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Global Medicine



Cardiovascular disease in low- and middle-income countries associated with environmental factors

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REVIEW

Prevention in practice

Cardiovascular disease in low- and middle-income countries associated with environmental factors

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Jagat Narula^{10†}, and Fausto Pinto ^{11†},
on behalf of the World Heart Federation Neglected Cardiovascular Disease and Air
Pollution Expert Groups

- Growing recognition that the profound environmental changes have occurred over the past century pose threats to human health.
- Many environmental factors, such as air pollution, noise pollution, as well as exposure to metals such as arsenic, cadmium, lead, and other metals, are particularly detrimental to the cardiovascular health of people living in low-to-middle income countries (LMICs).

Premature death due to pollution

- The analysis of premature death due to pollution was conceptualized by the World Health Organization (WHO) in the 1990s and expanded by the Institute of Health Metrics and Evaluation.
- In 2019, pollution was responsible for 9 million premature deaths annually; **one in six deaths globally:**
 - air pollution (6.7 million)
 - water pollution (1.4 million)
 - exposure to toxic chemicals such as lead in particular (900 000).
- More than **90% of pollution-related deaths occur in LMICs.**
- Incidence of cardiovascular disease (CVD) is increasing in LMICs, and it is recognized that cardiovascular causes account for over half of the mortality attributed to air pollution.
- **The impact of environmental factors on the cardiovascular system in individuals living in LMICs has only received limited attention.**

MORTALITY RISK FACTORS – 2019 RANK

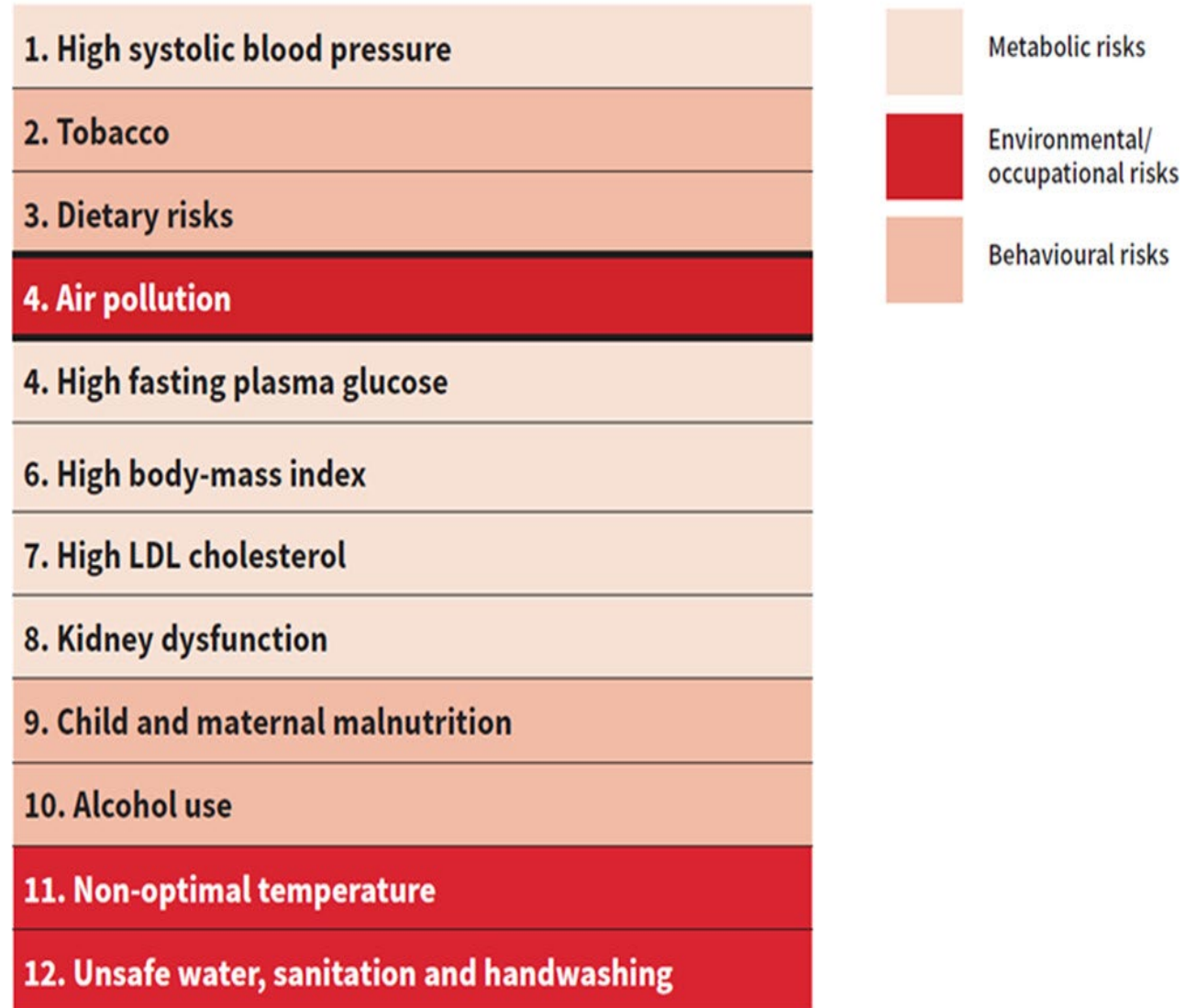


Figure 1. Ranking of air pollution relative to other leading risk factors for global mortality.

Who contributes to global carbon emission?

