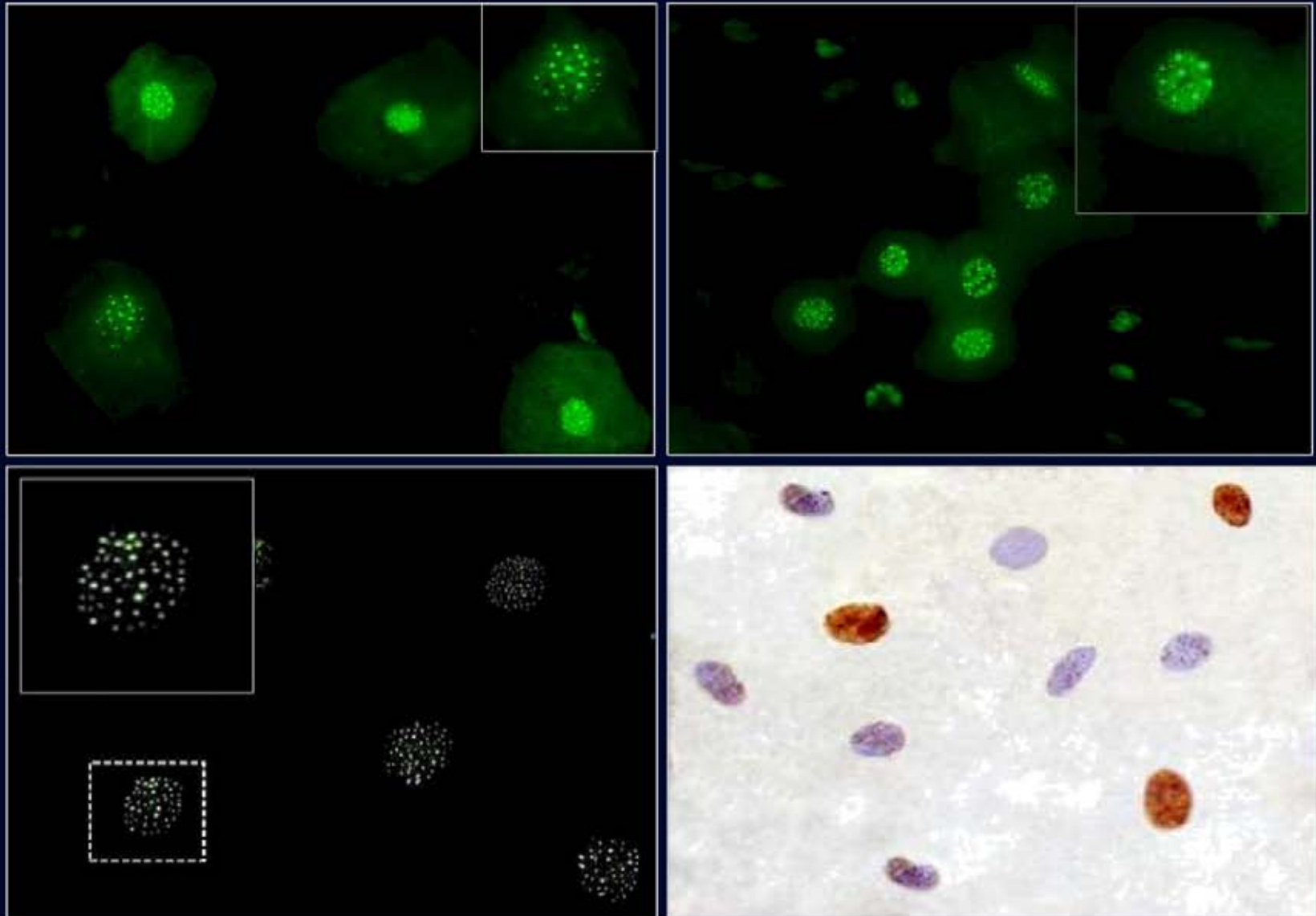
- Benzene: 21.4 $\mu\text{g}/\text{m}^3$
- Benzo[a]pyrene: 3.82 ng/m^3

