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To cite: Hadley MB, Vedanthan R, Ebi KL, et al. Climate cardiology. *BMJ Global Health* 2022;**7**:e008860. doi:10.1136/bmjgh-2022-008860

Handling editor Seye Abimbola

Received 18 February 2022
Accepted 13 April 2022

INTRODUCTION

Climate change represents a grand challenge to global health,¹ compromising the public health imperative to which many clinicians have dedicated their lives. Likewise, cardiovascular disease (CVD) remains the leading cause of global mortality.² We review key interactions between climate change and cardiovascular health and identify interventions that will provide cobenefits for people and planet (figure 1).

CLIMATE CHANGE AND THE HEALTHCARE SECTOR

The earth absorbs solar radiation and emits some of this energy as infrared radiation. Atmospheric greenhouse gases (GHGs), particularly CO₂, N₂O, methane and water vapour, absorb and reemit this heat energy, leading to higher temperatures in the air, land and sea.³ As a result of human activities, GHG levels are the highest they have been in at least 800 000 years, leading to increasing global surface temperatures and associated climate change.³

Major emitters of GHGs include fossil fuel burning (vehicular emissions, manufacturing, electricity, heating), agriculture, deforestation and ruminant meat production (eg, cattle).¹ Indeed, GHG emissions to support a high red-meat diet are approximately twice that of vegetarian diets.⁴ Additionally, healthcare delivery is extraordinarily energy-intensive compared with other commercial and service activities.⁵ Globally, the healthcare sector is responsible for 4.4% of all GHG emissions, as well as 2.8% of fine particulate matter air pollution (PM_{2.5}).⁶ In the USA, nearly 10% of GHG emissions are produced by the healthcare sector, more than the entire UK.^{1 5}

CLIMATE HAZARDS FOR CARDIOVASCULAR HEALTH

The environmental and social consequences of global warming will increase the prevalence and severity of cardiovascular risk factors over this century.^{1 7} Climate change leads to more frequent extreme weather events, air pollution exposures, ecosystem collapse and declines in

SUMMARY BOX

- ⇒ Climate change and cardiovascular disease represent grand challenges to global health in the 21st century.
- ⇒ We review the interactions between climate and health and suggest specific interventions with benefits for both patients and planet.
- ⇒ Climate change is a result of increasing concentrations of atmospheric greenhouse gases, with major emissions stemming from fossil fuel burning, livestock production and the healthcare sector itself.
- ⇒ Consequences for humanity include extreme weather events, air pollution exposures, ecosystem collapse, declines in nutritious food production, poverty and disruption of social services. Together, these factors have both direct and indirect effects on global cardiovascular health.
- ⇒ Key opportunities to protect cardiovascular health while reducing greenhouse gas emissions include: transitioning from high red-meat to plant-based diets, expanding greenspaces, using clean burning stoves, practising resource efficiency in healthcare and transitioning from vehicular to active transportation.
- ⇒ We propose a new field of climate cardiology to study and implement these opportunities.

global food production and the nutritional quality of major cereal crops.^{1 4 8} These have direct effects on cardiovascular health, as well as indirect effects mediated and/or moderated by other structural and social determinants of health (eg, poverty, inequality, housing quality), underlying susceptibilities (eg, ageing), disruption of social services, and the capacity of health systems to manage climate hazards.^{1 4} We describe several key pathways below.

Extreme weather events

Extreme weather events (eg, heat waves, cyclones, droughts, floods) damage healthcare infrastructure and disrupt access to cardiovascular care and other essential services.¹ Heat waves affect hundreds of millions of people and increase the risk of stroke, ischaemic heart disease and cardiovascular mortality, particularly among the elderly and those with underlying CVD.^{1 9} In 2019 alone, high temperatures were responsible for an estimated 93 000



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Figure 1 Interventions (purple) with cobenefits to reduce the global burden of cardiovascular disease (red) and mitigate climate change (blue). GHG, greenhouse gas; CVD, cardiovascular disease.

cardiovascular deaths globally.² Additionally, changes in weather and seasons may affect sunlight exposure and circadian rhythms that are associated with markers of cardiovascular function.⁹ Extreme weather events also are associated with trauma, stress, and depression that are risk factors for ischaemic heart disease.¹

Shortage of nutritious foods

Diets low in fresh produce, whole grains and seafood are responsible for over 3million cardiovascular deaths annually worldwide.² Desertification is driving further decline in global agricultural yield of fresh produce and whole grains, particularly in low-income regions.¹⁴ Moreover, increased atmospheric CO₂ decreases the content of protein and micronutrients in cereal crops sustaining hundreds of millions of people.⁸ Ocean acidification and warming lead to coral bleaching and reduced fishery and aquaculture productivity.¹ As a result of these declines, current estimates suggest 25million additional children might be undernourished by 2050.⁴ Population-level cardiovascular health is likely to worsen as imported high-calorie, energy-dense foods replace traditional diets rich in fresh fish, fruits, vegetables, and whole grains micronutrients.^{7 10}

Rising poverty and climate refugees

Together, famine, floods, storms, drought, landscape fires, sea level rise and ecosystem collapse may lead to homelessness, poverty, and the forced migrations of hundreds of millions of people, often to places ill prepared to provide cardiovascular health services for climate refugees.¹⁴ Moreover, low-income groups will be most affected, exacerbating poverty and transnational inequality.¹