- However, among the **20 lowest global contributors to carbon emissions (≤ 0.2 metric tons of CO₂/per capita), 19 are LMICs in sub-Saharan Africa.**
- The **greatest contributors to climate change (≥ 10.0 metric tons of CO₂/per capita) are wealthy countries (including the USA, Canada, Australia, and many middle Eastern countries) who have the greatest capacity to mitigate the impact of climate provocations on the cardiovascular health of their citizens.**

Cardiovascular effects of air pollution

- On a global scale, **air pollution is responsible for almost 20% of deaths related to CVD**, leading to an **average reduction in life expectancy by 20 months**, a figure closely rivalling the impact of **tobacco use (22 months)**. Reducing air pollution is crucial for global cardiovascular health, particularly in LMICs, where air pollution levels are highest.
- **Particulate matter is monitored and regulated according to its size, with PM₁₀ and PM_{2.5} (particles with a diameter of 10 and 2.5 μm, respectively) being measured by stationary monitoring networks globally albeit sparsely in some LMICs.** illustrates that LMICs in Africa, Asia, and the Middle East experience the highest levels of exposure to PM_{2.5} pollution.
- As do, **PM₁₀ and PM_{2.5} which can penetrate deep into the alveoli of the lung and activate inflammatory cells** attempting to defend against the particles.

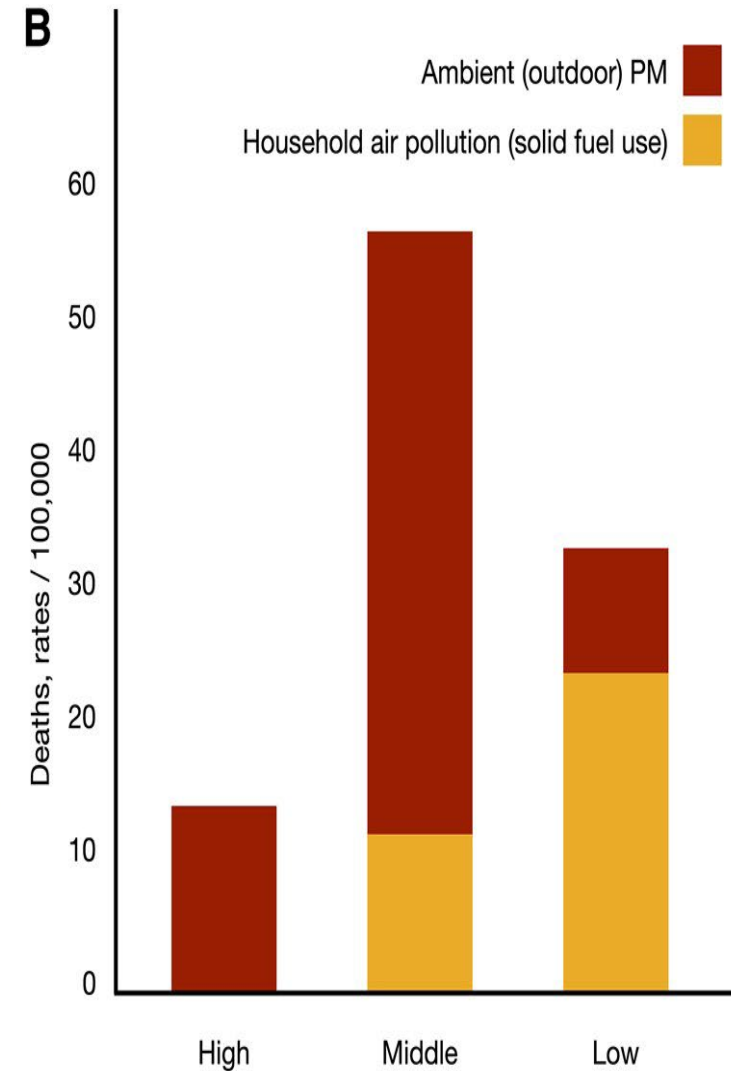
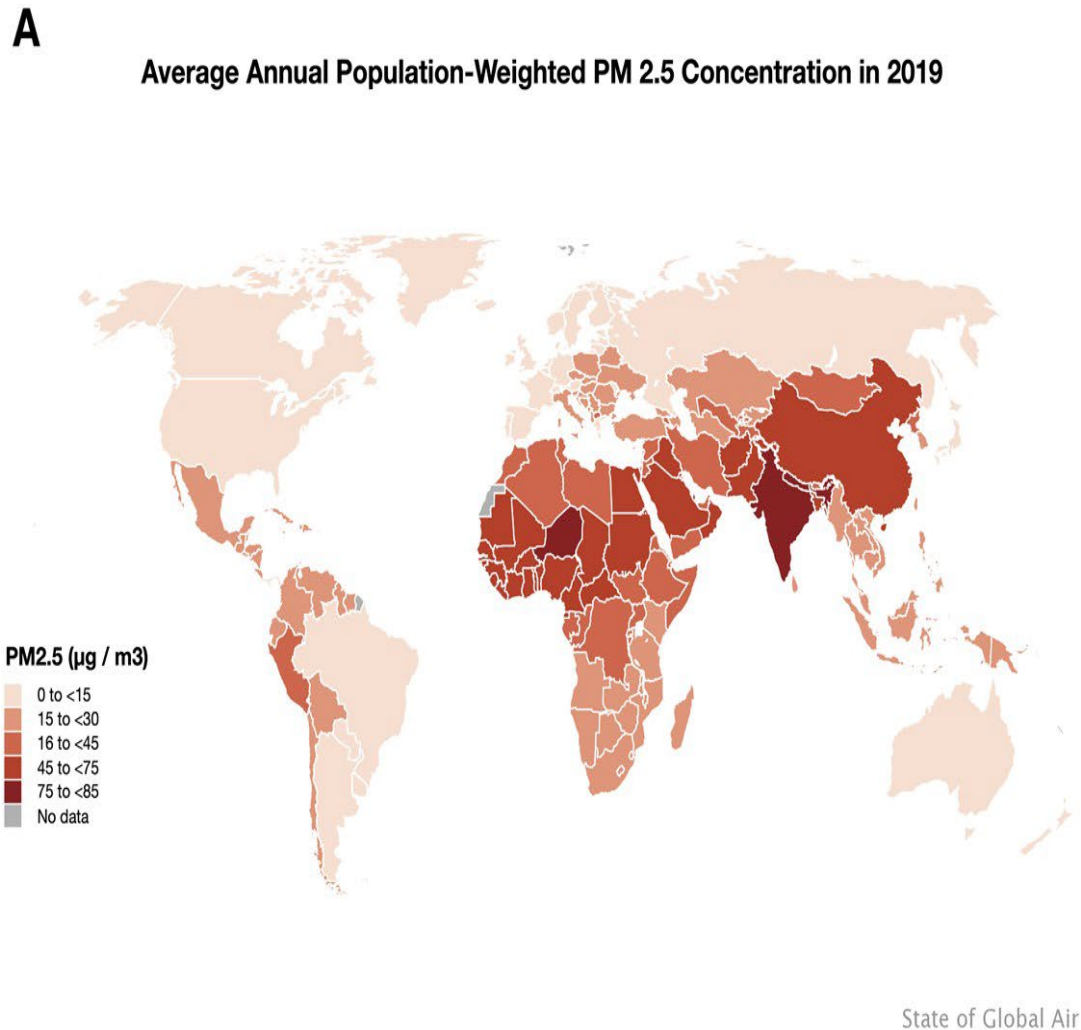


