



# Aging Hearts in a Hotter, More Turbulent World: The Impacts of Climate Change on the Cardiovascular Health of Older Adults

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## Abstract

**Purpose of Review** Climate change has manifested itself in multiple environmental hazards to human health. Older adults and those living with cardiovascular diseases are particularly susceptible to poor outcomes due to unique social, economic, and physiologic vulnerabilities. This review aims to summarize those vulnerabilities and the resultant impacts of climate-mediated disasters on the heart health of the aging population.

**Recent Findings** Analyses incorporating a wide variety of environmental data sources have identified increases in cardiovascular risk factors, hospitalizations, and mortality from intensified air pollution, wildfires, heat waves, extreme weather events, rising sea levels, and pandemic disease. Older adults, especially those of low socioeconomic status or belonging to ethnic minority groups, bear a disproportionate health burden from these hazards.

**Summary** The worldwide trends responsible for global warming continue to worsen climate change-mediated natural disasters. As such, additional investigation will be necessary to develop personal and policy-level interventions to protect the cardiovascular wellbeing of our aging population.

**Keywords** Environmental health · Climate change · Aging · Cardiovascular disease

## Introduction

Our modern era, beginning with the Third Industrial Revolution in the closing decades of the twentieth century, has been characterized by a global expansion of economic development and trade that has reached even the most remote corners of the world [1, 2]. Although the resultant

demographic transition has been experienced by most societies as an impressive increase in life expectancy, it has also led to a surge in cardiovascular disease burden coupled with an acceleration of climate change-mediated environmental hazards [3–6, 7•, 8–10].

As of 2019, 703 million people in the world were over 65 years of age, and that number is projected to grow to 1.5 billion, or one in six people globally, by 2050 [11]. This phenomenon has taken place not just in rich nations but also in most low- and middle-income countries upon the background of an atherogenic, obesogenic milieu typified by the proliferation of cheap processed foods high in salt, sugar, and saturated fats; increased white-collar work and urban living leading to reduced physical activity; and higher per capita income incentivizing maladaptive behavioral risk factors such as tobacco and alcohol consumption [12–15]. It is thus no surprise that global cardiovascular disease (CVD) prevalence has nearly doubled from 271 to 523 million cases between 1990 and 2019, with the majority of this burden shouldered by people over 60 years old [16]. Meanwhile, Earth's average surface temperature has risen 1.2 °C (approximately 2.2°F) in the past century due to man-made sources of greenhouse gases [17]. This

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global warming has not only accelerated the unpredictability of cyclic worldwide climate events like El Niño, but has also increased the frequency and severity of seasonal regional weather phenomena such as extreme heat waves, flash floods, and hurricanes [17, 18].

The growing global population of older adults finds itself particularly vulnerable to these climate consequences, as was tragically demonstrated in 2005 when nearly half of the 971 deaths from Hurricane Katrina in the USA befell individuals over the age of 75 [19]. Aside from the immediate casualties of the physical devastation imposed by these events, however, this group of people also experience a greater proportion of the health impacts of climate change, particularly CVD complications (Table 1). For example, nearly one in ten of the aforementioned Katrina mortalities was attributable to cardiovascular causes [19]. This surprising finding is due to a number of reasons, including both medical and societal factors: Older individuals have greater rates of pre-existing CVD and risk factors such as coronary artery disease, heart failure, stroke, obesity, and diabetes, leaving them at greater risk of decompensation from these conditions [20–22]. Additionally, aging is associated with changes in circulatory physiology, leaving older adults less able to adapt to sudden changes in their surroundings (Fig. 1). These include the inability to rapidly augment cardiac output in response to environmental stresses such as high temperatures and dehydration, vascular dysfunction leading to more sluggish heat dispersal at surface capillaries, and diminished capacity to redirect central blood stores to peripheral organs during sudden fluid loss [23]. Furthermore, frailty, a well-known syndrome of aging defined as a lack of physiologic reserve, is not only hypothesized to be accelerated by environmental pollutants, but is also itself an independent determinant of poor health outcomes from both heart disease as well as response to noxious ambient exposures [24–27]. Lastly, the reduced mobility of older people, a result of both physical and cognitive limitations and greater social isolation, makes them less able (and sometimes, less willing) to evacuate in a timely manner during natural disasters, leaving them to experience the worst direct and indirect effects of these climate catastrophes [28–30].

Given the ongoing nature of global warming and economic globalization, it is unlikely that we will see a reversal in the above trends [3, 17, 18]. As such, policymakers, researchers, and clinicians should pay greater attention to the unique cardiovascular risks posed by climate change to our aging population. Thus, in this review, we will attempt to summarize the major manifestations of our unstable planet on the heart health of our elders, while briefly offering some suggestions for how key stakeholders can begin to address these challenges.

