REVIEW ARTICLE

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Pollution and the Heart

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Cardiovascular diseases are the world's leading cause of disability and death. Such diseases were responsible in 2019 for an estimated 18.6 million deaths globally and 957,000 deaths in the United States.[1,2]

Great gains have been made in reducing the incidence of cardiovascular disease and related mortality in high-income countries. Identification of risk factors such as tobacco use, hypertension, dyslipidemia, physical inactivity, and diabetes in large, prospective, multiyear epidemiologic studies has been key. Recognition of these risk factors has increased awareness of cardiovascular diseases, enhanced early detection, and guided treatment and prevention. These advances have contributed to more than a 50% decline in mortality from cardiovascular disease in the United States since 1950.[3]

Pollution — unwanted material released into the environment by human activity — is another important yet often overlooked risk factor for cardiovascular disease (Fig. 1).[4] The Global Burden of Disease (GBD) study estimates that pollution was responsible for 9 million deaths worldwide in 2019, 61.9% of which were due to cardiovascular disease, including ischemic heart disease (31.7%) and stroke (27.7%) (Fig. 2A).[1] These numbers, large as they are, almost certainly undercount the full contribution of pollution to the global burden of cardiovascular disease because they are based on only a subset of environmental risk factors.[4]

Until now, pollution reduction has received scant attention in programs for cardiovascular disease control and has been largely absent from guidelines regarding the prevention of cardiovascular diseases, which have focused almost exclusively on individual behavioral and metabolic risk factors.[5] This is an important omission, since incorporation of pollution reduction into cardiovascular disease prevention could save millions of lives.

In this review, we summarize current evidence linking pollution to cardiovascular disease and suggest evidence-based strategies for disease prevention. We discuss strategies for reducing exposure to pollution in individual persons but argue that lasting prevention of pollution-related cardiovascular disease can be achieved only through government-supported interventions on a societal scale that control pollution at its source and encourage a rapid transition to clean energy. We note that these actions will also slow the pace of climate change and will thus produce a double benefit. Only through a multipronged strategy that combines pollution prevention with control of individual risk factors can the global epidemic of cardiovascular disease be contained.

AIR POLLUTION

Air pollution is a complex mixture that varies in concentration and composition according to time and place and is greatly influenced by weather.[5,6] It includes particulate and gaseous primary pollutants such as nitrogen oxides (NO_x), sulfur dioxide, and carbon monoxide, which are released directly into the atmosphere, as

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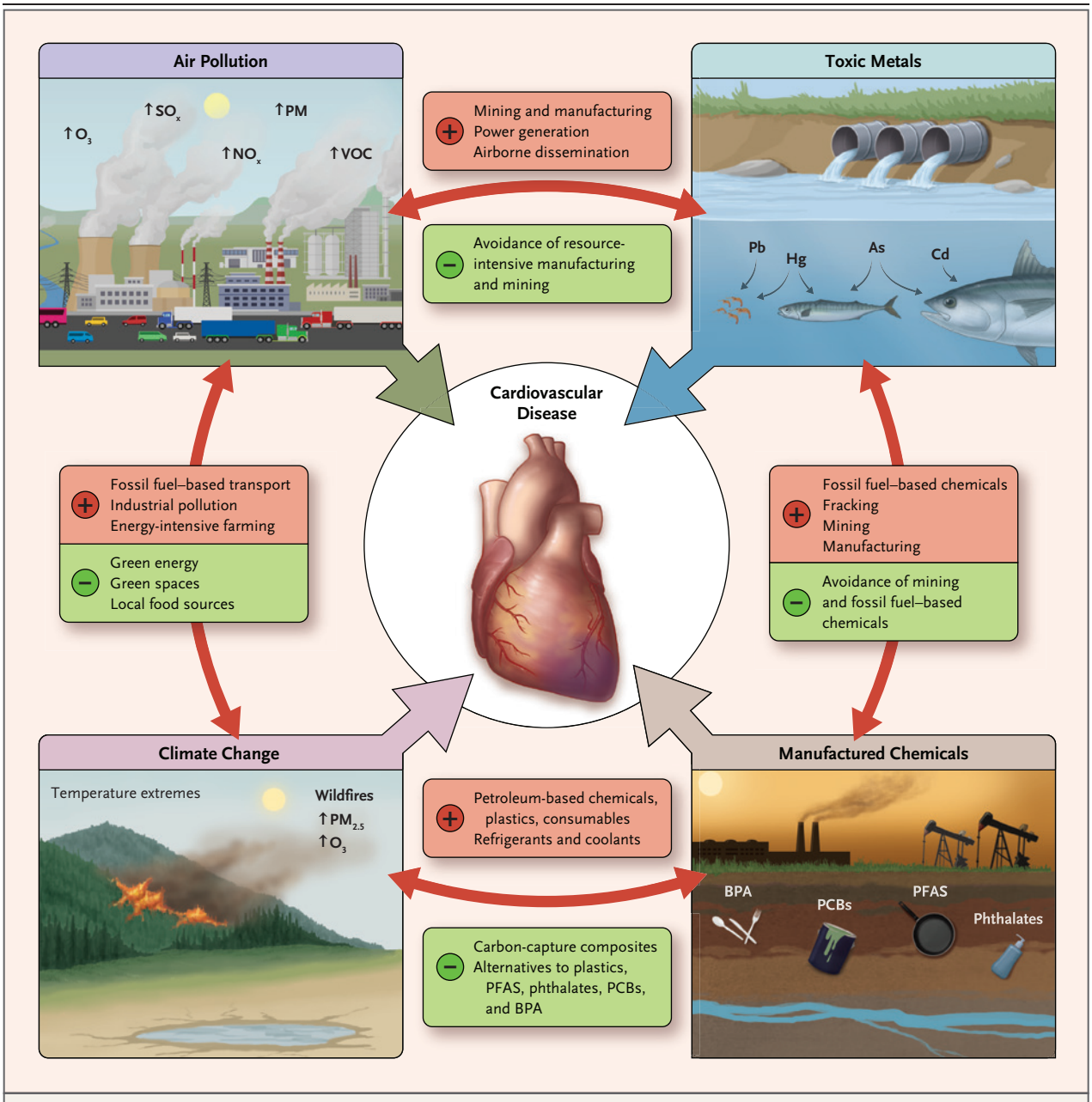

