

Review Article

Pollution and its impact on cardiovascular health

Vinay Kamath*, Gregg Cantor

¹Syosset High School, Syosset, New York, United States

²St. Francis Hospital and Heart Center, Roslyn, New York, United States

Received: 08 August 2025

Revised: 13 September 2025

Accepted: 25 September 2025

*Correspondence:

Vinay Kamath,

E-mail: kamathv97@gmail.com

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ABSTRACT

Cardiovascular disease is the leading cause of mortality globally accounting for about 18 million deaths annually with more with more than 3 million occurring in low and middle-income countries. There is increasing body of data supporting pollution as leading cause of morbidity and mortality. The WHO estimates that almost 99% of the world population is exposed to risk of air pollution that are higher than the ambient recommended levels. The risks are dramatically increased in developing countries. There is an increasing body of data supporting pollution as a significant contributor to cardiovascular disease. In addition to being an increasing cause of deaths annually, the economic losses are estimated to be more than 4 trillion dollars. This review focuses on air, soil, water, and noise pollution and the harmful effects they create on the cardiovascular system. These effects on people can be mitigated on an individual and societal level, which will cause improvement of cardiovascular health. There is an urgent need to increase awareness of this issue and to implement population-based strategies to reduce this risk.

Keywords: Air and noise pollution, Cardiovascular disease risk, Microplastics

INTRODUCTION

Pollution is increasingly recognized as an important cause of morbidity mortality and a preventable risk factor for cardiovascular disease. It is estimated that pollution was responsible for more than 5 million deaths due to cardiovascular disease in 2019. Globally, nearly 20% of cardiovascular deaths were attributable to air pollution in 2019.¹ Although clinical trials are lacking, there is an increasing body of data that shows that air, particulate, soil, noise, and water pollution increase the risk of developing heart disease. There was nearly a 50% reduction in the incidence of CAD when strategies that reduce environmental pollution were combined with the adoption of healthy lifestyle interventions. In addition to cardiovascular disease, there is an increased risk of stroke and cerebrovascular disease as well. The traditional risk factors for cardiovascular disease including hypertension, hyperlipidemia, smoking, diabetes, obesity, and sedentary lifestyle, are well recognized. To combat this, the

ACC/AHA guidelines on the prevention of heart disease recognize the importance of maintaining a healthy lifestyle, monitoring blood pressure, and keeping a good exercise regimen (150 minutes of accumulated moderate intensity physical activity). In addition, there has been an increasing focus on increasing awareness and developing evidence-based strategies to mitigate the effects of pollution to further reduce cardiovascular risk. To this end, the joint opinion from the world health federation has now aimed to generate enough awareness to reduce the impact of air pollution to achieve a 25% decrease in cardiovascular mortality by 2025.² Urgent and sustainable interventions are needed to increase awareness and provide practical methods to achieve this goal. World health day celebrated on April 7th highlights the impact of planetary health on individual health and long-term outcomes. A combination of interventions at the individual and societal levels will be needed to achieve a sustainable reduction in pollution and further improve cardiovascular mortality.

AIR POLLUTION

Although combined into one entity, the US environmental protection agency recognizes six major air pollutants—small particulate matter with diameter $<2.5\ \mu\text{m}$ (PM 2.5), ozone, nitrous oxide, carbon monoxide, sulfur dioxide and lead. Each of these are independently associated with increasing the cardiovascular mortality. Air pollution is complex and dynamic as it is related to different sources and can vary in different parts of the world. We highlight the 3 main including particulate matter, ozone and nitrous oxide. Approximately 92% of the world population live in areas that exceed the WHO annual quality guidelines for PM2.5. A large majority of this exposure in developing countries comes from using solid fuels for cooking especially in poorly ventilated homes. Outdoor pollution stems from a combination of fossil fuel combustion, industrialization and increased incidence of wildfires attributed to climate change. This has led to acute worsening of air quality in many parts of the world including most recently in Greece, United States and Canada. Short-term exposure to particulate matter specifically PM 2.5 increases the risk of hypertension, atrial fibrillation, heart failure, and cardiovascular mortality.³⁻⁵ Long term exposure is associated with increased risk of MI, ischemic heart disease and stroke.⁵ Alarming, 20% of the global burden of diabetes mellitus (DM) was attributed to PM 2.5 exposure with 13% of deaths due to DM related to PM 2.5. With increasing incidence of DM in developing countries from fast foods and poor lifestyle choices, it is imperative that we recognize and work to reduce this risk.