Figure 2: PM_{2.5} exposure remains high across much of the world. (A) The highest exposures to PM_{2.5} pollution occur in Asia, Africa, and the Middle East.

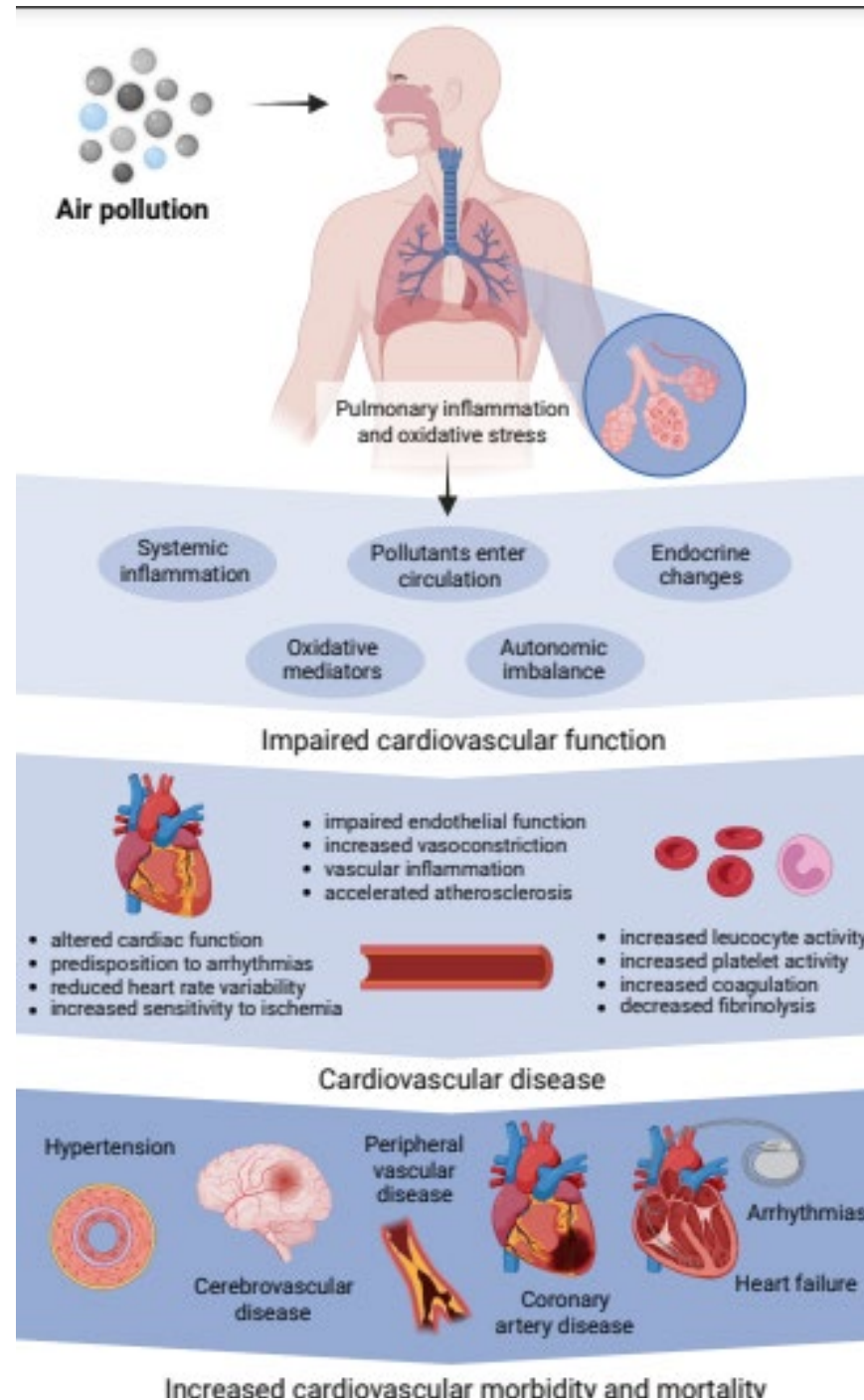


Figure 3 Biological mechanisms by which inhaled pollutants cause cardiovascular morbidity and mortality.