Metabolically active carcinogens induce DNA damage



Comet assay in PBL & AEC

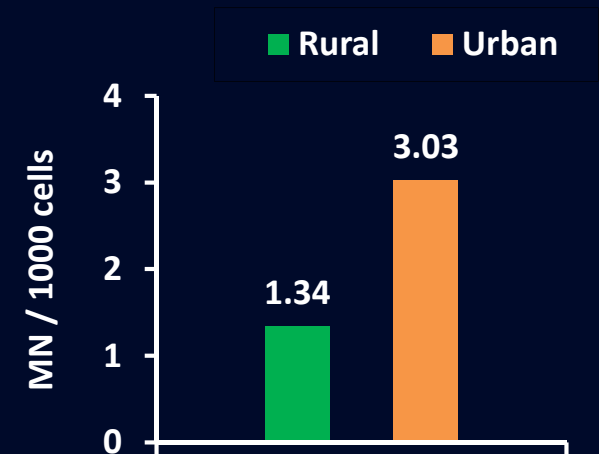
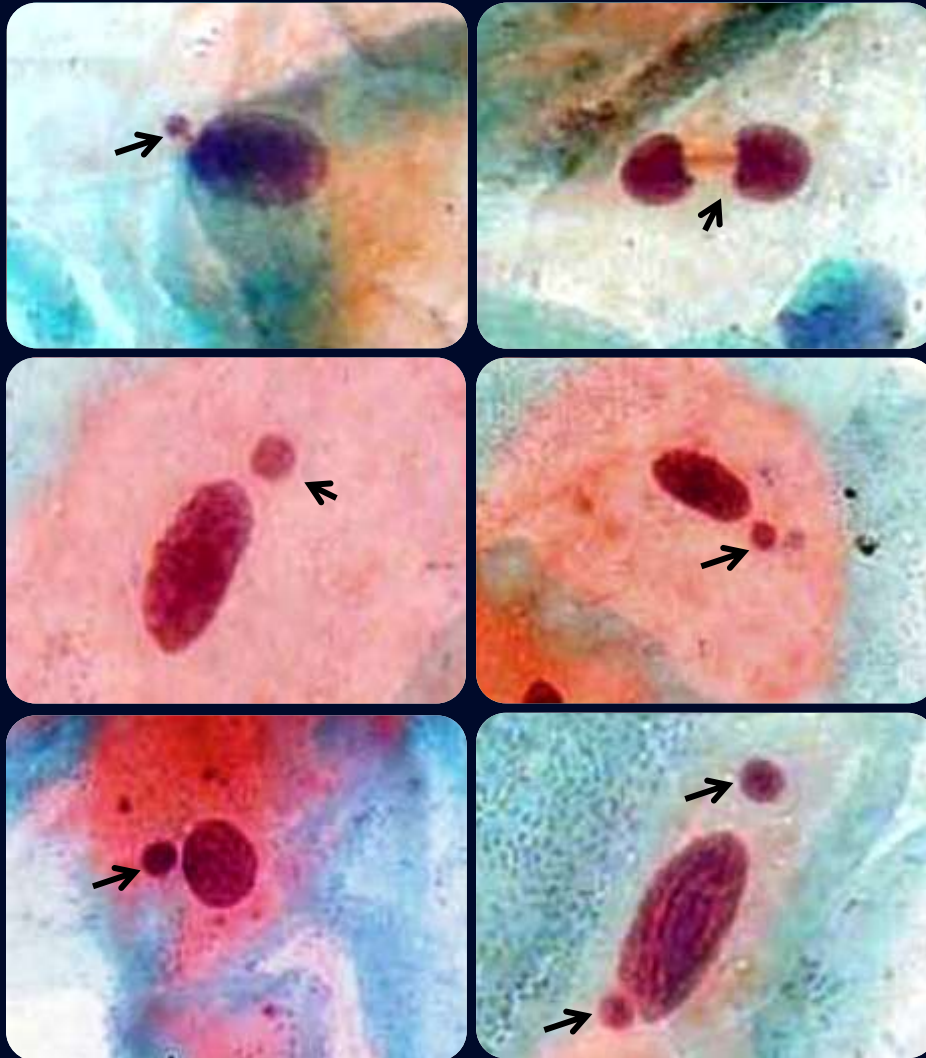
DSB : γ H2AX expression



MN (Chromosomal breaks)