## Air Pollution and Wildfires

Air pollution is responsible for 6.7 million global deaths each year, making it the greatest environmental determinant of human morbidity and mortality [31–33]. Half of these deaths are from CVD and over half are in people over the age of 65 years [31, 32]. Airborne environmental exposures can be classified as either chronic (from both outdoor and indoor ambient sources) or acute (from singular personal and population-level exposures). Due to the immense number of sources of air pollution, there are thousands of distinct inhalable compounds that can be found in poor air. Briefly, the solid components are classified by particulate matter under 10  $\mu\text{m}$  in diameter (PM10), 2.5  $\mu\text{m}$  in diameter (PM2.5), and < 0.1  $\mu\text{m}$  in diameter (ultrafine particles) [34]. These contaminants are often measured in conjunction with the most common gaseous pollutants, which include sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), and ozone (O<sub>3</sub>). Encounters with all of these substances have been reported to affect human CVD outcomes to varying degrees. Short-term inhalation injury has been tied to escalations in cardiovascular hospitalization rates for acute complications such as myocardial infarction, stroke, and heart failure exacerbations [34, 35]. Simultaneously, long-term airborne exposures have been correlated with the progression of chronic heart diseases like coronary atherosclerosis and cardiometabolic risk factors such as hypertension and diabetes [33–36]. The pathophysiologic dynamics governing these phenomena differ considerably depending on the toxin combination, but they are believed to be complex processes involving varying degrees of autonomic imbalance, endothelial dysfunction, systemic inflammation, hypothalamus–pituitary–adrenal axis instability, and prothrombotic pathway activations [34].

Climate change has been linked to worsened air quality through several mechanisms. On the most global level, increased worldwide temperatures are predicted to lead to reduced wind speed and slower air circulation, concentrating existing urban air pollution locally [37, 38]. Next, it is believed that global warming has contributed to elevated ground-level ozone levels, which have been noted to interact with PM2.5 to worsen cardiovascular health status and mortality [31, 39–43]. Additionally, warmer weather and greater rainfall in certain regions have led to increased airborne pollen and mold spore counts, which have been linked to surges in emergency room visits for myocardial infarctions and strokes, as well as all-cause cardiovascular mortality [44–47].

The aging process is associated with impaired pulmonary vascular epithelial barrier function, likely a multifactorial process that includes reduced regenerative capacity

**Table 1** Select environmental manifestations of climate change and their impacts on the cardiovascular health of older adults

Phenomenon	Cardiovascular impacts	Impacts and vulnerabilities relevant to older adults
<b>Air pollution and wildfires</b>	<p>Climate change worsens ground-level air pollution by reducing air circulation, while increasing the frequency and severity of wildfires</p> <p>Particulate matter and ozone have both been tied to exacerbations of underlying cardiac conditions as well as chronic atherosclerotic and metabolic disease</p>	<p>Older adults have both higher underlying prevalence of cardiovascular conditions as well as reduced pulmonary vascular barrier functions, increasing their vulnerability to inhaled toxins</p> <p>Air conditions can mitigate much of the harmful effects of airborne pollutants, but are less likely to be used by older adults, even when available</p>
<b>Heat waves</b>	<p>Extreme heat not only leads to dehydration, it also stresses the myocardium with increased cardiac output requirements for skin-level circulatory heat dispersal</p>	<p>The majority of temperature-related deaths during heat waves are due to cardiovascular stress in older adults</p> <p>Older adults are more likely to be on medications such as diuretics for heart failure and chronic kidney disease, reducing their body's fluid volume reserve</p>
<b>Extreme weather events and natural disasters</b>	<p>Natural disasters, including hurricanes and blizzards, are associated with stress-related acute coronary events</p> <p>Widespread physical devastation can disrupt cardiovascular care infrastructure such as pharmacies, dialysis/infusion centers, and catheterization laboratories</p>	<p>Older adults often lack the physical and social mobility to evacuate in a timely manner from natural disasters</p> <p>The reduced circulatory reserve of older adults amplifies their susceptibility to the myocardial and metabolic demands imposed by physical activity in cold weather conditions and snow</p>
<b>Pandemic and epidemic diseases</b>	<p>Global warming has increased the risk of zoonotic infectious disease transmission by increasing vector species' habitat ranges, while exacerbating seasonal infectious disease epidemics such as influenza</p> <p>Pandemic disease disrupts cardiovascular care systems by delaying interventional procedures and diagnostic tests</p>	<p>Aging is associated with immunosenescence, which not only lowers resistance to infections, but also reduces vaccine effectiveness and induces pro-atherosclerotic autoinflammation</p>

CVD cardiovascular disease

## Heart

Aging is associated with reduced myocardial contractility. This leaves older adults less capable of augmenting cardiac output in response to heat-related dehydration and metabolic burden

Older adults are also more likely to be on medications such as diuretics and beta blockers, which further blunt the ability of the heart to respond to environmental stress-related cardiac demand



## Lungs

Aging leads to impaired pulmonary vascular barrier function due to poor epithelial progenitor cell recovery and extracellular matrix loss, leaving older adults more susceptible to the effects of inhaled particles and toxins



## Kidneys / Gut

Increasing age results in a reduction of the body's ability to redirect blood flow from the splanchnic vasculature to surface capillaries for heat dispersal