Noise pollution and cardiovascular disease

- Noise pollution research—mostly in developed countries—goes back several decades but is amongst the **least studied of environmental pollutants** for its impacts on cardiovascular outcomes.
- **Acute exposure to high traffic-related noise levels**, as well as **chronic exposure to even lower decibels of noise**, can affect stress responses. This in turn is known to trigger **elevated blood pressure, endothelial dysfunction, inflammatory cytokine surge, and oxidative stress—all mediating factors for CVD.**
- A meta-analysis conducted as part of the WHO Environmental Noise Guidelines for the European region (2018) showed that for an increase in road traffic noise of 10 dB (after 53 dB), the relative risk of ischaemic heart disease was 1.08 [95% confidence interval (CI) 1.01–1.15].
- **Night-time aircraft noise** was seen to affect sleep quality triggering a stress response, and associated reactive dysfunction, including oxidative stress and inflammatory responses similar to those of established pathways of traditional risk factors.

Exposure of metal pollution on cardiovascular disease in low-to-middle income countries

- Metal pollution is detrimental to health, largely due to the activation of physiological pathways that are known to modulate cardiovascular risk.
- It is linked to endothelial damage, promotes atherogenesis, and increases blood pressure.
- Review focus on metals such as **lead, cadmium, and arsenic**, which have consistently been shown to be associated with the development and progression of CVD.

A background image showing an industrial facility, likely a refinery or power plant, at sunset. The sky is a mix of orange, yellow, and blue. In the foreground, there are large, white, cylindrical structures, possibly storage tanks or chimneys, partially obscured by a semi-transparent white shape. The facility's lights and smokestacks are visible in the distance, with smoke rising from them. The water in the foreground reflects the lights and the sky.

Exposure of metal pollution on CVD in LMIC

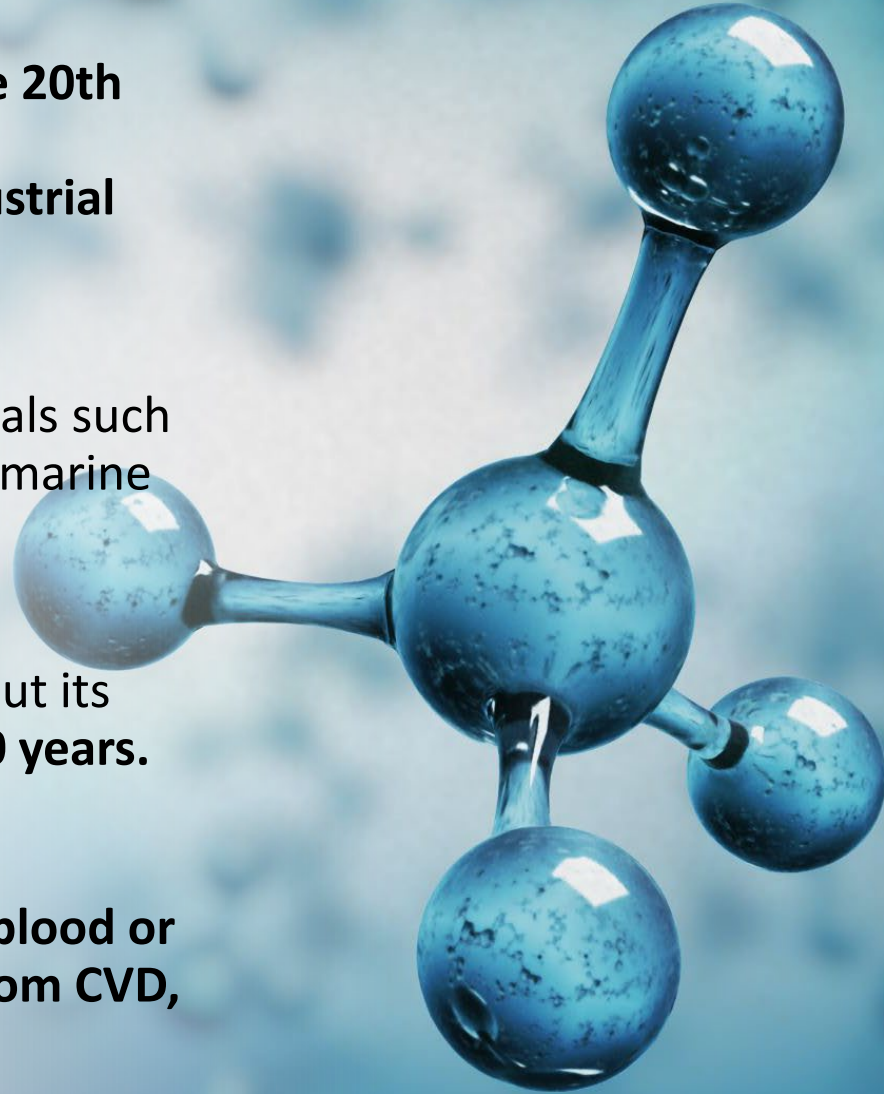
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Lead