Figure 1. Pollution, Climate Change, and Cardiovascular Disease.

Plus and minus signs indicate potentiators and mitigators of pollution, respectively. The abbreviation As denotes arsenic, BPA bisphenol A, Cd cadmium, Hg mercury, NO_x oxides of nitrogen, O_3 ozone, Pb lead, PCBs polychlorinated biphenyls, PFAS perfluoroalkyl substances, PM particulate matter, $PM_{2.5}$ PM that is less than 2.5 μm in aerodynamic-mass median diameter, SO_x oxides of sulfur, and VOC volatile organic compounds.

well as secondary pollutants such as ozone that are formed in the atmosphere. Additional components are volatile and semivolatile organic aerosols such as benzene, toluene, xylene, 1,3-butadiene, and polycyclic aromatic hydrocarbons.[7]

Air pollution includes ambient (outdoor) and household (indoor) pollution. Ambient air pollution arises principally from fossil-fuel combustion. Pollutants released into the atmosphere from stationary sources such as coal-fired power

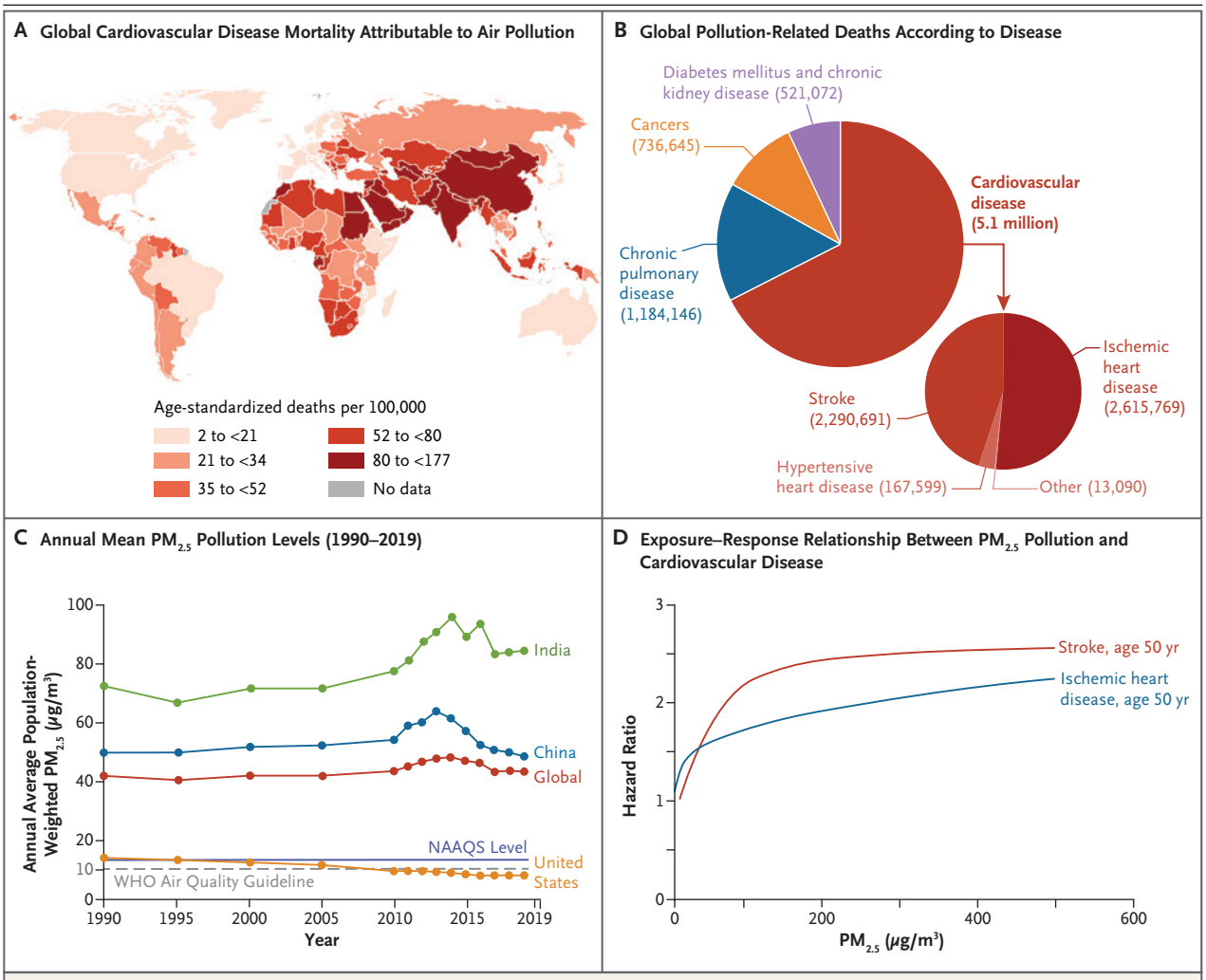

Figure 2. Air Pollution and Cardiovascular Disease.

Panel A shows age-standardized deaths per 100,000 persons in 2019 that were attributable to $PM_{2.5}$ air pollution, according to country. Data are from the 2019 Global Burden of Disease (GBD) Study.[1] Panel B shows the numbers of deaths from pollution-related noncommunicable disease globally, according to the cause of death, in 2019. Data are from the 2019 GBD Study.[1] Panel C shows annual mean population-weighted $PM_{2.5}$ levels in the United States, China, and India from 1990 through 2019. $PM_{2.5}$ estimates were derived with the use of a blended model combining satellite observations, global chemical transport models, and ground-level data from 10,408 monitors representing urban and rural data in 116 countries. To derive population-weighted averages, $PM_{2.5}$ levels were adjusted by population size. The lavender line represents the U.S. National Ambient Air Quality Standard (NAAQS) of 12 μg per cubic millimeter, and the dashed gray line represents the World Health Organization (WHO) annual mean air-quality guideline level of 10 μg per cubic millimeter. Panel D shows exposure–response relationships between $PM_{2.5}$ air pollution and cardiovascular disease, modeled for a 50-year-old person. The response function represents a meta-regressed Bayesian, regularized, trimmed (MR-BRT) curve derived by relaxing the log-linear assumption with the use of cubic splines. Data are from the 2019 GBD Study.[1]

plants and steel mills and from mobile sources (e.g., cars, trucks, and ships) are the principal contributors to ambient air pollution.

In low-income countries, household air pollution is caused mainly by the combustion of biomass fuels — wood, coal, straw, dung, and charcoal — in home cook stoves and disproportionately affects women and children.[8] In high-income countries, sources of household air pollution include natural gas combustion, wood-burning stoves, fireplaces, incense, candles, aerosol sprays, and volatile cleaning products. Household air pollution is amplified in poorly designed buildings with inadequate ventilation.[5]