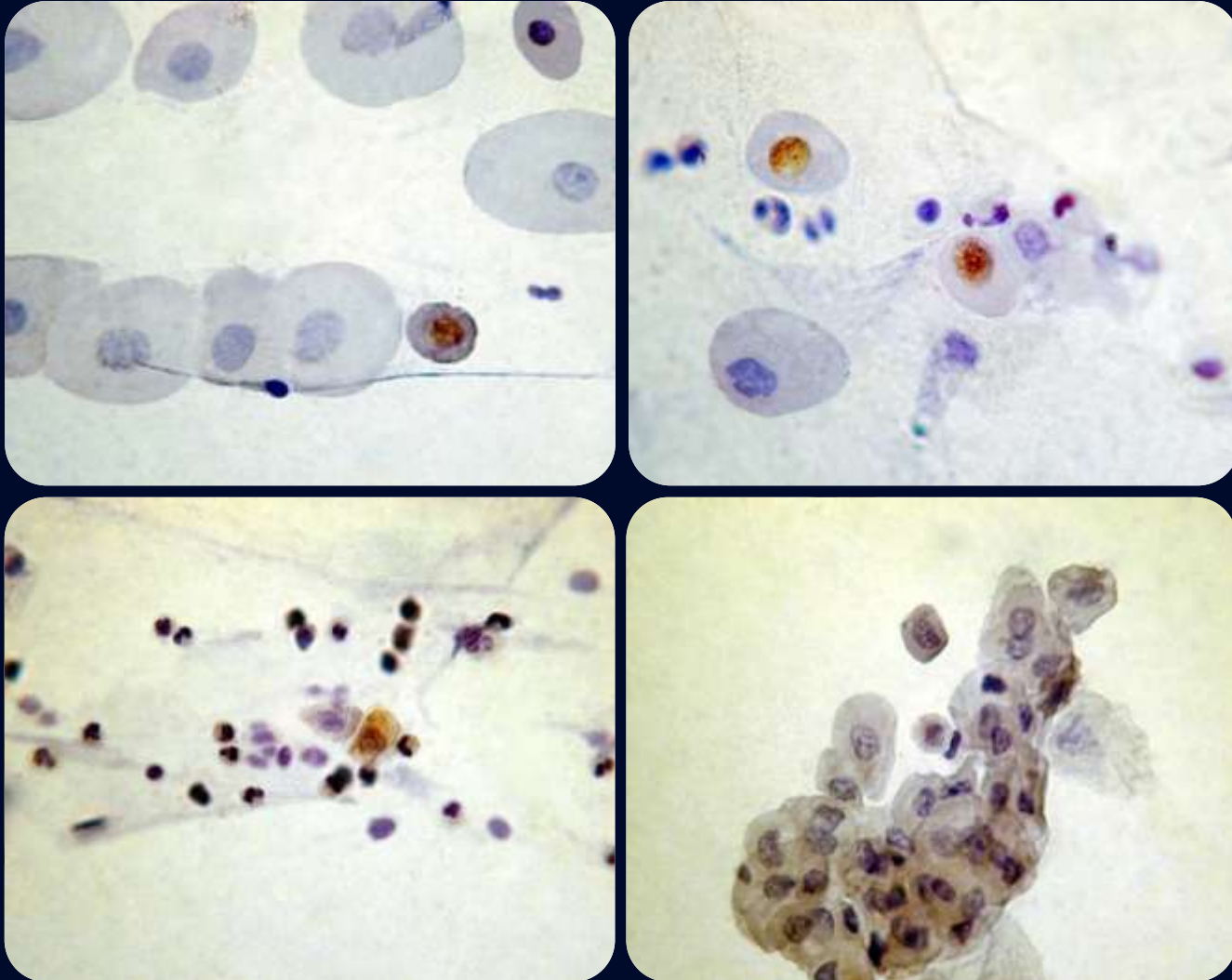


Chromosomal damage



MN assay in BEC & AEC

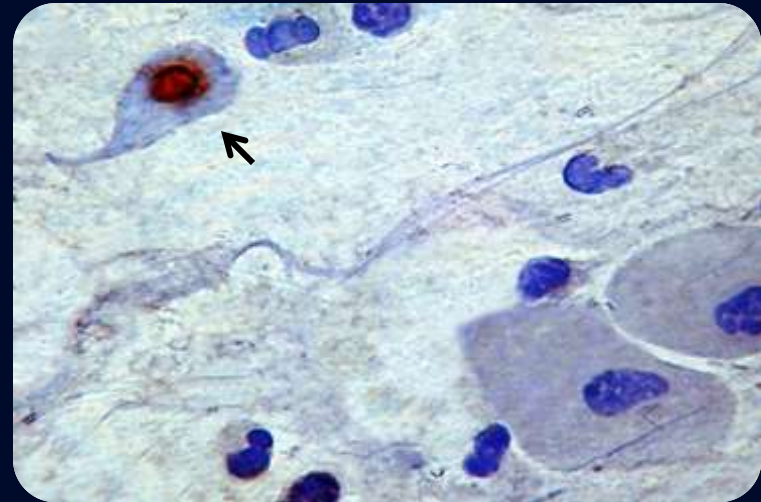
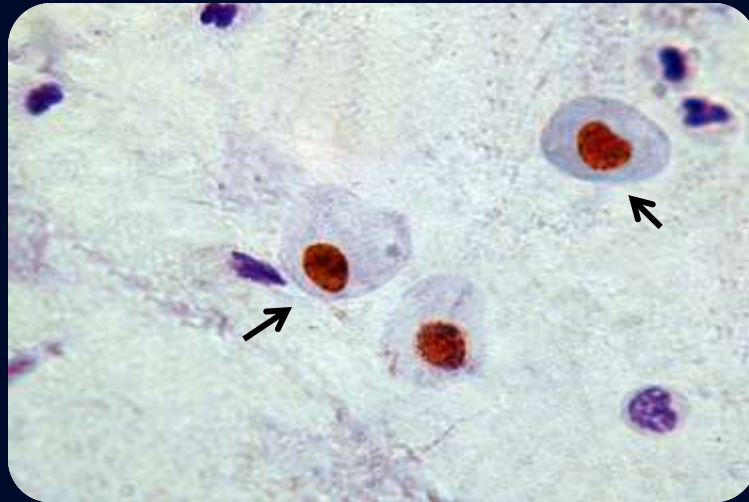
Deficiency in DNA repair



