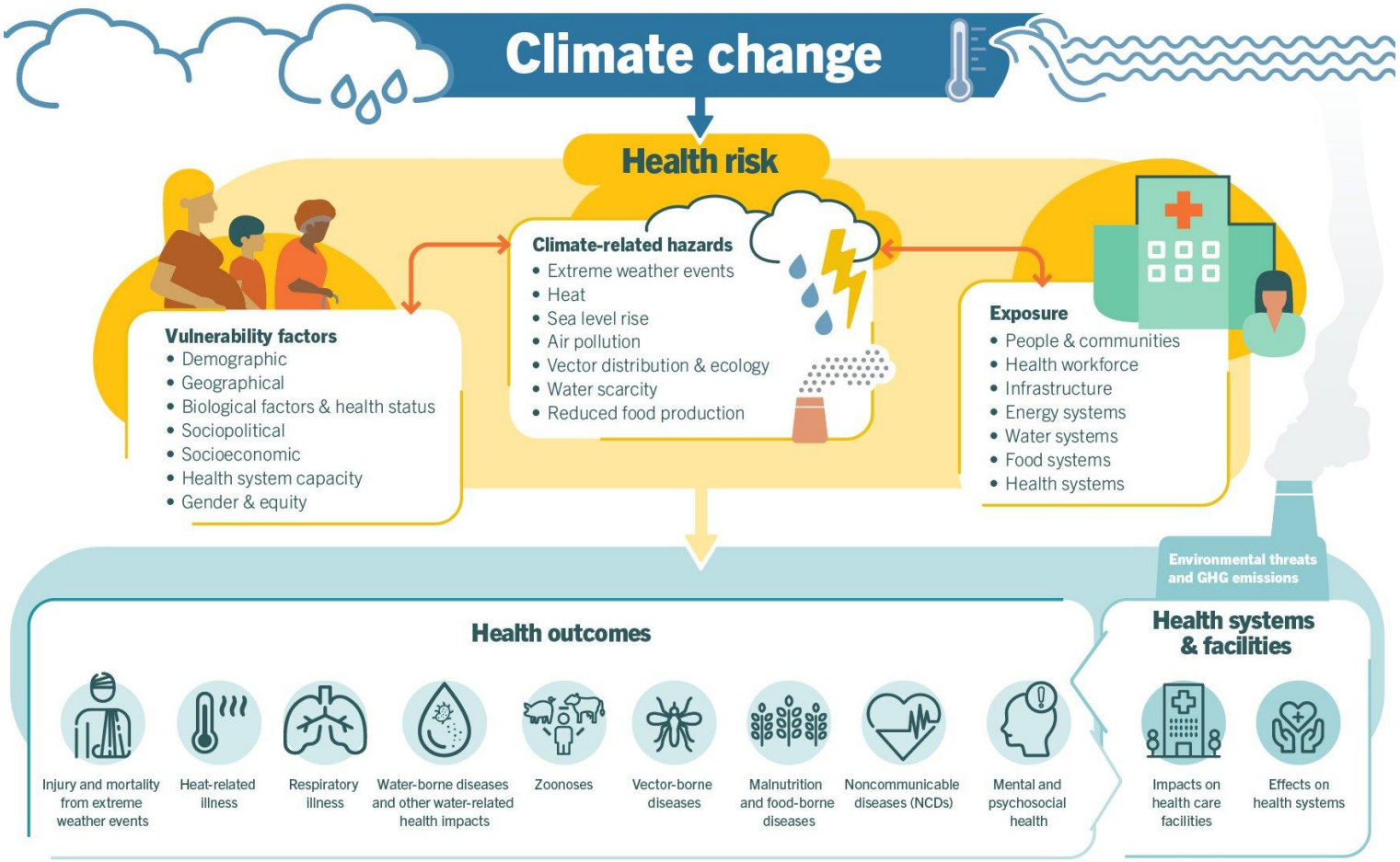
Air pollution, allergens and respiratory health
Pollution episodes, traffic emissions, pollen trends, combined effects with heat

