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

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Air pollution in Indian cities

Critical $[\text{PM}_{10} > 90 \ \mu\text{g/m}^3]$

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

High $[\text{PM}_{10} 61 - 90 \ \mu\text{g/m}^3]$

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

Moderate $[\text{PM}_{10} 31 - 60 \ \mu\text{g/m}^3]$

Kochi, Shillong, Chennai

Low $[\text{PM}_{10} \text{ up to } 30 \ \mu\text{g/m}^3]$

Aizwal

CPCB, 2009
Particulate pollutant levels in past 10 years were far above NAAQS.

Vehicular emission contributes to 70% of pollution load.

**Air Pollution in Kolkata**

1. Ultadanga
2. Shyambazar
3. Minto Park
4. Moulali
5. Raj Bhavan
6. Picnic Garden
7. Beliaghata
8. Mominpur
9. Behala
10. Hyde Road
11. Gariahat
12. Tollygunge
13. Baishnabghata
14. Topsia
15. PCB
16. Park Circus

**WBPCB**

- Monitoring Sites

**Annual average PM\textsubscript{10} conc. during (2002-2005)**

- PM\textsubscript{10} levels: 80 - 90, 90 - 100, 100 - 110, 110 - 120, 120 - 130, 130 - 140, 140 - 150, 150 - 160
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

![Bar chart showing prevalence of upper respiratory symptoms (URS, Dyspnea, LRS) in rural and urban areas.](chart.png)
Air pollution

Increases prevalence of upper respiratory symptoms ...

![Graph showing prevalence of symptoms](image-url)
Seasonal impact on LRS

<table>
<thead>
<tr>
<th>SES</th>
<th>Dry cough</th>
<th>Wet cough</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Medium</td>
<td>2.31*</td>
<td>1.72*</td>
</tr>
<tr>
<td>Low</td>
<td>3.34*</td>
<td>2.20*</td>
</tr>
</tbody>
</table>

Inverse correlation with SES

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The graph shows the seasonal impact on LRS with the highest percentage in winter for dry cough and cough with phlegm, decreasing in summer and further in monsoon. The PM10 levels also show a decreasing trend from winter to monsoon. The table indicates a higher incidence of dry cough and lower incidence of wet cough with higher SES.
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

![Graph showing lung function metrics](image)
Air pollution adversely affects lung function

[Bar charts showing reduced lung function percentages for rural and urban areas.] 

- Rural: 18%
- Urban: 41.2%
- Urban, EO: 35.3%
- Urban, OE: 47.4%
Reduced lung function
Air pollution and COPD

![Bar chart showing the percentage of individuals with COPD in rural and urban areas.]

- Rural: 0.7%
- Urban: 3.4%
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
Does air pollution affect the immunity?
Immune alterations

- CD4+ cells
- CD8+ cells
- CD19+ cells
- CD16+56+ cells

CD4+ cells
CD4 (FL2) 48%
CD8+ cells
CD8 (FL1) 53%

Rural vs. Urban

CD4 cells

Rural
Urban

CD8 cells

Rural
Urban

CD19 cells

Rural
Urban

CD16+56+ cells

Rural
Urban

Rural

Urban

* Statistical significance

Legend:
- Rural
- Urban
Immune alterations ...

1. CD11b neutrophil, 2. CD11b monocyte, 3. CD18 neutrophil, 4. CD18 monocyte
Does air pollution affect the cardiovascular system?
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

- **Hypertension**
  - Rural: 10.6%
  - Urban: 29.1%

- **Tachycardia**
  - Rural: 3.1%
  - Urban: 15.1%
Giant platelets
Air pollution activates blood platelets

- **Platelet P-selectin**
  - Rural: 1.6%
  - Urban: 4.7%

- **Soluble P-selectin**
  - Rural: 166 mg/l
  - Urban: 346 mg/l
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

Control       Kolkata

Platelet-leukocyte aggregates cardiovascular risk

CVD
Oxidized low-density lipoprotein in blood

- **Control**: 47.4
- **Exposed**: 160.9

Plasma OxLDL (U/ml)
Anti-cardiolipin antibodies in serum

- **IgG (GPL U/ml)**
  - Control: 5.4
  - Exposed: 12.2

- **IgM (MPL U/ml)**
  - Control: 8.2
  - Exposed: 15.1
Air pollution and the heart

PM$_{2.5}$, UFP → ROS → $\text{oxLDL}$ → Foam cell → Plaque formation → Rupture → CVD

Liver → Coagulation factor, CRP, IL-6 → Platelet activation → Thrombosis → CVD
Does air pollution damage the chromosomes and the DNA?
Micronucleus formation
Excess comet formation suggests increase in DNA damage
Comet assay in PBL
Comet assay in epithelial cells
Air pollution and risk of lung cancer
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

**Bar Chart:**
- **X-axis:** ROS, SOD
- **Y-axis:** MFI, U/ml
- **Legend:**
  - Rural
  - Urban
- **Data Points:**
  - ROS:
    - Rural: 587
    - Urban: 982
  - SOD:
    - Rural: 698
    - Urban: 540
Does air pollution affect mental health?
Neurobehavioral symptoms

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

Depression (BDI-II score ≥ 14)

- Rural: 20.7%
- Urban: 54.3%

PM$_{10}$ ($\mu$g/m$^3$)

Years of exposure

BDI score

PM$_{10}$ ($\mu$g/m$^3$)

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