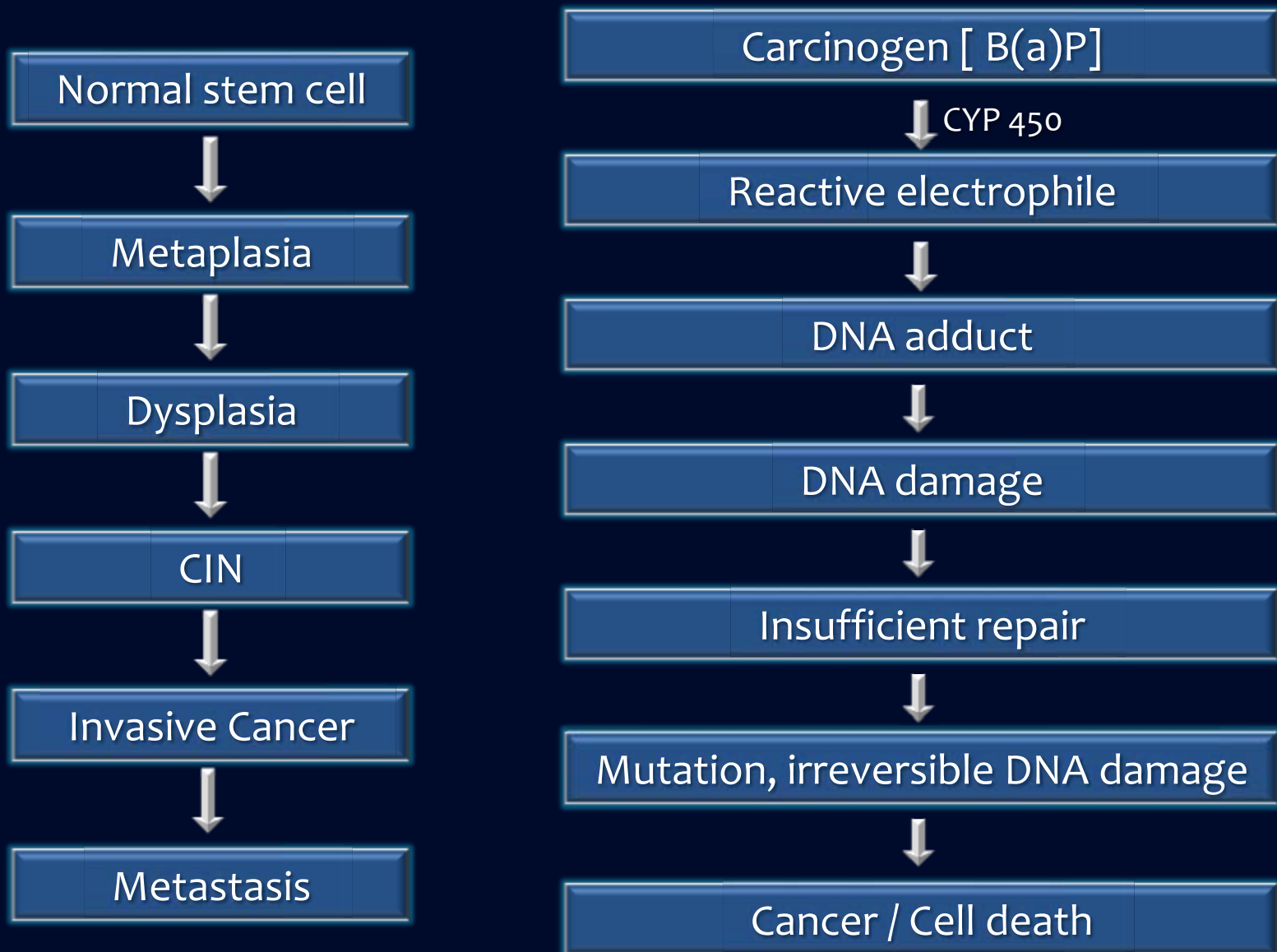
NHEJ, MMR, BER in airway epithelial cells

Up-regulation of Akt

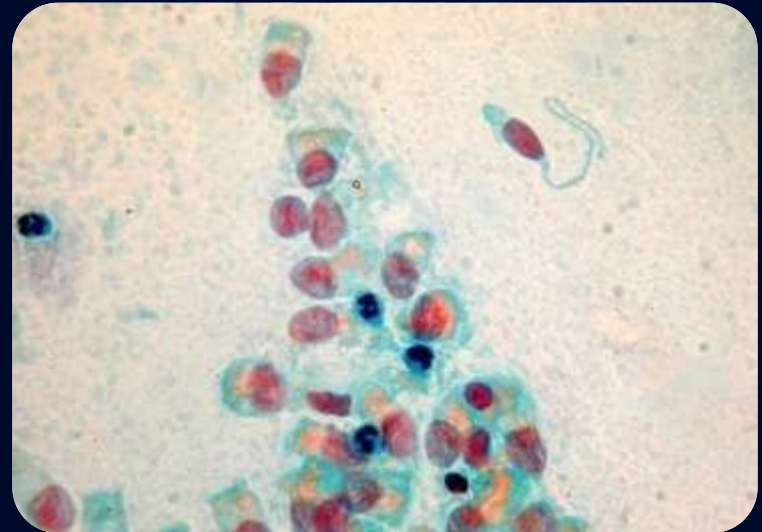
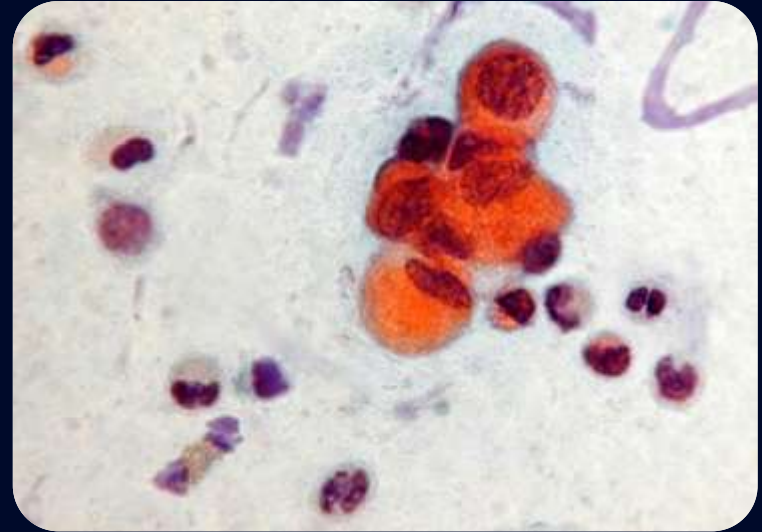
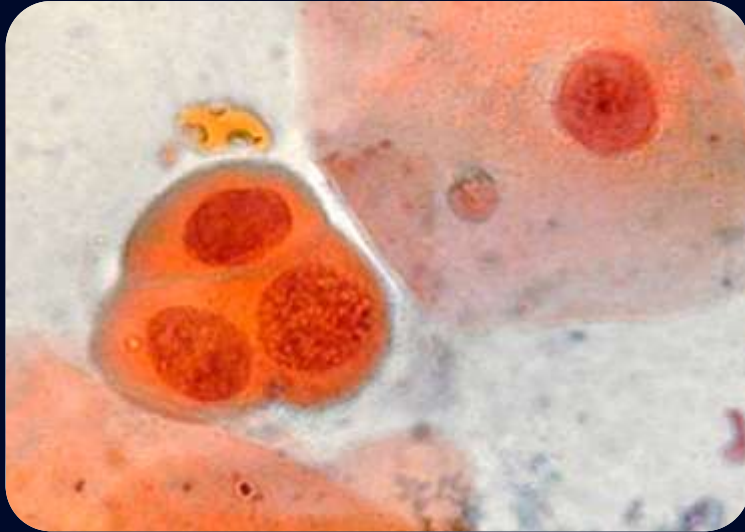
Proliferation advantage