Household air pollution from biomass fuel use is an increasing problem in developing countries that merit a special highlight. Biomass fuel including wood, charcoal, dung and crop residue is burned in indoor and outdoor stoves for cooking and heating. Inhalation of wood smoke is associated with increase in arterial wall thickness, systolic blood pressure and increase in exposure to pollutant black carbon.^{6,7} Replacement of traditional cookstoves with cleaner burning stoves was associated with lower blood pressure.⁸

Ozone is associated with worsening of respiratory illness, COPD exacerbation and increasing pulmonary and circulatory mortality.⁹ Nitrogen oxides, carbon monoxide and sulphur dioxide are primarily related to burning of organic fossil fuels. Each of these are associated with higher risk of atherosclerosis, ischemic heart disease and increased cardiovascular mortality.^{10,11} The multi-ethnic study of atherosclerosis and air pollution (MESA air) found that increased concentration of PM 2.5 was associated with progression of coronary calcifications that are considered markers for CAD.¹² There is growing data on the cardiovascular impact of lead accumulation. Tobacco use is a common source of lead exposure. Although leaded petroleum is banned in most countries, it continues in some low-income countries leading to increasing exposure to lead. Children and pregnant

women are increasing vulnerable to neurologic and cardiovascular complications. Alarming, blood lead levels have shown a positive correlation with risk of myocardial infarction and increase in systolic and diastolic blood pressures.¹³

Possible mechanism by which air pollution contributes to atherosclerosis was outlined in detail in a paper by the American heart association.¹⁴ Activation of oxidative stress, vasoconstriction, elevation of systemic and pulmonary blood pressure, platelet and thrombotic activation, increased myocardial oxygen demand and impaired coronary vasodilatation all increase the risk of acute coronary syndrome, stroke, decompensated heart failure and cardiac arrhythmias. Indeed, as documented in the mortality risk factors of 2019, air pollution ranked higher than LDL cholesterol and alcohol use. Climate change primarily caused by fossil fuel combustion has escalated the effects of air pollution on human health. Increased temperature directly increases mortality. For every 1-degree centigrade increase above a baseline of 26 degrees, there is a more than 4-fold increase in CV mortality.¹⁵ There are also indirect detrimental effects, including extreme weather patterns, seasonal weather events, and increased incidence of infectious diseases that play a large role.

SOIL AND WATER POLLUTION

Harmful substances in soil and water can adversely affect cardiovascular health. Plastic and heavy metals are among the most common pollutants. Plastics are ubiquitous in the presence across the world. They are cheap to produce, durable and have extremely long lives. Unfortunately, a lot of the plastics are not recycled and end up in landfill. Between 1950 and 2017, 7 billion tons of plastics end up as waste.¹⁶ As the plastics breakdown, the environmental concentrations of microplastic and nanoplastics (MNP), polymer-based particles ranging from 500 μm in diameter down to 1 nm, have increased. These can accumulate in the body and stay in the body for decades. Rising global concentrations of environmental microplastics and nanoplastics (MNPs) drive concerns for human exposure and health outcomes. In a recent study, MNP concentrations in normal decedent brain samples were 7-30 times greater than the concentrations seen in livers or kidneys. More concerning was the higher MNP presence in brain samples in decedent patients with dementia.¹²

Phthalates and BPA are extensively used in packaging medical and personal care products and have been shown to have poor health consequences. They are thought to increase insulin resistance, oxidative stress, and increase risk of hypertension. BPA is ubiquitously used in canned foods and beverages. Clinical trials have demonstrated increased risk of diabetes and an increase in systolic pressure after drinking from BPA-lined canned beverages compared with consuming from glass-bottled beverages.^{17,18}

