What have we learned in the last decade about health effects of air pollution?

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Outline - Health Effects of Air Pollution

- Biological Mechanisms & Epidemiological evidence
- Overall health burden of air pollution
- Are there any thresholds/safe levels?
- Air pollution/Environmental inequality
- Air pollution and COVID-19
- Air pollution and climate change
- Conclusions
Biological Mechanisms behind Health Effects of Air Pollution

- Inflammation, oxidative stress
- Carcinogenicity
- Most evidence for PM (PM$_{2.5}$)
- Air pollution enters the human body through inhalation (skin, digestion)

We inhale 10,000 liters of air/day
Air pollution, respiratory and cardio-metabolic system

3. BLOOD

Circulating PM constituents
- UFP, soluble metals
- Organic compounds

Activated-inflamed tissue niches
- Vascular/fat
- Hypothalamus
- Liver
- Bone marrow

Activated mediators of oxidative stress & inflammation
- (adipo)cytokines
- Oxidative stress (NADPH oxidase)
- TLR-4 activation
- Rho Kinase activation
- WBC homing (M1 phenotype)

PM and/or constituents transmitted into blood

Lung oxidative stress & inflammation

2. SYSTEMIC INFLAMMATION “SPILL-OVER”

Lung cell derived cytokines
- Activated cells (Toll-like, NLR)

Cells: Activated WBCs
- Cytokine: IL-1/6, TNF
- BP Δ: ET-1, LT, AT-2
- Oxidized: LDL, HDL
- HPAA: Δ metabolome

Sub-acute & chronic pathways

Insulin resistance
- Glucose (Diabetes)
- Obesity

Vascular dysfunction
- Blood pressure
- Atherosclerosis (plaque instability)

1. CNS

ANS imbalance
- ↑ SNS, ↓ PSNS
- ↑ HPAA

ACUTE PATHWAYS

Fat lipolysis
- Insulin resistance
- Insulin resistance
- BP + heart rate

Skeletal muscle
- Vasoconstriction
Air pollution and the brain

Figure 1. Air pollution impacts on the brain through multiple pathways (Block et al. 2009).
Air Pollution contains carcinogenic substances

The International Agency for Research on Cancer (IARC) has classified:

• **Outdoor air pollution** as *carcinogenic to humans* (Group 1) in **2013**. *Sufficient evidence* that exposure to outdoor air pollution causes **lung cancer** (Group 1).

• **Particulate matter** was evaluated separately and was also classified as *carcinogenic to humans* (Group 1).

• **Diesel engine exhaust** (occupational and in ambient air) as *carcinogenic to humans* (Group 1) in **2012**. Based on sufficient evidence that exposure is associated with an increased risk for **lung cancer** (2012).

Source: https://monographs.iarc.fr/ENG/Monographs/vol105/mono105.pdf
Which diseases have been linked to air pollution and who is most susceptible?
Health Effects of Air Pollution

Elderly most susceptible!
Health Effects of Air Pollution

Children outcomes

- Respiratory disease mortality
- Respiratory disease morbidity
  - Asthma and asthma related outcomes
  - Lower respiratory infections
- Metabolic disease
  - Type 1 diabetes

- Childhood Cancers
  - Leukemia
  - Lymphomas
  - Central nervous system cancers

- Tumors originating in embryonic tissue
  - Neuroblastoma
  - Retinoblastoma
  - Nephroblastoma

- Neurodevelopment
  - Autism
  - ADHD
Health Effects of Air Pollution

Pregnancy and birth outcomes

Mother
- Hypertensive disorders in pregnancy
  - Preeclampsia
  - Gestational hypertension
- Gestational diabetes

Offspring
- Intrauterine growth restriction
  - Decreased birthweight
  - Reduced fetal growth
- Preterm birth
- Congenital anomalies
- Spontaneous abortion
- Stillbirth
- Infant death
Dose-response curves: mortality and PM$_{2.5}$/NO$_2$

- Linear association
- No safe exposure threshold below which air pollution is not harmful to human health
Environmental Inequality or Injustice ‘Double-burden’

- Air pollution levels are higher in countries and neighbourhoods with lower-socioeconomic status (SES)
- The poorest live closest to the pollution sources and are most exposed
- People with lower SES are more susceptible to adverse effects of air pollution:
  - more comorbidities
  - poorer lifestyle
  - poorer access to health care and information
  - less empowered to demand change
**Global Burden of Disease (GBD) Air Pollution**
- 4.2 million deaths in 2015*
- 6.7 million deaths in 2019**

Source:

** https://www.stateofglobalair.org/
Ongoing studies continue to explore air pollution’s role in the development of additional conditions including **asthma**, **cognitive disorders**, which are not currently included in the GBD estimates.
Air Pollution compared to other risk factors

**FIGURE 1** Global ranking of risk factors by total number of deaths from all causes in 2019.

- High systolic blood pressure
- Tobacco
- Dietary risks
- Air pollution
- High fasting plasma glucose
- High body-mass index
- High LDL
- Kidney dysfunction
- Malnutrition
- Alcohol use

Total number of deaths (millions) in 2019:

- Air pollution: 6.67 million

*Figure: https://www.stateofglobalair.org/sites/default/files/figure-i.svg*
Climate Change, Air Pollution and Health

Climate change impacts on air pollution:
- Heat → higher ground-level ozone
- Heat/droughts → dust resuspension, more frequent/intense sandstorms
- Warm weather/heat → more frequent wildfires
- Shared major sources of air pollution and greenhouse gases

Why climate change is also a public health problem

It’s not only the environment that’s at risk.
Air Pollution and COVID-19

- Exposure to air pollution can increase the risk of COVID-19 infection/death:
  - by compromising the individual's immune system’s ability to fight infections (air pollution and pneumonia/influenza)
  - by increasing the risk of predisposing chronic diseases
- COVID-19 lockdown measures have resulted in unprecedented short-term reductions in air pollution, showing a glimpse of what can be achieved, bringing about renewed interest and demand for clean air
Conclusions

• Air pollution – major global health risk factor

• Health burden is huge and likely to increase, as new diseases are linked to air pollution and populations aging

• Call for action is justified & urgent: current legislation does not protect human health adequately, any reductions in air pollution would bring substantial health benefits

• Climate change agenda, COVID-19, present opportunities for co-benefits of air pollution control and call for joint action

• More research needed in South Eastern Europe: locations with different PM constituents/sources, exposure levels, and population composition

• Medical societies, clinicians, patient organizations to play a role in spreading information and protecting citizens from adverse effects of air pollution
Bucharest, Sofia, Zagreb among 24 cities with EU’s highest air pollution costs

Bulgaria citizens concerned about rising air pollution amid coronavirus crisis

Is Belgrade really the most polluted city in the world? Data is alarming, health warning issued
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