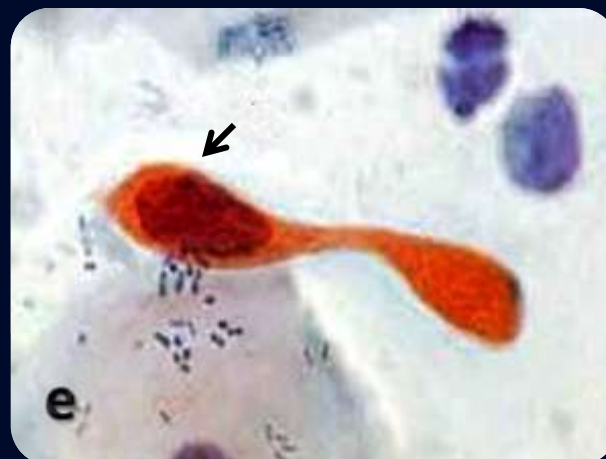
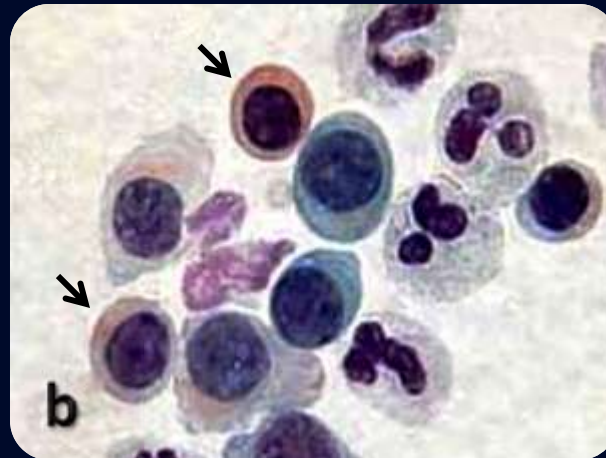
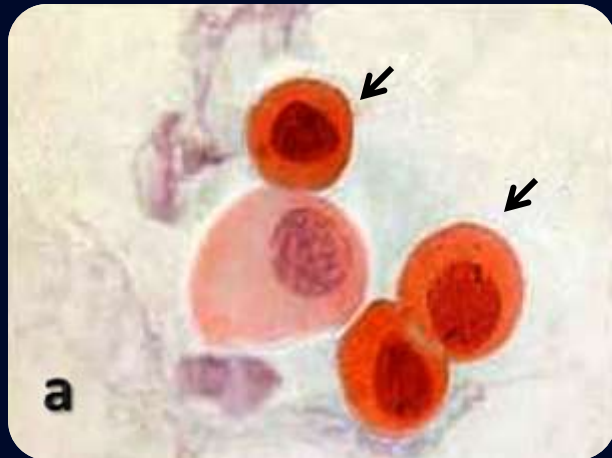
Journey towards cancer