Lastly, pesticides are used extensively in homes and agriculture to control pests. These chemicals have well-documented adverse effects, including cancer. For example, dichlorophenyl trichloroethane (DDT) is banned in most developed countries but is still used in developing countries for controlling vector-borne illness. It has been associated with an increased risk of hypertension and diabetes. Other metallic pollutants, including heavy metals like arsenic, cadmium, copper, and lead, can also increase the risk of stroke and cardiovascular disease. Exposure to some of these heavy metals (arsenic, cadmium, and titanium) is associated with cardiac and femoral atherosclerosis while the exact mechanism is unknown, most plausible scenario appears to be related to induction of oxidative stress, triggering inflammation and endothelial injury contributing and worsening atherosclerosis.^{18,20}

NOISE POLLUTION

Noise pollution is a significant risk factor for cardiovascular disease. It ranks second after air pollution

in harm for public health. In developing countries, transportation noise, car horns, music festivals and celebratory fireworks tend to cause periodic increases in noise pollution thresholds. In developed countries, industrial noise predominates. Both acute exposure and long term exposure to noise levels has been shown to have deleterious effects on health. A systematic review on noise and cardiovascular and metabolic effects has demonstrated association of noise to inducing acute MI.²¹ There is association of other cardiovascular disease including HF, atrial fibrillation, HTN and DM.²² Beyond damage to the auditory system, noise pollution can induce sleep disruption, emotional stress and increase the risk of cardiometabolic disease. The possible mechanisms including activation of the hypothalamic pituitary axis, inflammation, activation of sympathetic hormones leading to arrhythmias, MI and HF. WHO estimates that traffic noise in Europe will result in loss of 1 million disability adjusted life year due to noise related disease.²¹ Long term exposure triggers hormonal changes including increase in epinephrine, dopamine and cortisol that increase the risk of diabetes, obesity and hypertension.