AIR POLLUTION, DISEASE, AND PREMATURE DEATH

Air pollution is the world's fourth leading cause of disease and death. The World Health Organization (WHO) estimates that 91% of the world's population resides in places where annual mean air-pollution levels exceed the WHO guideline level of 10 μg per cubic millimeter. The GBD study estimated that air pollution was responsible for 6.7 million deaths (95% confidence interval [CI], 5.9 to 7.5 million) worldwide in 2019.[1,2] Of these deaths, 4.1 million (95% CI, 3.5 to 4.8 million) were due to ambient air pollution and 2.3 million (95% CI, 1.6 to 3.1 million) to household air pollution. Other estimates, which are based on alternative exposure measures and newer exposure–response functions, suggest that air pollution may be responsible for as many as 9 to 12 million deaths annually.[9-11]

Deaths from household air pollution are declining, but deaths attributable to ambient air pollution have increased by 51% since 1990 and continue to rise.[1] Without aggressive intervention, it is projected that these deaths could double by 2050, with the greatest increases occurring in South and East Asia.[10]

Particulate matter (PM) is the most thoroughly studied component of air pollution and is strongly linked to multiple health effects.[12] PM is categorized into coarse particles (aerodynamic-mass median diameter, <10 μm [PM_{10}]), fine particles (<2.5 μm [$PM_{2.5}$]), and ultrafine particles (<0.1 μm [$PM_{0.1}$]). Multiple studies also link gaseous pollutants, most notably ozone, to increased morbidity and mortality.[13-15]

The relationship between $PM_{2.5}$ exposure and mortality is best described by a nonlinear exposure–response curve with steep increases at low exposure levels and some flattening at higher levels (Fig. 2D). The original integrated exposure–response function used in the GBD 2013 study estimated $PM_{2.5}$ concentrations from a variety of sources, including smoking, and assumed that risk is determined by total inhaled $PM_{2.5}$, regardless of source. In the GBD 2019 study, the inclusion of new data from additional studies allowed a recalculation, with more precise estimates.[1] The exposure–response relationship between air pollution and cardiovascular disease is now understood to extend down to exposure levels well below current U.S. National Ambient Air Quality Standards for $PM_{2.5}$ and ozone pollution.[13,16]

Emerging research suggests that air pollution from different sources, such as vehicular exhaust, industrial emissions, and coal smoke, may differ with respect to health risk, reflecting variations in chemical composition, toxic metal content, and oxidative potential.[17-19] Traffic-related air pollution, which is a major threat, contains large quantities of ultrafine particles, which may contribute disproportionately to cardiovascular toxic effects.[5,20]