- Exposure to lead increased dramatically in the USA and Europe in the beginning of the last century, mostly due to the use of leaded motor fuel and its associated exposure due to inhalation. Fortunately, the use of leaded motor fuel was phased out from the 1970s, leading to a decrease in exposure in the US population and elsewhere.
- In LMICs, lead is still extensively used in **plumbing, potteries glazed with lead salts, and exposure through unsound recycling of lead-acid batteries, electronic waste,** and its release through industrial fumes.
- Environmental exposure to lead is largely from **air pollution, soil, and drinking water.**
- **Lead promotes oxidative stress, endothelial dysfunction, proliferation of vascular smooth muscle cells, and fibroblasts. Furthermore, studies have demonstrated downregulation of nitric oxide, stimulation of the renin–angiotensin–aldosterone system, and increased sympathetic nervous activity, leading to hypertension.**
- A meta-analysis including a wider range of more than 25 studies globally of more than 50 000 individuals produced estimates of **increases in systolic blood pressure of 0.8–1.2 mmHg for each two-fold increase in the level of lead in blood.**

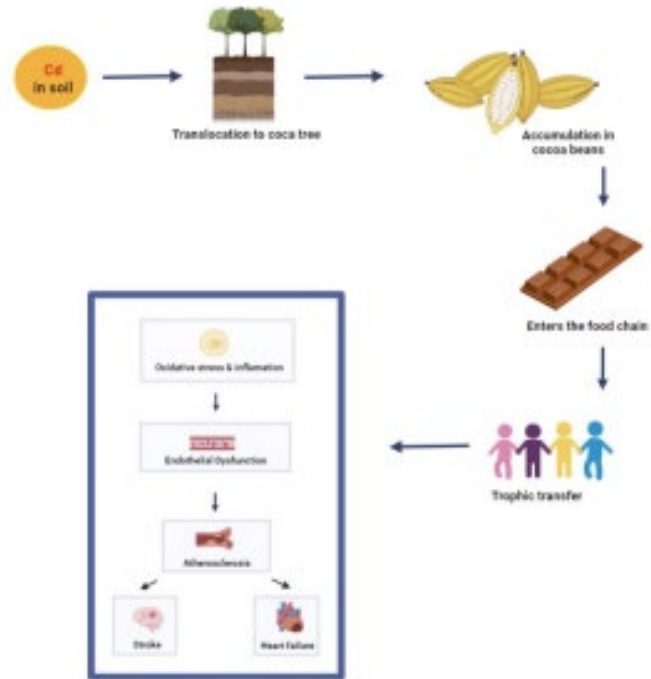
Cadmium

- Cadmium use **increased substantially during the 20th century in applications such as nickel–cadmium batteries, plastic stabilizers, metal coating, industrial releases, and fuel combustion.**
- Other sources for cadmium (and other toxic metals such as mercury, lead, chromium, and nickel) include marine fish and organ meats.
- Less than 5% of ingested cadmium is absorbed but its biological half-life in the **human body is up to 30 years.**
- **Epidemiological studies link cadmium levels in blood or urine with increased incidence and mortality from CVD, coronary artery disease (CAD), stroke, and HF.**



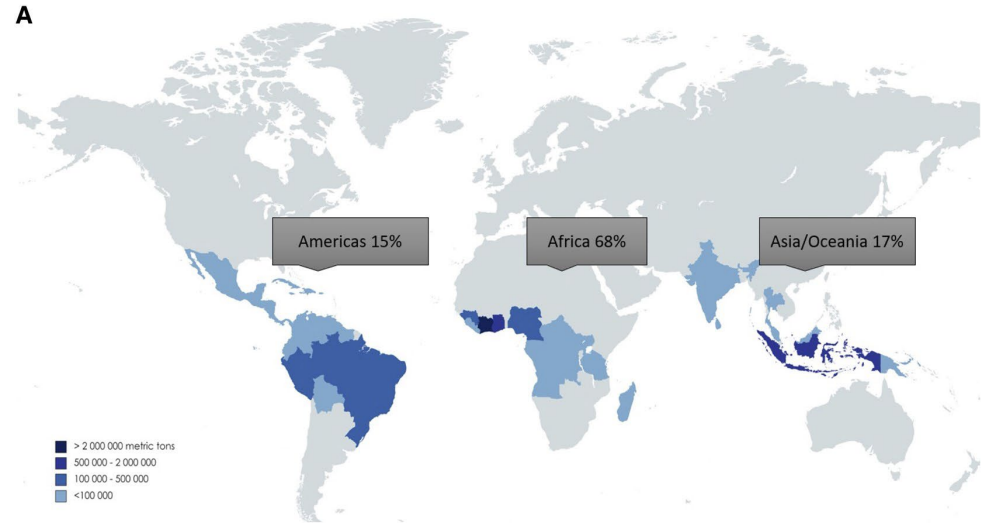
Cocoa-laden cadmium and global impact

- When soil is contaminated with cadmium, cocoa plants absorb the metal, leading to its accumulation in the cocoa beans.
- This does not only pose a serious health threat to cocoa producing countries, but also to regions with high cocoa consumption.