Prof. Em. Catherine Bouland

School of Public Health - Université libre de Bruxelles

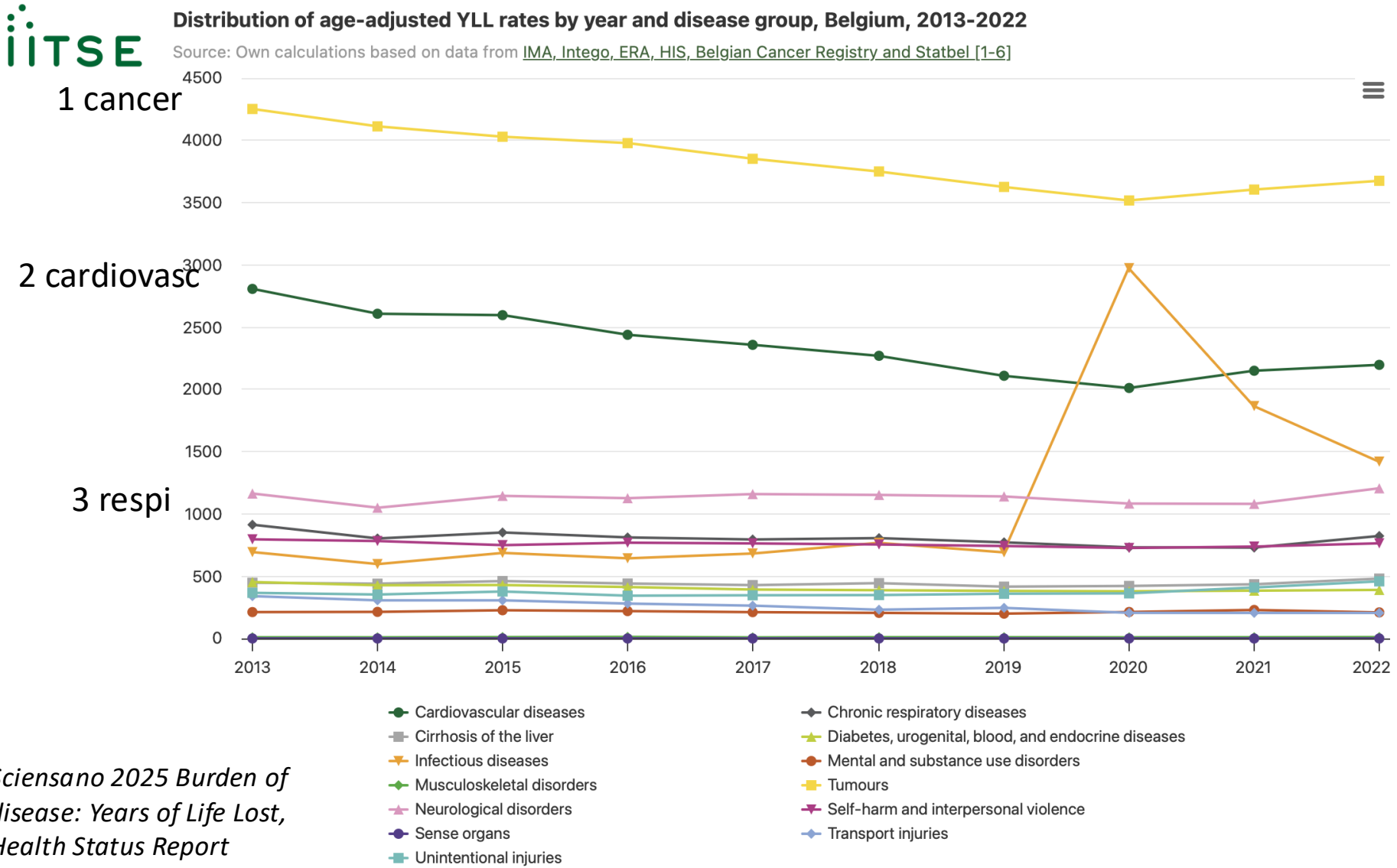
catherine.bouland@ulb.be

Health impacts of climate change



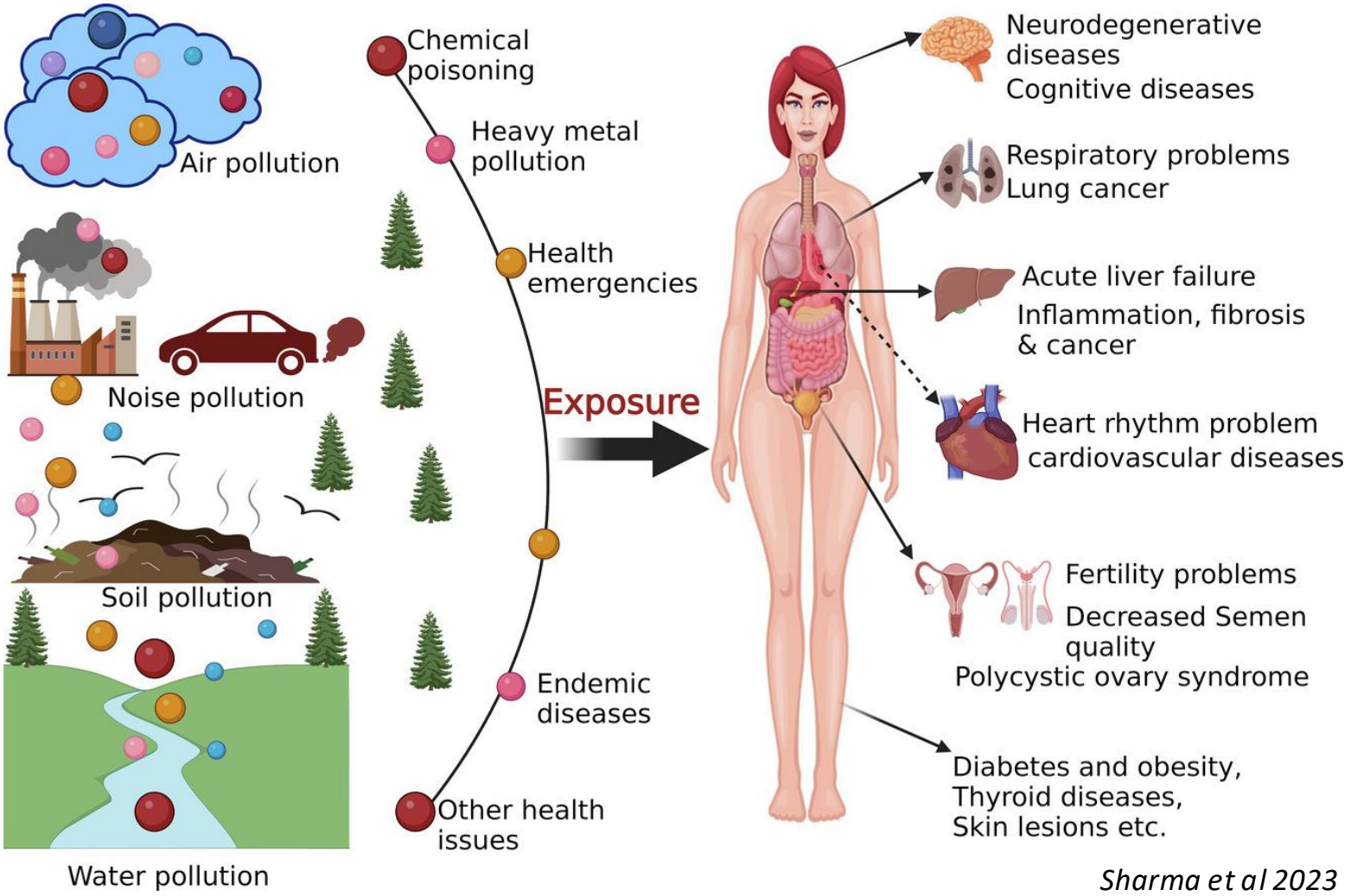
WHO 2023

Evolution of the Years-of-life lost in Belgium



Sciensano 2025 Burden of disease: Years of Life Lost, Health Status Report

Health impacts of pollution



Sharma et al 2023

Along the life course

The Lancet Comission on pollution and health 2017, The Lancet

Pollution => respiratory disorders

Air pollution can exacerbate asthma, chronic obstructive pulmonary disease (COPD), pneumonia, bronchitis, and upper respiratory tract infections

⇒ Irritations, resulting in coughing and wheezing symptoms

⇒ Compromise the immune system's ability to defend against infections and diseases

⇒ Trigger or aggravate allergies (hay fever, asthma related to allergic reactions)

⇒ Pollutants penetrate deep in the respiratory tract ($PM_{2,5}$ and smaller)

- ⇒ Vascular system -> oxidative stress and Inflammation (cardiovascular, reproductive and metabolic outcomes)
- ⇒ Brain (neurodegenerative neuro-developmental outcomes)