Biologic factors such as advanced age, prior cardiovascular disease, cardiovascular risk factors, pulmonary disease, and immunosuppression can increase a person's susceptibility to air pollution.[5] Social determinants of health such as income inequality, poverty, food deserts, reduced tree cover, and proximity to highways and industrial facilities — many of them the legacy of structural racism — are associated with increased pollutant exposure and pollution-related cardiovascular disease.[21,22] Recent data support an interaction between air pollution and increased mortality from coronavirus disease 2019 (Covid-19).[23]

Climate change exacerbates the adverse effects of air pollution on health through multiple cascading mechanisms.[24] High temperatures enhance ground-level ozone formation and also increase the risk of wildfires and dust storms. $PM_{2.5}$ from wildfire smoke and dust storms increases the risk of cardiovascular disease, with effect estimates that are similar to those for anthropogenic $PM_{2.5}$.[25] High temperatures also increase the demand for electricity, which in turn increases fossil-fuel combustion and pollution.[24] Temperature extremes and temperature variability are associated with increased mortality from myocardial infarction and stroke.[26]

AIR POLLUTION AND CARDIOVASCULAR DISEASE

The effect of air pollution on cardiovascular disease varies substantially across the globe (Fig. 2B).[1,2,5] In high-income countries, air pollution accounts for fewer deaths from cardiovascular disease today than in the past, because laws, regulations, and new technologies have greatly reduced pollution. In the United States, air pollution levels have fallen by 70% since passage of the Clean Air Act in 1970.[27] In low-income and middle-income countries, by contrast, pollution is often severe and is worsening in some places (Fig. 2C). In many developing countries, the pro-

portion of deaths from cardiovascular disease that are attributable to pollution substantially exceeds the proportion of cardiovascular deaths due to smoking and other behavioral and metabolic risk factors.[1,28]

Short-term variation in $PM_{2.5}$ levels (from hours to days) is associated with increased risks of myocardial infarction, stroke, and death from cardiovascular disease.[5,26] The risk of these events increases by 0.1 to 1.0% for each short-term increment of 10 μg per cubic millimeter in the $PM_{2.5}$ level.[5] In some analyses, dose-related increases in risk have also been reported with NO_x and sulfur oxides (SO_x) but not consistently with ozone.[15,29,30]

Prospective cohort studies support a robust causal association between longer-term $PM_{2.5}$ exposures (1 to 5 years) and elevated mortality from ischemic heart disease. Increases of 16 to 31% for each increment of 10 μg per cubic millimeter in annual mean $PM_{2.5}$ exposure are reported across a wide range of concentrations.[31-33]

A meta-analysis of 35 studies showed that each increment in the $PM_{2.5}$ level of 10 μg per cubic millimeter was associated with a 2.12% increase in the risk of hospitalization or death from heart failure, with the strongest associations involving increased pollution levels on the day of exposure.[34] Air pollution has also been associated with an increased risk of atrial fibrillation and ventricular arrhythmias.[5,35]

AIR POLLUTION AND CARDIOVASCULAR RISK FACTORS

Ambient $PM_{2.5}$ pollution has been causally linked to multiple risk factors for cardiovascular disease — most notably, hypertension and diabetes.[5,7,36] Short-term increases in ambient $PM_{2.5}$ levels, as well as short-term experimental human exposure to pollution, have been associated with alterations in vascular tone and increased blood pressure.[7] On average, an increase in $PM_{2.5}$ exposure of 10 μg per cubic millimeter during the preceding day increases systolic and diastolic blood pressure by 0.5 to 1.0 mm Hg, with a wide range of responses and, in some persons, elevations as high as 5 to 10 mm Hg. Long-term exposures are associated with an increased incidence of new-onset hypertension, suggesting that air pollution is an underrecognized, remediable risk factor for the leading cause of death worldwide.[37-40]

Long-term $PM_{2.5}$ exposure is associated with increased carotid intima media thickness, coronary-artery calcification, abdominal aortic calcification, susceptibility to atherosclerotic plaque formation, left ventricular hypertrophy, and progression of chronic kidney disease.[41-46] In addition, evidence from clinical, epidemiologic, and experimental studies links $PM_{2.5}$ exposure to insulin resistance and type 2 diabetes.[1,5,47] These associations extend down to pollution levels below 5 μg per cubic millimeter.[1,5] Globally, airborne $PM_{2.5}$ pollution is estimated to contribute to about 3.2 million incident cases of diabetes each year and to 196,792 deaths from diabetes (95% CI, 136,301 to 258,392).[48]

TOXIC METAL POLLUTANTS

Metals such as lead, mercury, arsenic, and cadmium have long been implicated in the causation of cancer, neurobehavioral disorders, and renal disease (see the interactive graphic, available with the full text of this article at NEJM.org). Toxic metal pollutants are now linked by an increasing body of evidence to the risk of cardiovascular disease.[49,50,51]