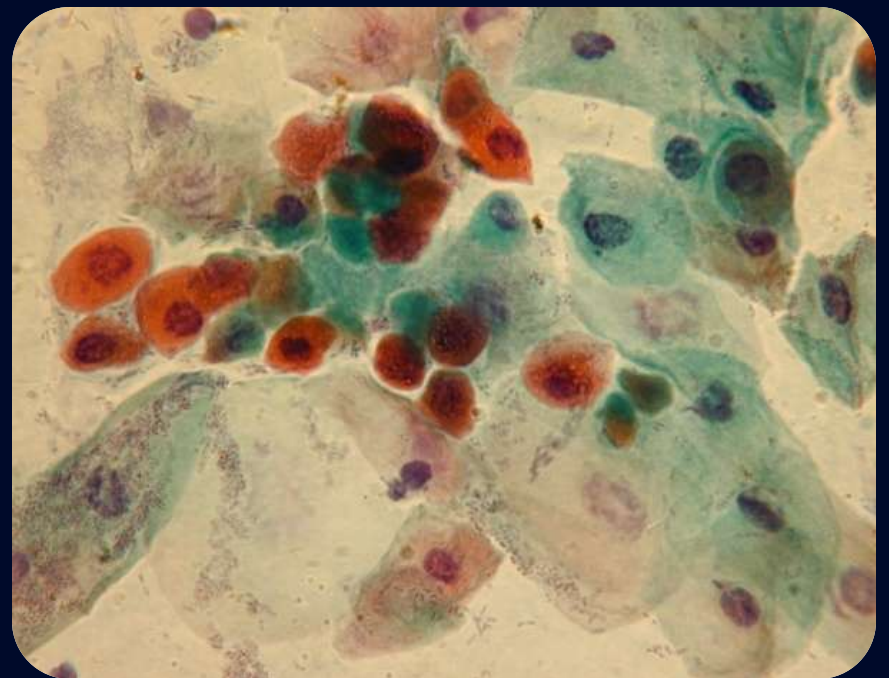
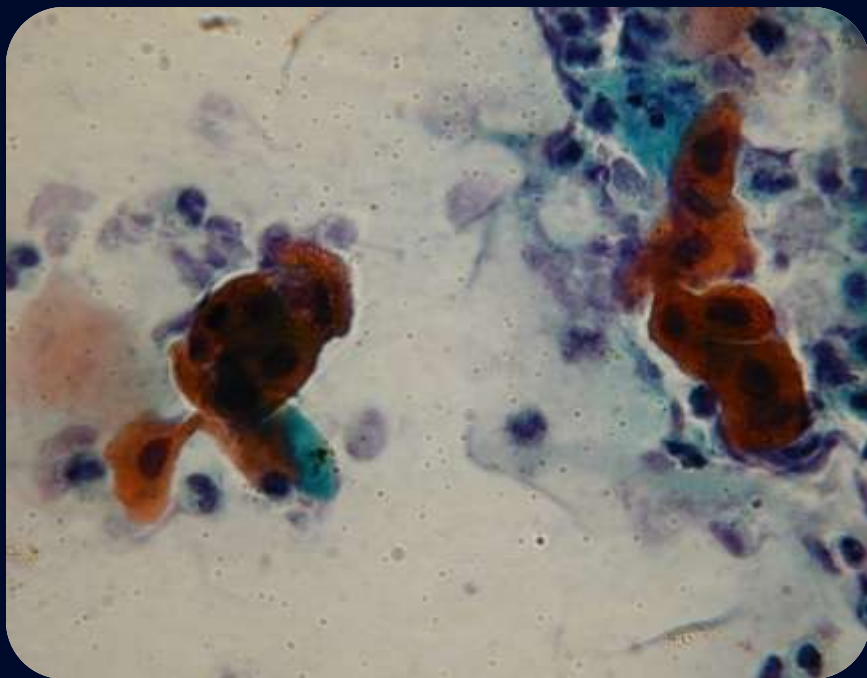
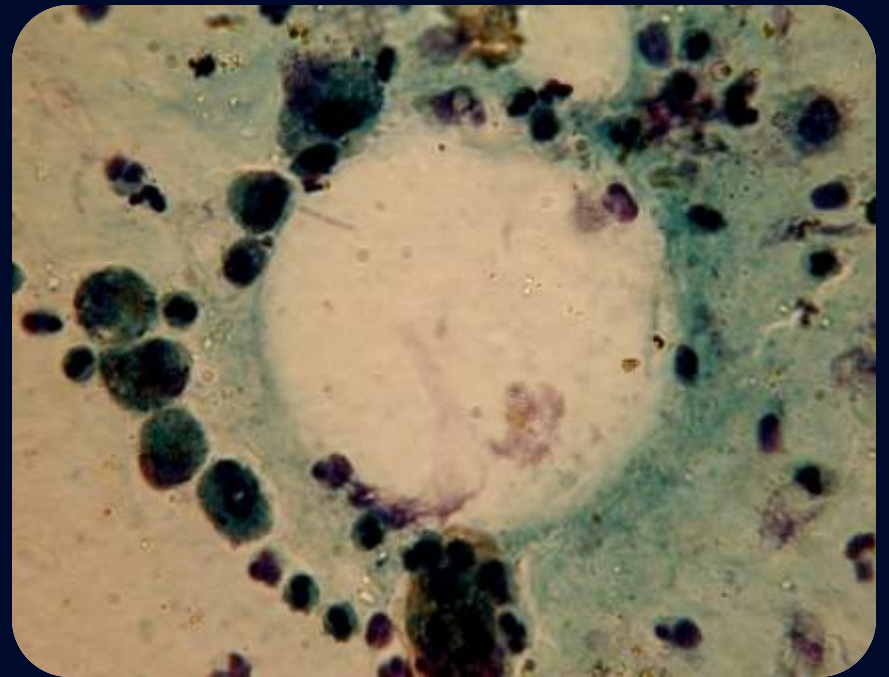
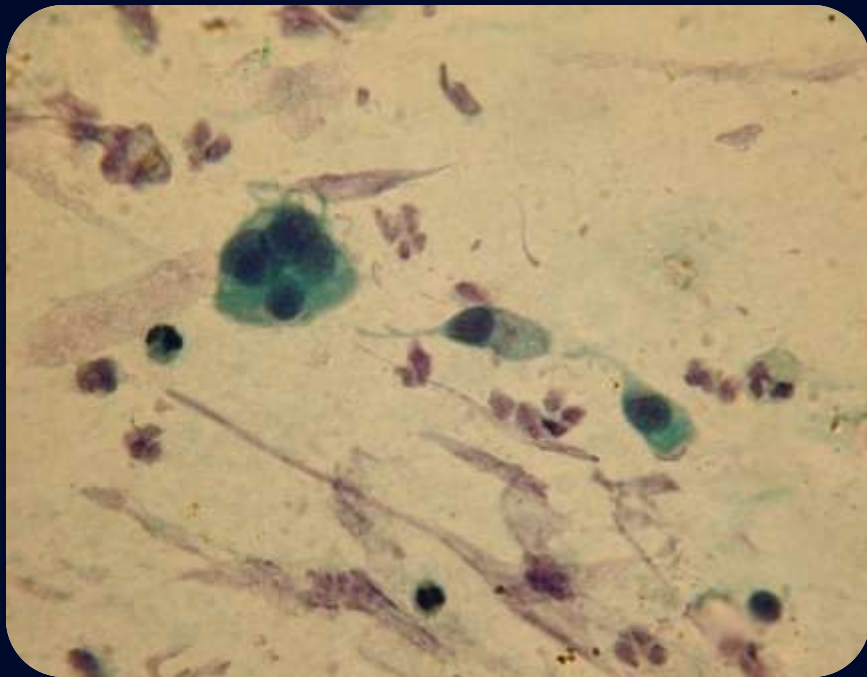