⇒ Toxicity and carcinogenicity

$PM_{2,5}$, O_3, NOx, SOx, HAP, Black Carbon

Pollution & temperature => respiratory disorders

Synergies temperature and atmospheric pollution

Grigorieva & Lukyanets 2021 & Demoury et al 2022:

- Increased risk for individuals with asthma & cold / with psychoses & hot
- Respiratory mortality:
- Modification effect
  - Higher effect of heat on days with higher O3, Black Carbon concentrations
  - Higher effect of cold on days more polluted with PM2,5, NO2
  - Lower effect of cold when pollution by O3
- Increased exposures -> stronger effect
- Rare situations « low O3 and high T°» & « high O3 and low T° »

=> Reducing the levels of air pollution could contribute to the reduction of the short-term effects of temperatures on mortality.

Pollution, aeroallergens, temperature & health

Alemayehu Ali et al 2026 :

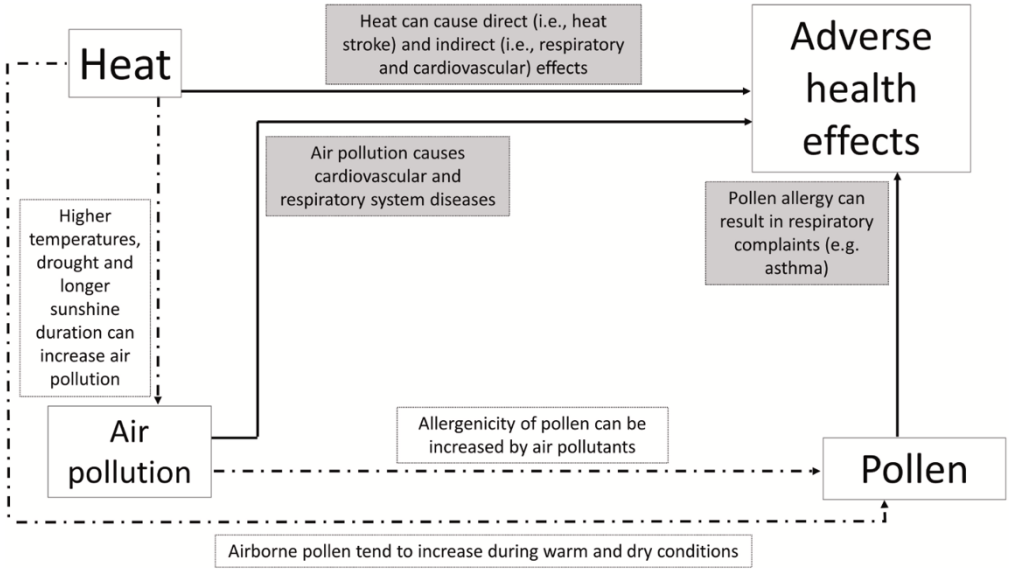
- The risk of allergic rhinitis and asthma increases with high maximum temp. modified by pollen levels / weak association with O3 or PM2,5

  (=when high pollen, risk increases when temperature increases)
- Aeroallergens appear to be the primary drivers of short-term allergic respiratory morbidity, with heat and ozone contributing to increased risk under extreme environmental conditions

Pollution, aeroallergens, temperature & health

Scholten et al 2024:

- Simulatenous threshold exceedance of heat, air pollution and airborne allergenic pollen
- Each parameter is associated with with similar adverse health outcomes
- Co-exposure patterns differ across the year and the region
- Co-exposure/ stronger effect?



Pollution, aeroallergens, temperature & health

Reichelt et al 2025:

Rising temperatures => increase in total pollen load

Weather conditions => rupture of pollen grains (dispersion)