An interactive graphic is available at NEJM.org

LEAD

Lead is estimated to have been responsible for 901,000 deaths globally and 21,000 deaths in the United States in 2019, with nearly 75% of these deaths due to cardiovascular disease.[4,49,50] Although lead exposures have declined in high-income countries, they remain high globally as a result of the rising demand for lead batteries and continued use of lead paint.[50]

Lead is a known risk factor for hypertension. Exposure to lead in animal models induces increases in blood pressure, which are reversible with chelation.[49,50] Until recently, lead was thought to have few toxic effects in adults with blood lead levels below 40 μg per deciliter. However, new data from a long-term follow-up study of 14,289 U.S. participants in the Third National Health and Nutrition Examination Survey, who had a mean blood lead level of 2.71 μg per deciliter, suggest that a relationship between lead and mortality from cardiovascular disease extends down to blood lead levels below 3 μg per deciliter.[52] On the basis of these findings, the number of deaths from cardiovascular disease in the United States could be up to 10 times as high as current estimates.

MERCURY

Coal combustion and artisanal gold mining are the two main sources of mercury pollution.[53] Coal contains mercury, which vaporizes during combustion, enters the atmosphere, and precipitates into lakes, rivers, and oceans. In aqueous environments, metallic and inorganic mercury are converted to highly toxic methylmercury. Methylmercury in aquatic environments accumulates (i.e., bioconcentrates) in the food chain and reaches high levels in predator species such as tuna that are consumed by humans.[54]

Methylmercury has long been known to be a potent developmental neurotoxicant. Recent data suggest that it is also associated with a dose-dependent increase in the risks of death from cardiovascular disease and nonfatal myocardial infarction.[55]

ARSENIC

Contamination of drinking water by naturally occurring arsenic is the main source of human exposure to arsenic and affects an estimated 100 million people worldwide.[56] Exposure hot spots have been identified in Bangladesh, Thailand, Taiwan, and northern Chile. In the United States, elevated levels of arsenic in groundwater are found in northern New England and the Southwest.

Consistent, dose–response associations have been documented between arsenic exposure and coronary heart disease, peripheral arterial disease, and type 2 diabetes.[50,51,56] A weaker association has been reported between arsenic exposure and stroke.[51,56] Experimental exposure accelerates atherogenesis and appears to cause tissue damage through oxidative and inflammatory pathways. Decreased mortality from cardiovascular disease has been reported after reductions in arsenic exposure.[50]

CADMIUM

Tobacco smoke; workplace exposure; and consumption of green, leafy vegetables (e.g., spinach and lettuce), cereals, and tubers grown in contaminated soils are the major sources of cadmium exposure. Dietary cadmium exposure can be reduced by eating a wide range of fruits and vegetables.

Experimental evidence indicates that cadmium is atherogenic. Increased risks of coronary artery disease, peripheral arterial disease, and stroke, as well as increased mortality from cardiovascular disease, have been noted in epidemiologic studies of exposed populations.[50,51] A systematic review showed a dose-dependent increase in the risk of all cardiovascular disease end points except stroke, even at very low exposures (urinary cadmium level, <0.5 μg per gram of creatinine).[57]

In a multicenter, randomized, double-blind trial involving patients with a recent myocardial infarction, weekly intravenous chelation therapy with EDTA, a drug that binds divalent and some trivalent cations, including lead and cadmium, reduced the composite end point of all-cause mortality, myocardial infarction or coronary revascularization, stroke, or hospitalization (hazard ratio, 0.82; 95% CI, 0.69 to 0.99; P=0.04).[58] In a prespecified analysis of data from patients with diabetes, the results seemed to suggest stronger effects, an observation currently being tested in a prospective study of cardiovascular disease outcomes in high-risk patients with diabetes (ClinicalTrials.gov number, NCT02733185).

CHEMICAL POLLUTANTS

The production of manufactured chemicals has increased exponentially in the past 50 years, resulting in wide environmental dissemination and extensive human exposure.[59] Three classes of manufactured chemicals have been implicated in an increased risk of cardiovascular disease and risk factors for cardiovascular disease: halogenated hydrocarbons, perfluoroalkyl substances (PFAS), and plastic-associated chemicals. Many of these are chemicals that were released into the environment decades ago (legacy chemicals), whereas others are more recent contributors to pollution.

Halogenated hydrocarbons of concern include polychlorinated biphenyls (PCBs), dioxins, brominated flame retardants, and organochlorine pesticides.[59,60] These compounds are lipophilic, bioaccumulative, and highly persistent in both living organisms and the environment. The production of most of these chemicals has been banned under the Stockholm Convention on Persistent Organic Pollutants, but they remain abundant in the environment.[61] Consumption of contaminated meat and fish is the main exposure route. Halogenated hydrocarbons have been associated with dyslipidemia, insulin resistance, and obesity.[60] PFAS, which are used in water repellants and fire-fighting foams, are strongly