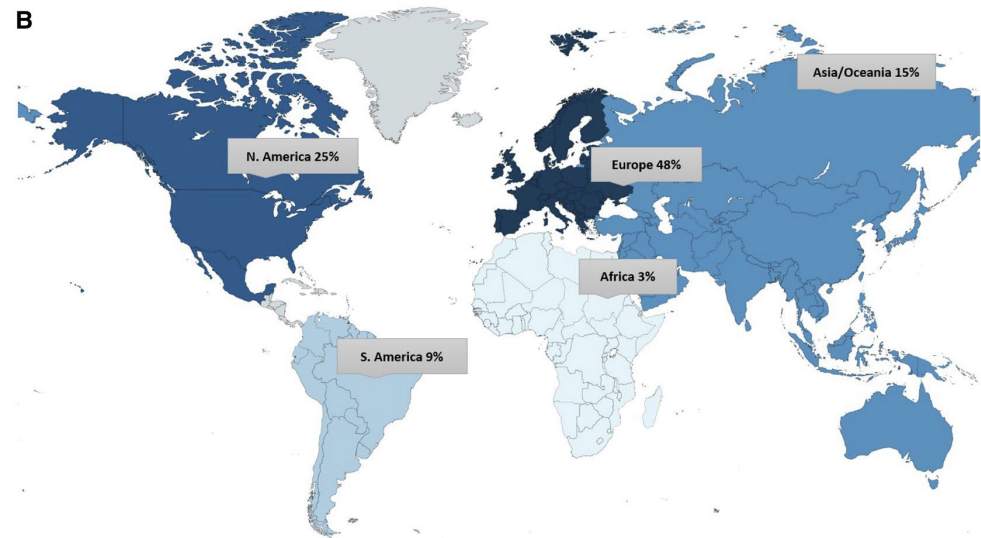


Cocoa-laden cadmium and global impact

- The case of cadmium transmission via chocolate underscores that the prevalent notion of **'Not-In-My-Backyard' (NIMBY)**, in which local residents resist proposed developments near their homes, does not shield inhabitants of industrialized nations from the enduring effects of cadmium pollution.



Global cacao production



Global cacao consumption

Arsenic

The main source of arsenic exposure in humans is **groundwater, food (i.e. mainly grains, rice, fish)**, and occupational exposure to **pesticides and herbicides**.

Millions of people around the world live in areas where the naturally occurring level of arsenic in drinking water exceed the WHO recommended limit of 10 µg/L.

Arsenic elicits profound molecular, cellular, and organ-level responses upon exposure. At the molecular level, arsenic disrupts critical cellular processes by impeding enzymes and proteins pivotal for DNA repair

Arsenic exposure has been correlated with vascular dysfunction and elevated predisposition to CVDs.

Many studies have shown high levels of arsenic exposure globally, but evidence suggests that effects such as **neovascularization, angiogenesis, and vessel remodelling can occur at even relatively low levels of exposure.**