⇒ risk of allergic sensitization

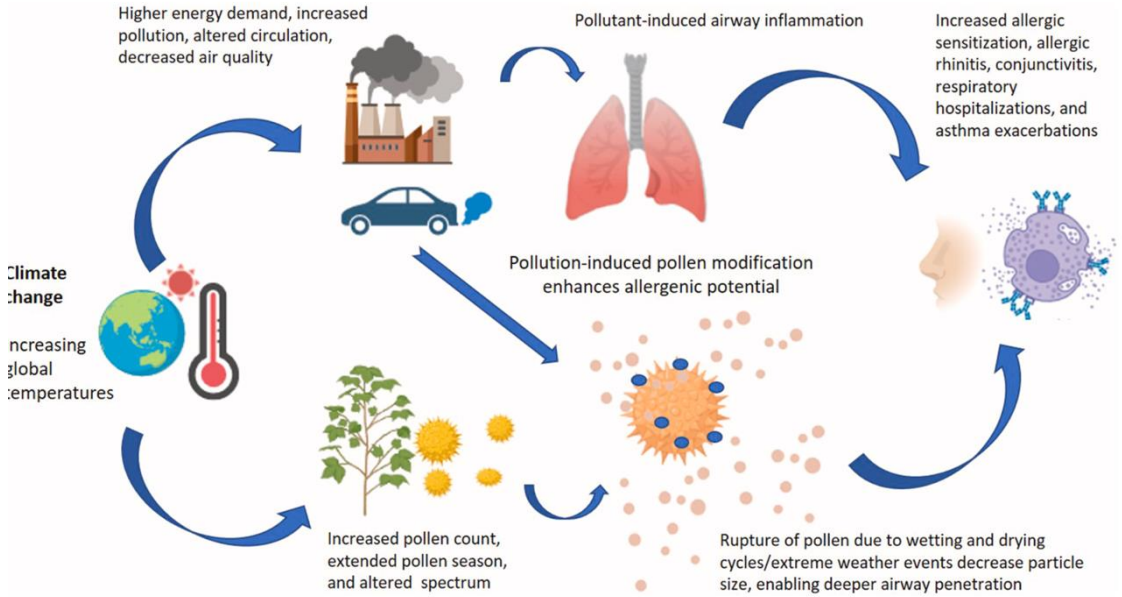
⇒ allergy hospital admissions

⇒ asthma exacerbations

Diversity and concentrations

- Migration of species from South to North
- Human exposure to alien pollen (immune system not prepared)

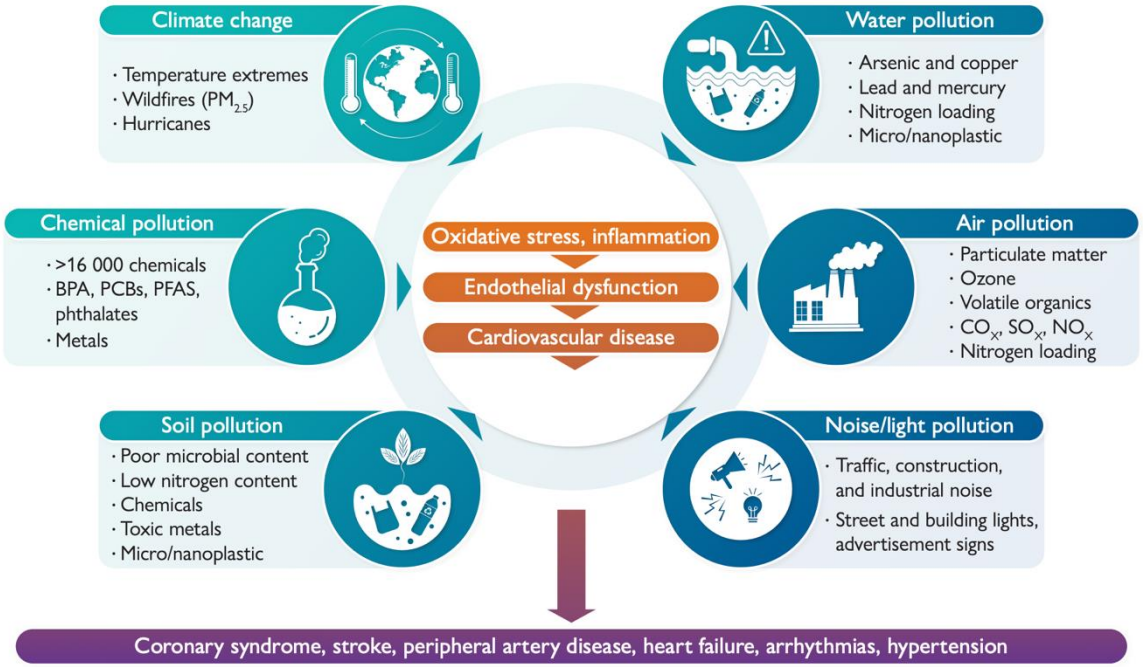
Allergenicity increases when high NOx concentrations