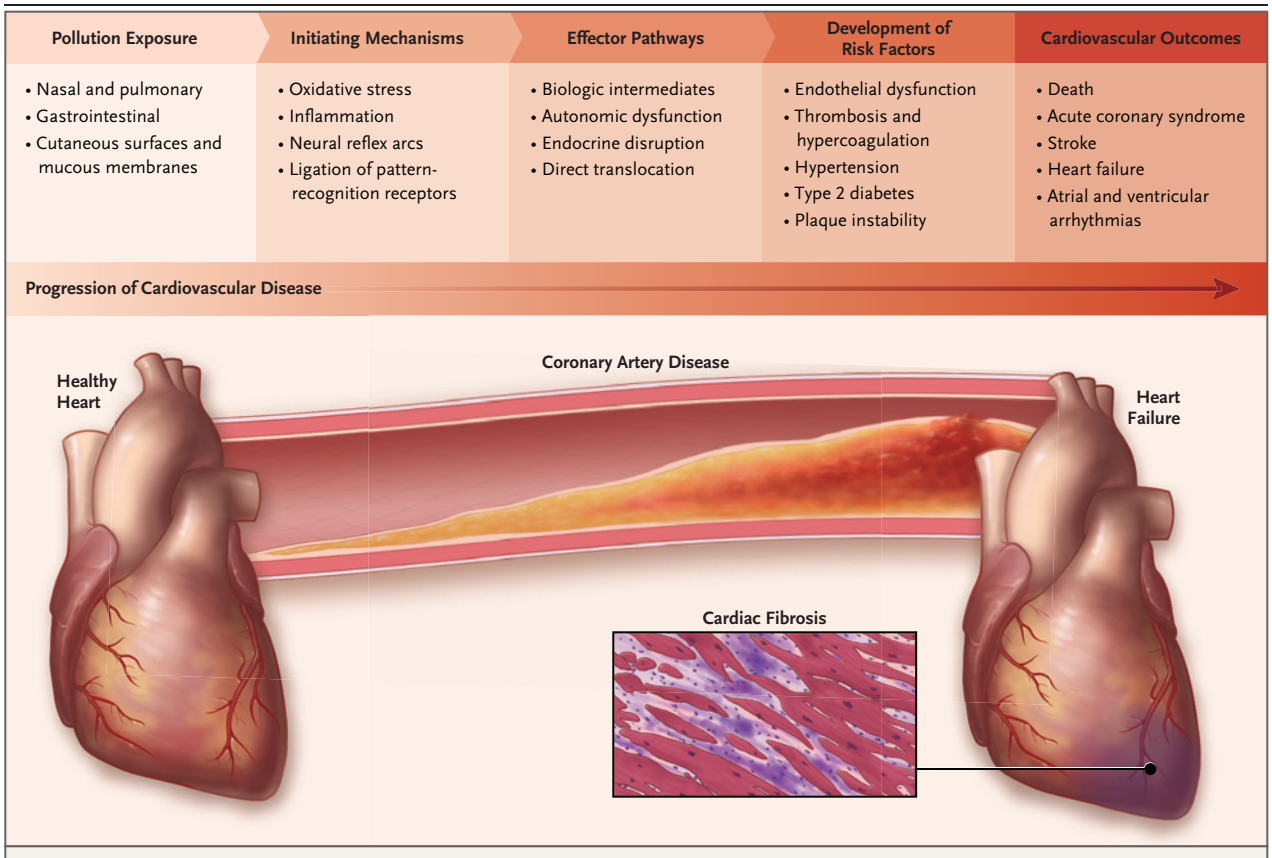

Figure 3. Mechanistic Framework Linking Pollution to Cardiovascular Risk Factors and Disease.

linked to obesity and type 2 diabetes.[59,60] Although many PFAS are banned under the Stockholm Convention, manufacture of some PFAS continues.

Plastic-associated chemicals include bisphenol A (BPA) and phthalates. These materials are abundant in personal care products, food preservatives, pharmaceuticals, and paper products. Both chemicals are endocrine disruptors and are associated with increased risks of diabetes and obesity.[60] A meta-analysis estimated that the pooled relative risk of type 2 diabetes is 1.45 (95% CI, 1.13 to 1.87) in relation to BPA exposure and 1.48 (95% CI, 0.98 to 2.25) in relation to phthalate exposure.[62] Analysis of the dose–response relationship between BPA and diabetes showed an increase in relative risk of 1.09 (95% CI, 1.03 to 1.15) for each increase of 1 ng per milliliter in the urinary BPA level.[62]

BPA has recently been removed from many personal care products, which are now marketed as "BPA-free." However, BPA has been replaced in some of these products by other toxic chemicals, such as BPA's chemical cousin, bisphenol S (BPS), a practice termed "regrettable substitution," which is permitted under current chemical regulatory policy in the United States.

POLLUTANT-MEDIATED CARDIOVASCULAR EVENTS

The mechanisms through which pollutants cause cardiovascular toxic effects are complex and varied. For air pollution and lead, these mechanisms are well delineated, but for other metals and most chemical pollutants, they are poorly understood.[5,36] The mechanisms can be classified under three broad headings (Fig. 3): initiating mechanisms, effector pathways, and risk factor development.

Initiating mechanisms occur at the locus of initial exposure. They include inflammation, activation of neural reflex arcs, and ligation of pattern-recognition receptors. For toxic metal exposures and many chemical exposures, depletion of

endogenous antioxidants and oxidative stress appear to have central roles (see interactive graphic).