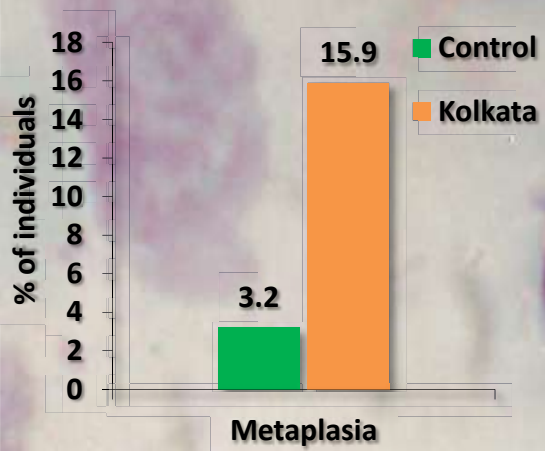
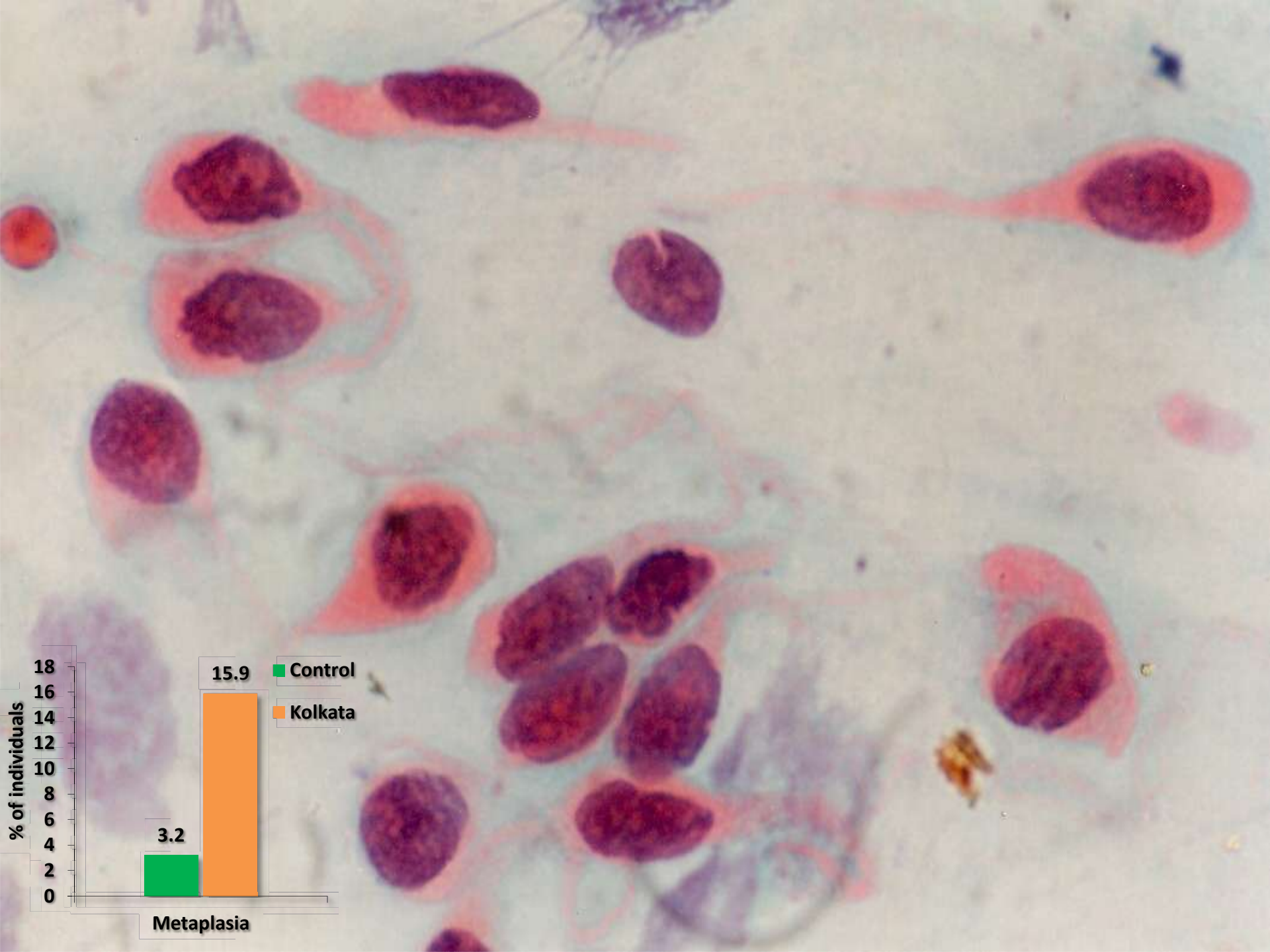
Airway cells following DNA damage, precancerous changes