Pollution exposures

Air pollution from fossil fuel combustion, industrial emissions, and landscape fires are responsible for nearly one in five (3.54million) cardiovascular deaths globally.² Noise pollution from road traffic has been associated with increased risk of ischaemic heart disease.⁹ Chemical pollutants from industry, ore refineries and fossil fuel combustion increasingly contaminate global food and water supplies.¹¹ Lead, in particular, is consistently associated

with atherosclerotic CVD and responsible for over 848 000 cardiovascular deaths annually worldwide.^{2 11}

OPPORTUNITIES TO MITIGATE CLIMATE CHANGE AND REDUCE THE GLOBAL BURDEN OF CVD

Priority should be given to interventions that both prevent CVD and reduce net GHG emissions. Such interventions are often highly cost-effective by mitigating poor cardiovascular outcomes and consequences of climate change.^{1 4 5} The burden of CVD attributed to climate change accumulates over a lifetime of hazardous exposures, beginning as early as childhood, but often not manifesting as cardiovascular events until later in life. Thus, attempts should be made to protect individuals of all ages from such exposures. Here, we identify six high-yield interventions (figure 1), which should be prioritised according to local conditions and context.

Transition from high red-meat to plant-based diets

Red meat, which contains high levels of saturated fat, is an established risk factor for atherosclerotic CVD, responsible for 738 000 cardiovascular deaths in 2019.² Reorienting to sustainable, plant-based diets promotes cardiovascular health and mitigates global warming.¹² Food subsidies and taxation should be restructured to make red meat more expensive and locally sourced, and plant-based foods more available and affordable. A recent analysis found that levying GHG taxes on global food commodities could reduce CO₂ emissions by nearly 1 billion tons and avert hundreds of thousands of cardiovascular deaths annually.¹³

Transition from vehicular to active transportation

Physical inactivity is an established risk factor for cardio-metabolic diseases, including obesity, diabetes and atherosclerosis, responsible for 639 000 cardiovascular deaths in 2019.² Commuting by biking or walking reduces GHG emissions and reduces the prevalence of obesity, diabetes, and cardiovascular risk.^{1 4} Active transportation can be promoted by the development of good cycling infrastructure and regulations to make driving inconvenient and expensive.¹ A recent analysis demonstrated that policies to increase rates of walking and cycling, such as those

implemented in Paris and Copenhagen, reduce both mortality and CO₂ emissions.¹⁴

Expand greenspaces

Residential proximity to vegetation is associated with lower levels of stress, physical inactivity, diabetes and CVD.⁹ Additionally, tree canopies provide more reflective surfaces, reduce urban temperatures and may reduce heat-related cardiovascular risk.⁴ Greenspaces also mitigate climate change by removing CO₂ from the atmosphere and help to offset global deforestation and desertification.

Transition to clean energy

Fossil fuel combustion is the principal source of both CO₂ emissions and fine PM_{2.5}. Over 90% of the global population is exposed to levels of PM_{2.5} exceeding WHO guidelines, resulting in over 3.5 million attributable cardiovascular deaths in 2019.² Currently, renewables account for only 24% of total electricity generated.¹ Reductions in fossil fuel emissions necessary to meet the Paris Agreement would dramatically reduce air pollution exposures, averting over 20 million attributable deaths over the next 30 years.¹⁵ Transitioning away from coal, oil and gas and towards solar, wind, geothermal and hydroelectricity therefore provides the greatest opportunity to protect both the planet and cardiovascular health.

Provide clean stoves

Over two billion people are exposed to hazardous levels of PM_{2.5} from inefficient stoves burning coal or biomass for cooking or heating indoors.² This practice releases considerable GHGs and was responsible for over one million cardiovascular deaths in 2019.² Providing clean cooking stoves is a cost-effective method to improve global cardiovascular health, with the benefit of reducing GHG emissions.

Practice resource efficiency in healthcare

Several interventions can promote cardiovascular health and reduce the carbon footprint of healthcare. First, healthcare systems must expand efforts in CVD prevention, reducing the burden of disease and resource-intensive interventions.⁵ In particular, providers should promote prompt telemedicine visits, local ambulatory care and empowered self-care over inpatient management.⁵ Second, hospitals can reduce wasteful practices that may have health consequences, including overtreatment, overprescribing and unnecessary interventions.⁵ Third, health systems should invest in disaster planning and early warning systems to prepare for waves of illness associated with extreme weather events, wildfire smoke or climate refugees. Finally, medical education should incorporate teaching and research on the environmental health and sustainable practices in healthcare. Hospitals that reduce wasteful practices can realise substantial financial benefits and become leaders in their communities in the fight against climate change.¹⁵

CONCLUSION

The window is closing to prevent the worst effects of climate change. The healthcare sector must take urgent action to

prevent the climate crisis from undermining cardiovascular health. We have described six opportunities for providers and policymakers to mitigate both GHG emissions and the health impacts of climate change.⁵ A new field of climate cardiology can study and implement such opportunities to protect patients and planet.

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Contributors Writing the manuscript: MH; critical revision: RV, KLE and VF. All gave final approval and agreed to be accountable for all aspects of this work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing is not applicable to this article as no new data were created or analyzed.

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