Effector mechanisms include activation of rapid neural pathways and release of biologically active intermediates (inflammatory cytokines, oxidized lipids, immune cells, microparticles, and microRNA). Endocrine disruption occurs with many manufactured chemicals and with air pollution.[5,7,61]

The development of risk factors for cardiovascular disease, such as hypertension and type 2 diabetes, is a late-stage event resulting from chronic, pollution-induced oxidative stress and inflammation.

The mechanisms underlying increases in blood pressure after exposure to air pollution and lead appear to involve redox-mediated alterations in vascular and autonomic tone.[49,50] Persistent inflammation and endocrine disruption may be triggered by air pollution, arsenic, cadmium, and many manufactured chemicals and may contribute to insulin resistance.[5,50,56,57,60] Prolonged exposure of laboratory animals to inhalational $PM_{2.5}$ results in transcriptional and epigenetic reprogramming.[47,63]

PREVENTING POLLUTION-RELATED CARDIOVASCULAR DISEASE

The first step in preventing pollution-related cardiovascular disease is to overcome neglect of pollution in disease prevention programs, medical education, and clinical practice and acknowledge that pollution is a major, potentially preventable risk factor for cardiovascular disease. Physicians can act on this information by obtaining a brief history of pollution exposure for each patient when relevant, assessing individual susceptibility, and providing guidance on pollution avoidance. If the initial history suggests clinically significant exposure, follow-up investigation may be warranted. The occupational history is key for identifying workplace exposures. A recent American Heart Association statement on personal protective actions against air pollution provides a useful framework and could be extended to other pollutants.[64]

Anticipatory clinical guidance should be tailored to a particular patient's exposures and susceptibilities. Such guidance can include recommendations to minimize vigorous outdoor exercise on "bad air" days; reduce hazardous occupational exposures; avoid use of gas stoves, fireplaces, plug-in scents, incense, and other sources of household air pollution; use N95 masks, in-home air cleaners, and air conditioning; choose less congested commutes; and avoid travel to heavily polluted regions (Fig. 4).[64] Patients with risk factors for cardiovascular disease, a history of cardiovascular disease, or pulmonary disease should be advised to check the Environmental Protection Agency's Air Quality Index (https://www.airnow.gov/aqi/aqi-basics/) when planning outdoor activities and to limit such activities on days when the air quality is unsafe.

Although few clinical trials have directly shown that reductions in pollution exposure result in a decreased risk of cardiovascular disease, data from multiple epidemiologic and experimental investigations provide a consistent, actionable body of evidence supporting the cardiovascular health benefits of pollution control.[65,66] Innovations in digital health technologies, such as platforms that integrate data from portable sensors and ground-level monitors, have the potential to further heighten awareness of air pollution, inform individual behaviors, and enhance the provision of individualized guidance.[64,67]

An enduring reduction in pollution-related cardiovascular disease will require more than changing individual behaviors. It will necessitate wide-scale control of pollution at its sources. The most effective strategy for achieving this goal is a rapid, government-supported transition from all fossil fuels — coal, gas, and oil — to clean, renewable energy.[68,69] Household air pollution in low-income countries is most effectively controlled by providing poor families with affordable access to cleaner fuels.[4]

Governments have multiple tools to accelerate the transition to wind and solar energy and thus prevent pollution-related cardiovascular disease. These tools include creating incentives and tax structures that favor renewable energy; ending current massive, taxpayer-supported subsidies for the fossil-fuel industry; and taxing pollutant emissions through application of the "polluter pays" principle.[70] Such actions have proved to be highly cost-effective. Every dollar invested in air-pollution control in the United States since 1970 is estimated to have yielded a return of $30.[71] Control of lead pollution has been similarly cost-effective.[72] These economic benefits of pollution control reflect reductions in health care costs