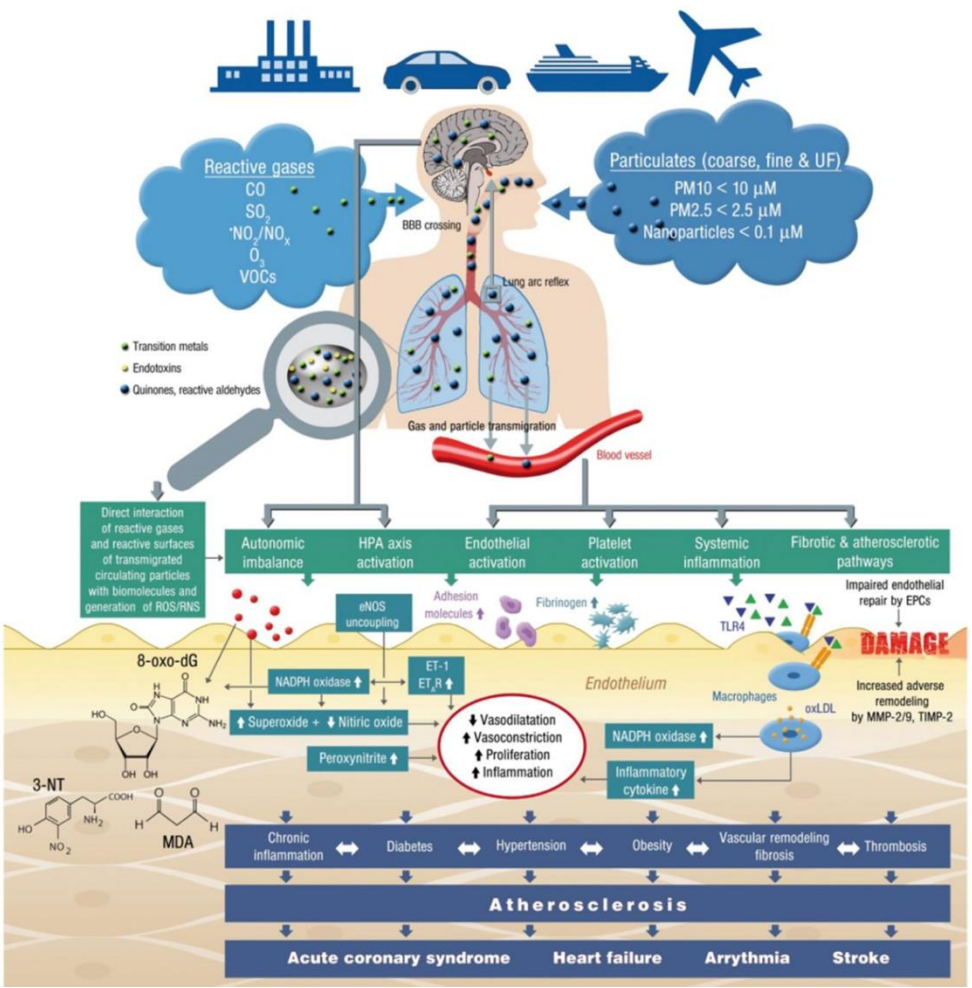
Pollution & cardiovascular disorders

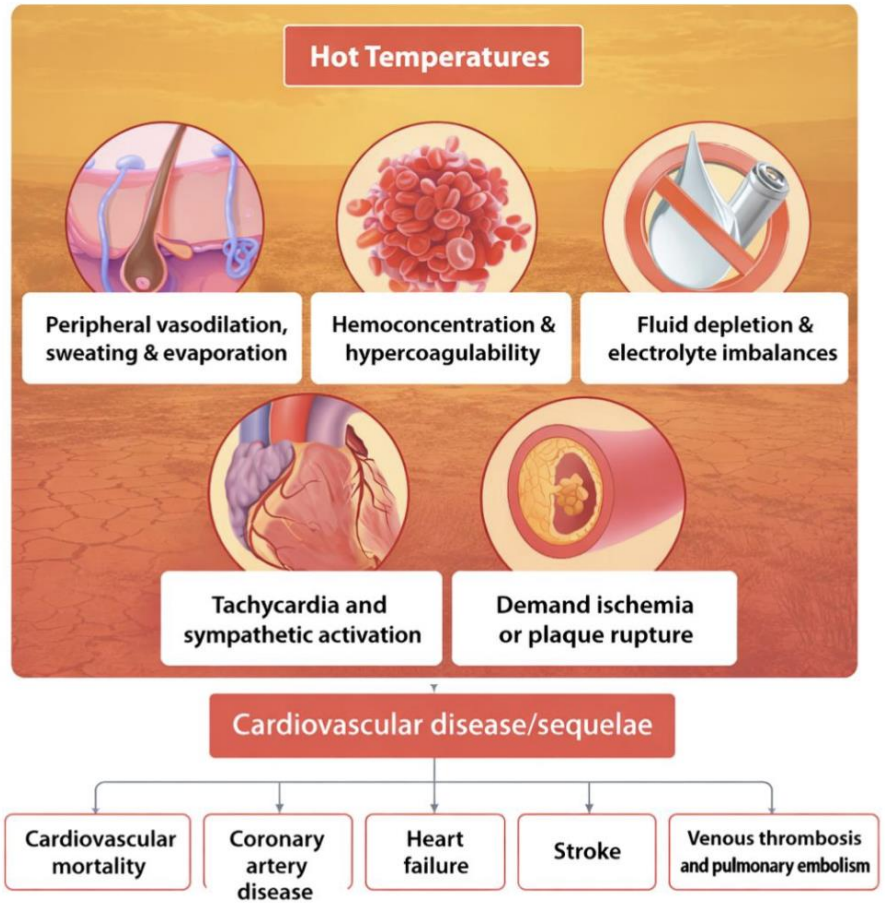
Cardiovascular disorders including increased risk of heart disease due to prolonged exposure to pollutants in the air, such as fine particulates and nitrogen dioxide, is associated with an increased risk of heart attacks, strokes, and other conditions related to the cardiovascular system. Pollutants that may cause high blood pressure levels can increase the risk of hypertension and cardiovascular diseases.

Piepoli et al 2026



Mechanisms of air pollution and heat on cardiovascular disorders





Temperature and air pollution /cardiovascular outcomes

- Rising temperatures and excessive heat exposure are associated with increased thrombogenicity secondary to **oxidative stress**, **inflammation**, **reduced circulatory volume** and **vasodilatation** causing reflex increases in heart rate and cardiac contractility, and thrombosis

- **Oxidative stress** and **inflammation** are responses to air pollution exposure at multiple levels of the pathological process. Several pathways link pulmonary inhalation to the CV system, including the passage of pollutants (especially ultrafine particles) and in turn release of inflammatory and oxidative mediators into the circulation leading to an acute phase response, changes to the autonomic nervous system influencing cardiac function and alterations in endocrine pathways mediated alterations in the central nervous system

Piepoli et al 2026 (A clinical consensus statement of the European Society of Cardiology)

Immune system / pollution & heat

PM2.5, ozone, and nitrogen oxides (NOx) can trigger inflammation and oxidative stress in the body. When exposed to these pollutants, chronic inflammation can occur, inhibiting immune function and weakening the immune response, which can impair immunity and weaken immune defence against pathogens.