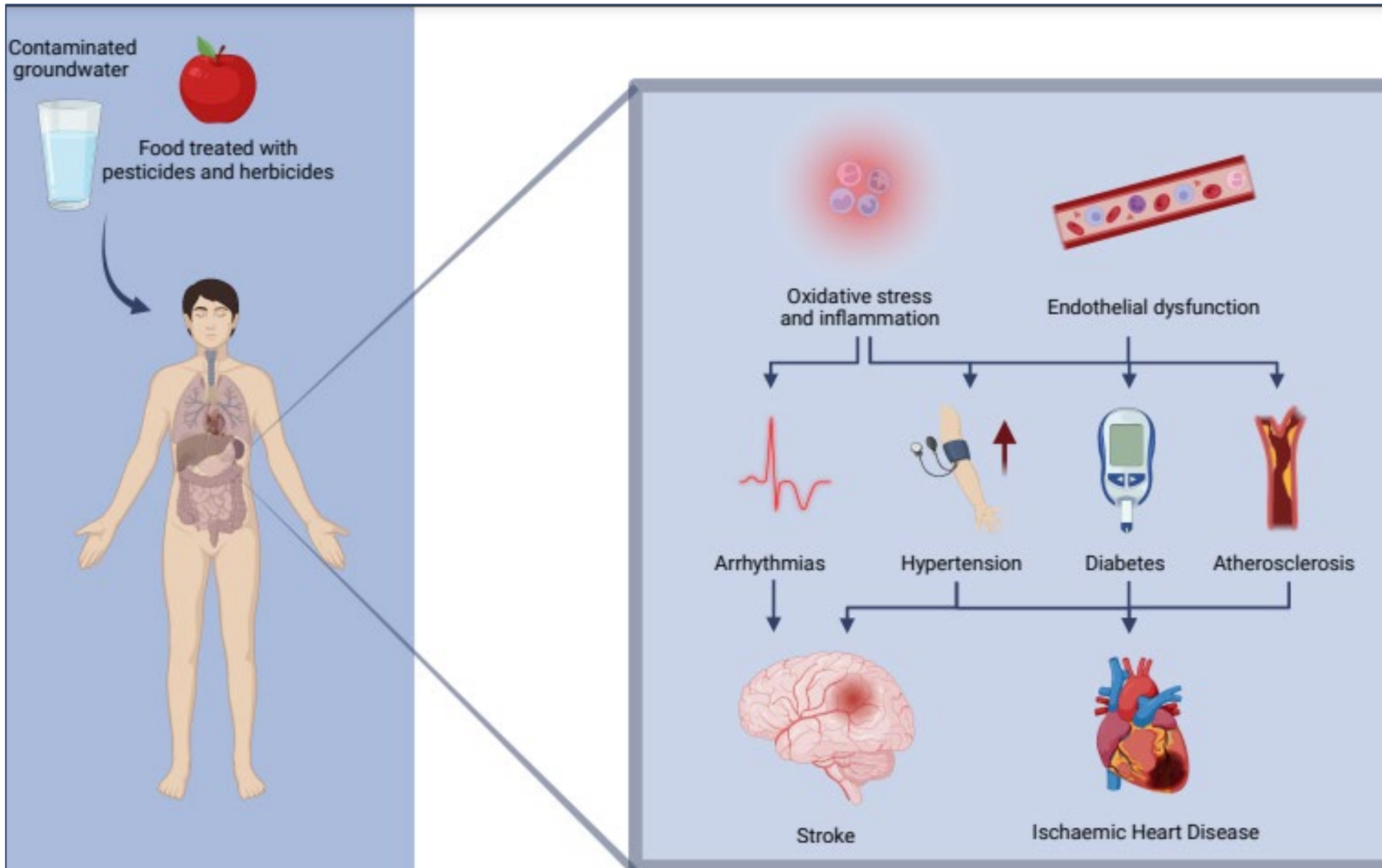
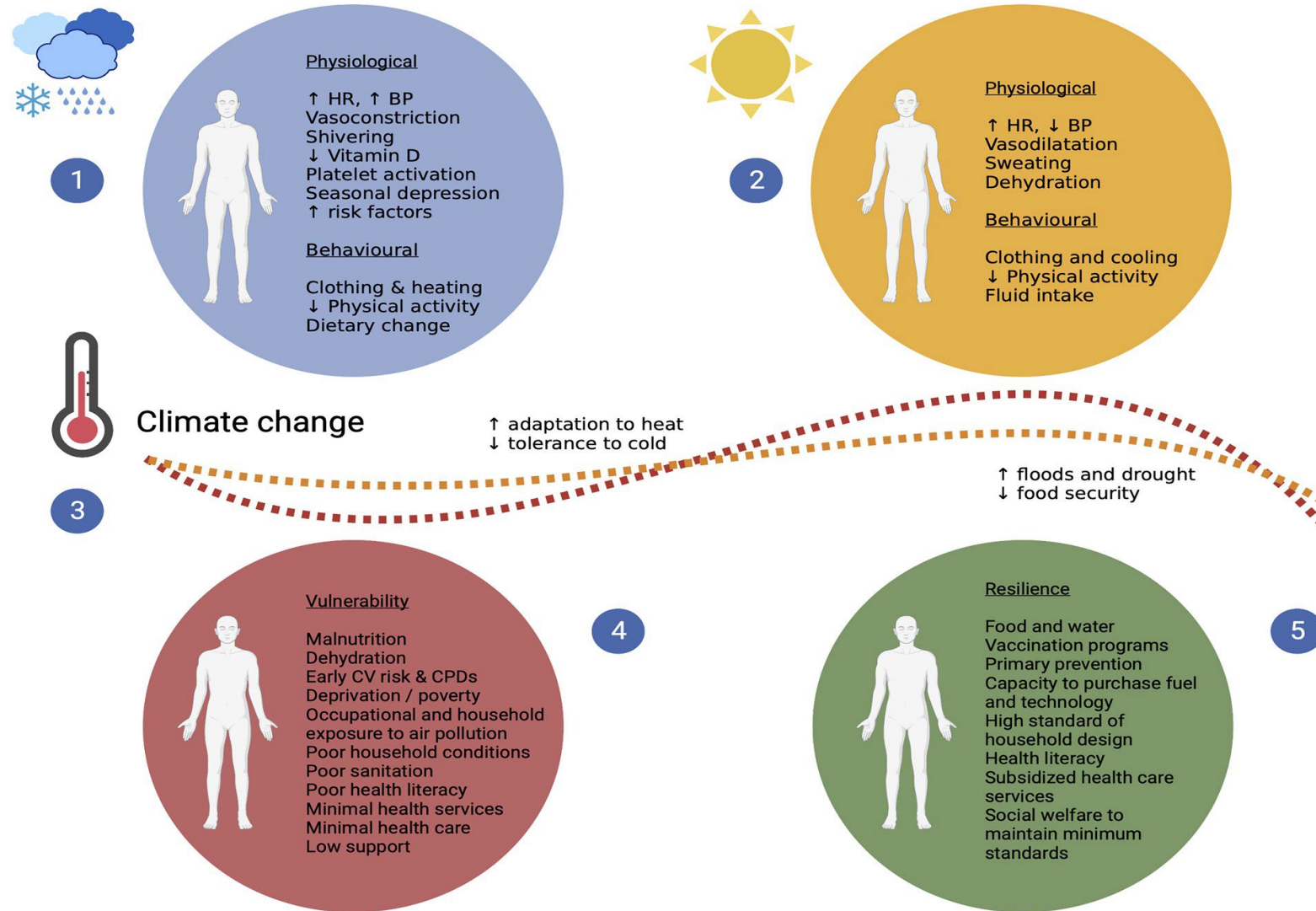