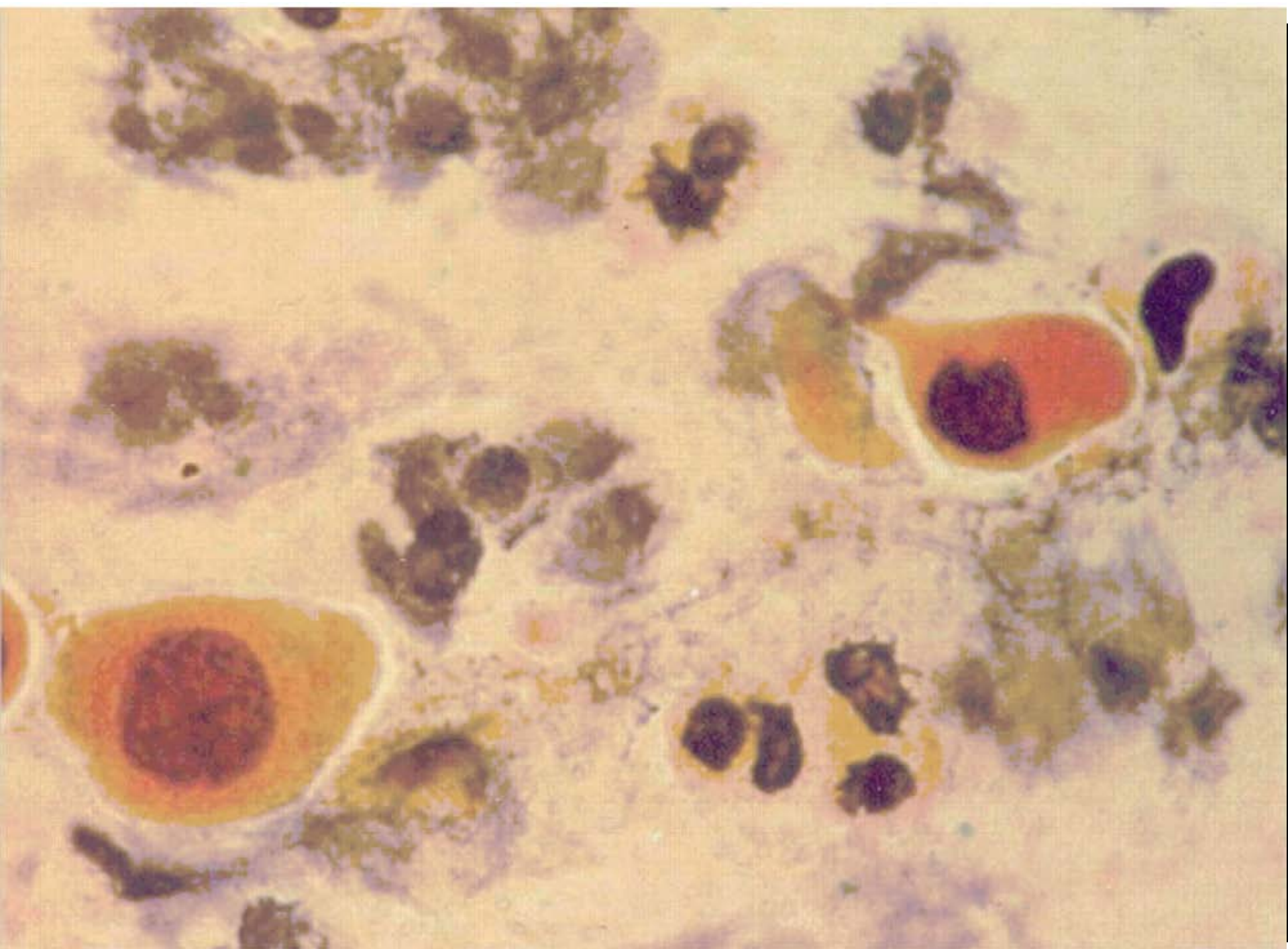


Metaplasia and dysplasia of airway cells among never-smoking biomass-using women









Cancer incidence in rural and urban Delhi

Site of cancer	Rural	Urban
Male (overall)/100,000	55.2	116.9
Lung (%)	6.5	13.8
Oral (%)	8.0	11.4
Larynx (%)	4.0	7.9
Female (overall)/ 100,000	47.7	116.7
Breast (%)	7.8	30.2
Uterus (%)	10.3	17.5
Ovary (%)	3.3	8.5
Gall bladder (%)	3.5	7.4

Manoharan *et al*, 2009, 2010

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THANK YOU