Neurodevelopmental disorders / pollution & heat

Oxidative stress and inflammation in the brain, including fine particles (PM2.5), ozone, and nitrogen oxides. Neuronal damage, impaired neurotransmitter function, and cognitive deficits result from these pollutants that generate (ROS) reactive oxygen species.

Neurological disorders impair cognitive function particularly in children (reduction in intelligence, learning disability, and behavioural difficulties)

Increased risk of neurodegenerative disease (Alzheimer's and Parkinson's) when exposed to them over a long period of time to pollutants triggering inflammation

Reproductive disorders / pollution & heat

Piepoli et al 2026:

- Air pollution, especially fine PM and traffic-related emissions, has been associated with low birth weight, preterm birth, and impaired placental function. Environmental pollutants can cross the placenta and affect foetal development, increasing the risk of birth defects.
- Extreme heat exposure during pregnancy, increasingly frequent due to climate change, has been linked to increased risks of preterm birth, stillbirth, and low birth weight. Mechanisms may include maternal dehydration, systemic inflammation, oxidative stress, and impaired placental perfusion.

Adélaide et al 2026:

- Heat exposure during the two first trimesters of pregnancy was associated with reduced foetal growth, which might partly be due to reduced gestational duration. Heat exposure during the third trimester was associated with increased foetal growth. O3 concentrations influenced the association in both directions depending on pregnancy weeks.

Thanks for your attention