Figure : Arsenic pollution

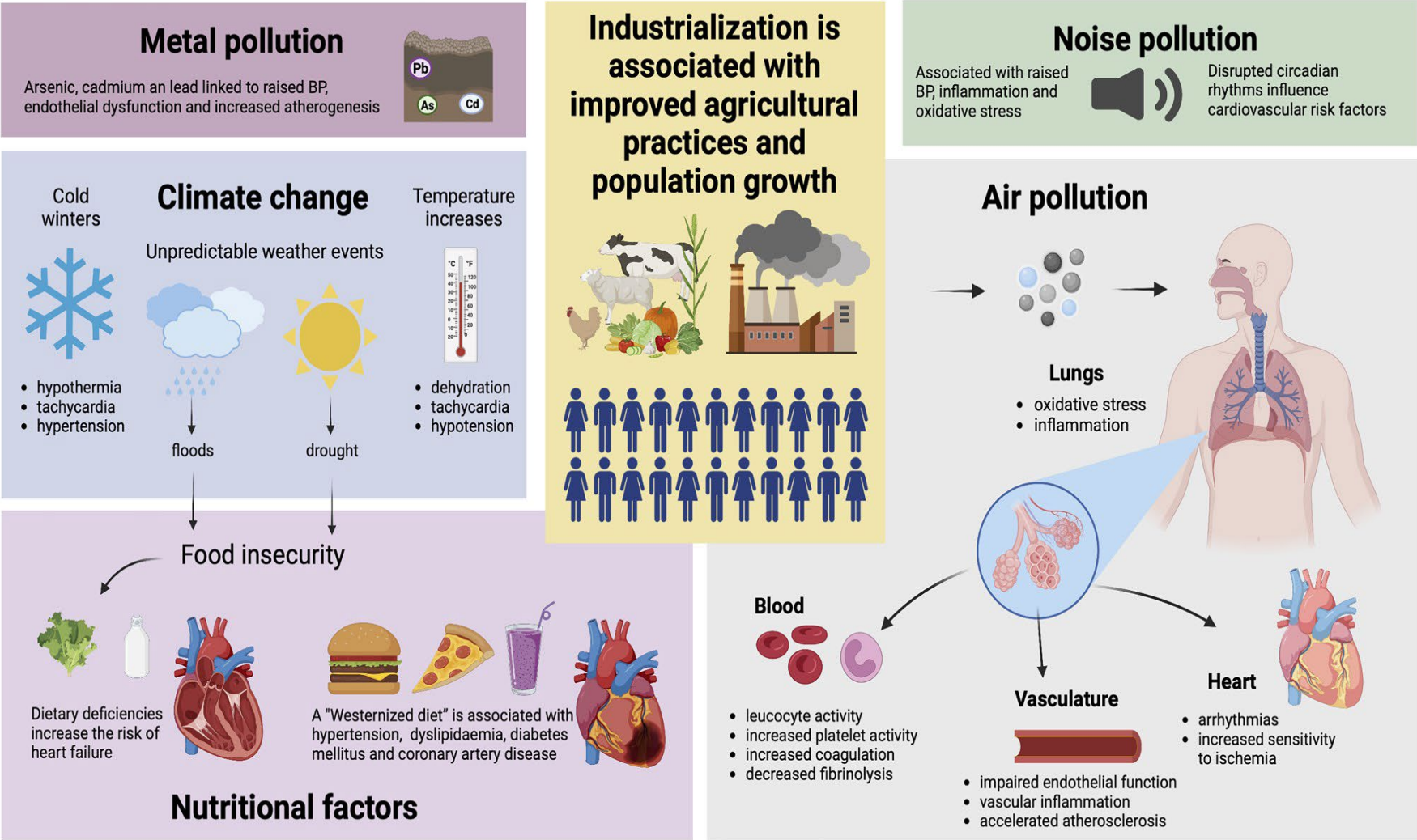
Nutritional factors and CVD in LMIC

- Large observational cohort studies have shown that consumption of ultra-processed foods are associated with increased incidence of cerebrovascular and CAD, and greater risk of cardiovascular mortality.
- Poor diet emerged as the primary behavioural risk factor for CVD in LICs in the PURE study, carrying a weight equal to, if not greater than, tobacco use.
- Malnutrition research traditionally focuses on undernutrition or overweight separately. However, the global nutrition transition has given rise to the **double burden of malnutrition, where individuals can experience both undernutrition and overnutrition in their lives.**
- Early-life malnutrition has lasting effects on biological pathways, increasing the risk of disease susceptibility later in life.

Figure 1: Extreme climate condition : Biobehavioural and socioeconomic drivers of cardiovascular vulnerability



Graphical Abstract



Conclusion and what can be done 1

- Most pollution remains in the vicinity of its source, in the country of origin.
- Growing evidence showing that some pollutants travel long distances by air, in oceans and rivers, even by means of food products that are consumed in countries far from where they are produced. I
- It is not uncommon that HICs dispose their waste in LMICs, where safe waste management is not always in place, which further aggravate soil and water pollution in the recipient LMIC.
- This in turn leads to the contamination of vegetables, cereals, cocoa products, and seafood produced in LMIC for export to other regions, having a profound effect on global food safety.
- **The consequences of environmental factors are of particular importance for children, as the negative effects on public health will be long lasting and, as highlighted above, have an impact on many organs system including the cardiovascular system.**

Conclusion and what can be done 2

- The NIMBY (**‘Not-In-My-Backyard’**) approach to the negative impact of environmental factors and pollution is common.
- Many consumers, including clinicians, assume that waste separation will be sufficient to mitigate the impact.
- As such, clinicians should not only be cognizant of the impact of the environment on the health but should promote improved awareness and advocate for systemic change to reduce environmental risks.
- We all need to adopt a more modest lifestyle, whereby we reduce our carbon footprint and use less resources, avoid unnecessary waste, and produce less pollutants.
- Indeed, pollution needs to be tackled by policy-makers at a global level, as it has become one of the most important threats to humankind, impacting the cardiovascular system and far beyond.
- Clinicians and medical organizations have a role in education on health risks of environmental factors.
- The full footprint that pollution has on the cardiovascular system will only be seen in the decades to come.

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JOINT OPINION






Taking a Stand Against Air Pollution—The Impact on Cardiovascular Disease

A Joint Opinion From the World Heart Federation, American College of Cardiology, American Heart Association, and the European Society of Cardiology

Michael Brauer, ScD , Barbara Casadei, MD, DPhil , Robert A. Harrington, MD, Richard Kovacs, MD, Karen Sliwa, MD, PhD, and the WHF Air Pollution Expert Group



Thank you

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