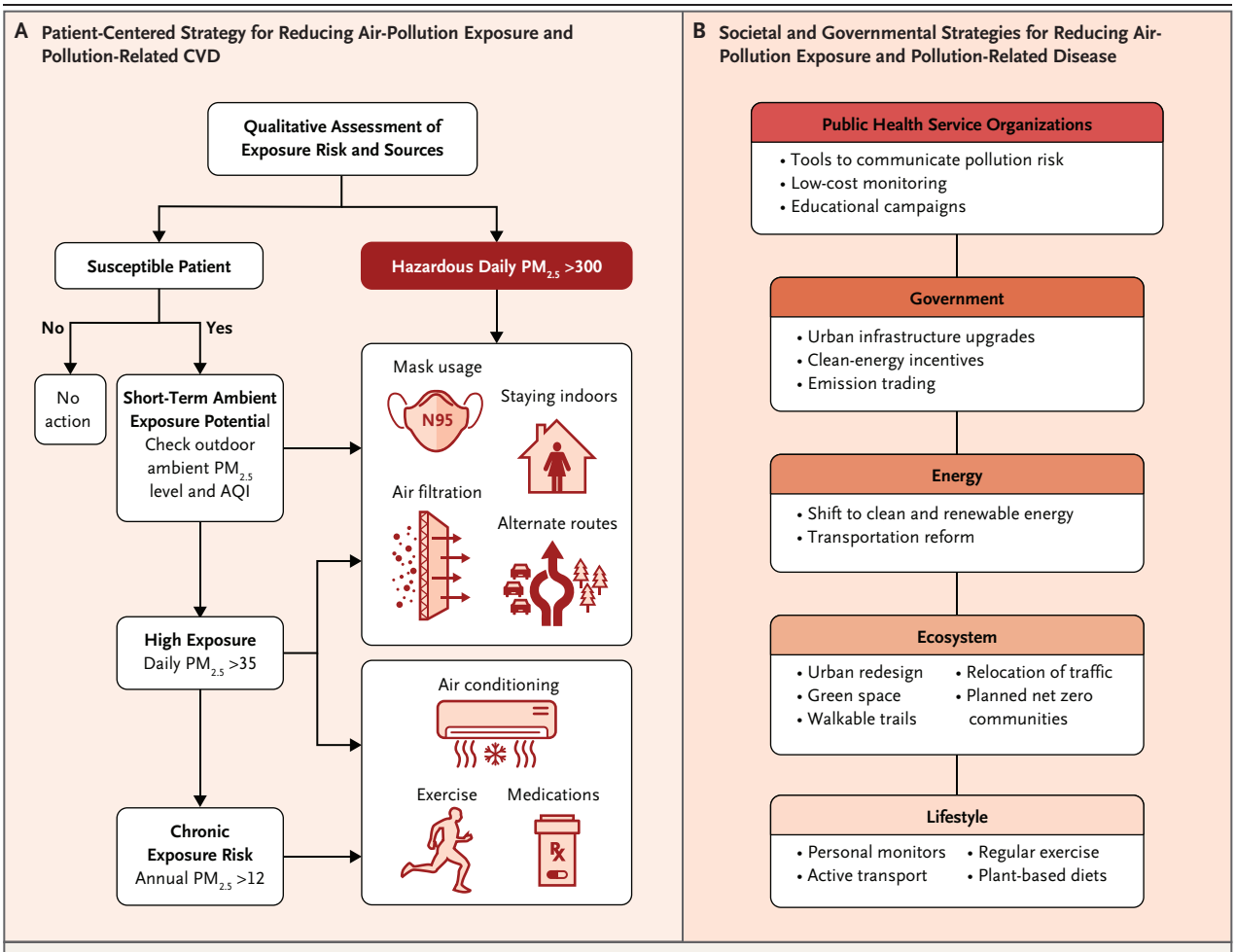

Figure 4. Strategies for Preventing Pollution Exposure and Pollution-Related Cardiovascular Disease (CVD).

Panel A shows a patient-centered strategy for reducing air-pollution exposure and pollution-related CVD. Assessment of exposure sources includes evaluation of exposure to ambient air pollution on the basis of the patient's ZIP Code and evaluation of exposures to household air pollution sources such as solid fuel combustion, inadequate in-home ventilation, prolonged time spent in traffic, urban residence, and residence close to highways. Susceptible patients are categorized according to the level of risk. Patients at very high risk are those with atherosclerotic CVD (ASCVD) and coexisting conditions, a recent hospitalization for an acute coronary syndrome, heart failure, chronic obstructive pulmonary disease, or asthma. Patients at high risk are those with established ASCVD (10-year risk, >20%), diabetes, or stage 3 or 4 chronic kidney disease with one or more risk factors. Patients at risk because of special demographic characteristics include pregnant women, elderly persons, and transplant recipients. Threshold values of 12 μg and 300 μg per cubic millimeter represent daily and annual average values, respectively, and correspond to the Air Quality Index (AQI) limits of 50 μg and 450 μg per cubic millimeter, respectively (https://airnow.gov/index.cfm?action=aqibasics.aqi). The value of 35 μg per cubic millimeter corresponds to the AQI limit for $PM_{2.5}$. Data are from Rajagopalan et al.[64] Panel B shows societal and governmental strategies for reducing air-pollution exposure and pollution-related disease.

and the increased economic productivity of healthier, longer-lived populations.[4]

Physicians, nurses, medical societies, and public health organizations are uniquely positioned to urge governments on behalf of their patients to end pollution and prevent disease. By pointing out to elected officials the well-documented links among pollution, climate change, and human health and by noting that actions to control pollution will also control climate change and vice versa, medical professionals are in a powerful position to catalyze enduring action.

Two recent developments support the feasibility of a societal-scale transition to clean energy: an increase by a factor of almost 5 in the fraction of the world's electricity generated from wind

and solar power since 2010 and concomitant steep reductions in the cost of producing electricity from renewables.[73] It is now cheaper in many parts of the United States and around the world to produce electricity from wind and solar power than to produce it from any fossil fuel.[73]

CONCLUSIONS

Recognition of pollution as a major cardiovascular risk factor that is often overlooked in clinical practice opens up multiple opportunities for prevention and control. An understanding of the role of pollution can inform anticipatory clinical guidance. Such an understanding can also guide physicians, medical societies, public health authorities, environmental agencies, accountable care organizations, health insurers, and governments in developing evidence-based societal strategies for preventing cardiovascular disease that link pollution prevention with the control of behavioral and metabolic risk factors. Prevention of pollution-related cardiovascular disease through a large-scale transition from fossil fuels to clean, renewable energy will not only reduce cardiovascular disease and associated deaths but also slow the pace of climate change and thus benefit all humanity.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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