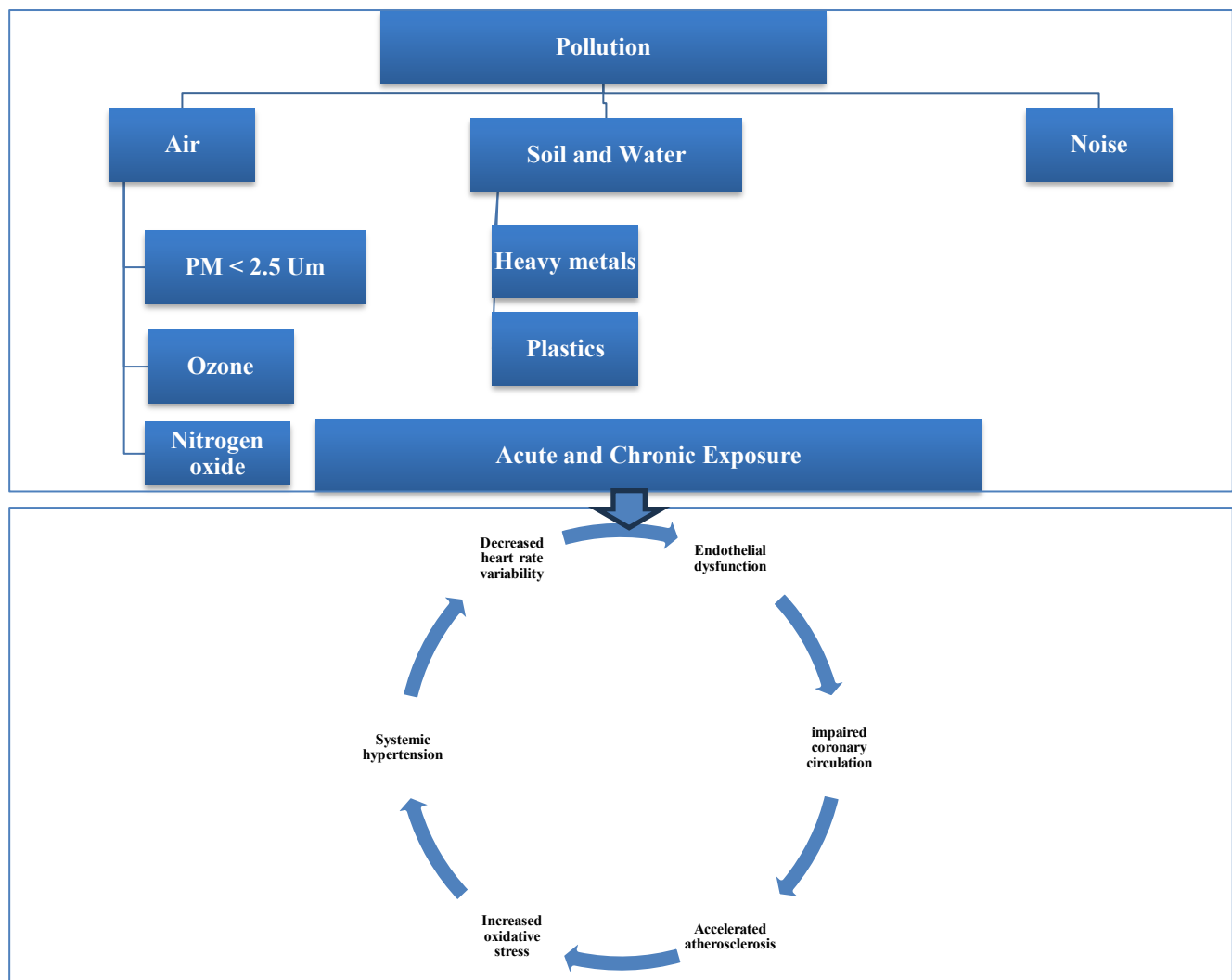


Figure 1: Summary of pollution and cardiovascular disease risk.

POLLUTION MITIGATION STRATEGIES

Reducing the impact of pollution requires intervention at the individual, societal, and governmental levels. Individual air pollution mitigation strategies include the use of personal masks, remaining indoors with an air purifier during times of high pollutant levels, and proper cooking ventilation, especially in developing countries. The use of N95 respirators and high-efficiency particulate air [HEPA] filters has been shown to significantly reduce exposure to PM 2.5. Additionally, a plant-based diet can reduce methane emissions by 30% due to animal farming being a major contributor of greenhouse gas emissions. As a result, the ACC/AHA/ESC has advocated for the adoption of plant-based diets to improve individual, societal, and global cardiovascular health. Also, another way to mitigate pollution levels is to reduce the use of single-use plastics, increase composting, regular recycling, and plant more trees. One other personal strategy includes increasing the use of renewable energy (instead of reliance on fossil fuels), which in turn decreases air pollution and contamination of the water supply.

These solutions should also be further implemented at the governmental level. In the United States, the environmental protection agency [EPA] already regulates and limits soil and water pollution. Several legislative acts that regulate and control the discharge of pollutants in soil and water include the clean air act, clean water act, toxic substances control act, and comprehensive environmental response, compensation and liability act. These acts provide a framework for the management, handling, and disposal of hazardous wastes to reduce the risk of contamination and human contact. In India, Pradhan Mantri Ujjwala Yojana has made clean cooking fuels accessible thus reducing the risk of diseases.²³ Even though there is a framework, more remains to be done. For example, more regulation is needed to avoid environmental accidents. For example, train derailments (such as what was recently seen in East Palestine) will have poor effects on the surrounding community. With stronger regulations, we can hope that these accidents do not happen again. The government can also reduce noise pollution in many ways. Such examples include reducing traffic exposure and limiting aircraft flights over residential neighborhoods. In urban cities, sounds generated by heavy machinery such as jackhammers, bulldozers, and cranes can cause significant disturbances, impacting both day and night, which should be taken seriously. In suburban areas, gas-powered blowers and landscaping equipment cause significant disruptions, and limiting these during certain hours of the day and possibly transitioning to less noisy electric blowers are all feasible strategies to reduce noise pollution.

CONCLUSION

Decreasing air, soil, water, and noise pollution is increasingly recognized as a feasible target to lower the

residual burden of cardiovascular disease in both developed and developing countries. Although differing in their composition and pathophysiology, they are all known to worsen cardiovascular health. There is an urgent need for increased recognition, education, and intervention at individual and governmental levels to achieve short and long-term success towards reducing the burden of pollution.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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Cite this article as: Kamath V, Cantor G. Pollution and its impact on cardiovascular health. *Int J Community Med Public Health* 2025;12:5296-300.