## Brain

Dementia is not only itself a predictor of worse clinical outcome from air pollution exposure, it is itself believed to be worsened by particulate matter inhalation



## Skin

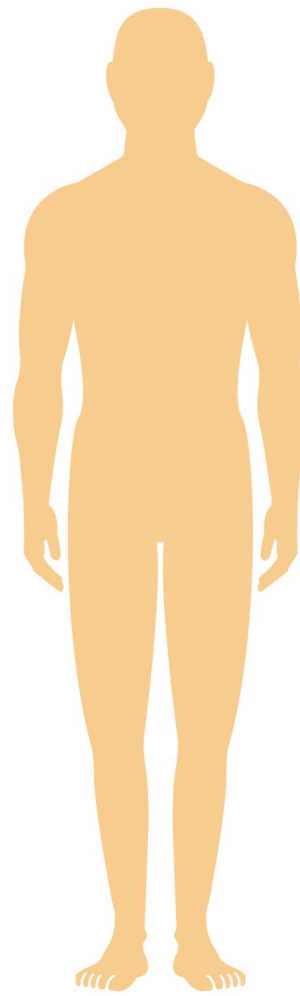
Aging is associated with reduction in thermoreceptor density, blunting the body's autoregulatory mechanisms against extreme heat and cold

Older adults have decreased overall sweat production, particularly from the core of the body, reducing evaporative cooling efficiency



## Immune System

Immunosenescence, a phenomenon of weakened innate and adaptive immunity leaves older adults more vulnerable to epidemic infectious disease, less responsive to vaccines, and more susceptible to pro-atherosclerotic autoinflammationthe heart to respond to environmental



**Fig. 1** Aging-associated physiological changes predisposing older adults to harm from climate change-mediated phenomena

of progenitor epithelial cells and poorer extracellular matrix recovery from acute inflammatory insults [48, 49]. The result is that older adults are less capable of protecting the air-blood barrier and are thus more susceptible to inhaled toxins. As such, it is no surprise that longitudinal ecological studies of both acute and chronic exposures to a variety of inhaled airborne pollutants have consistently found an elevation in cardiovascular events and mortality specifically among older individuals [50–56]. Furthermore, frailty and dementia, conditions of physiological and cognitive decline that accompany aging, are not only themselves connected to poor cardiovascular outcome from air pollution exposure, but are believed to themselves be worsened by airborne particulate matter inhalation [24, 26, 57–60].

Most noticeably, however, climate change has been linked to an acceleration in the frequency, intensity, and duration of seasonal extreme weather event-related deteriorations in air

quality [17, 18, 61]. These include wildfires and dust storms, which can rapidly raise PM<sub>2.5</sub> levels by orders of magnitude for hundreds of miles about their epicenters [10, 17, 18, 61]. Statewide investigations of wildfire smoke plume exposure in California have shown that adults 65 years of age and older have over twofold higher odds of suffering a cardiac arrest and 15% higher risk of finding themselves in the emergency room from a wide array of cardiovascular complications [62, 63]. Unfortunately, older people often lack the mobility, transportation resources, and technology proficiency to rapidly evacuate from natural disasters such as wildfires [28, 29, 64, 65]. This is because they are more likely to suffer from disability or dementia, or reside in institutional settings such as nursing homes. That said, independently living elders are also more likely to live alone and less likely to be able to drive themselves [3, 29, 66]. Furthermore, even when older adults have in-home air conditioning, which can be used to help filter airborne particulate matter

and mitigate some of its health risks, they are less likely to use it, frequently citing financial considerations as barriers to their use [67, 68]. Unfortunately, demographic trends do not favor a shift away from these concerns, as US census-based investigations suggest that aging populations may disproportionately reside in regions at highest risk of wildfire [69].

## Heat Waves

Similarly to its effect on wildfires, global warming has worsened the severity, frequency, and duration of heat wave events, with multiple continents recording their highest ever temperatures in the past decade [17, 18]. Heat waves directly claim thousands of lives each year, with nearly two thousand lost due to heat-related causes annually in the USA alone, making them deadlier than hurricanes, floods, blizzards, and tornadoes [70–73]. Older adults are by far the most vulnerable group to extreme heat events, as the highest percentage of heat wave-attributable mortalities are in individuals over the age of 65 years [70, 72, 74, 75]. Tragically illustrative of this example was a historic heat wave that struck continental Europe in 2003, killing 30,000 people [23]. The vast majority of the fatalities were in those over 75 years of age [76]. Again, the physical and socioeconomic limitations to the mobility of older adults prevent them from leaving regions of high heat in a prompt manner, relocating to air-conditioned spaces, or using air conditioning even when available [28, 29, 64–68]. The growing proportion of the world's older individuals living in urban centers and megacities are at further risk from “heat islands” that form from thermal trapping in manmade structures of concrete and steel [77, 78].

A number of physiological changes from the aging process raise the predisposition of older people to heat-related circulatory collapse. First, aging is tied to reductions in evaporative cooling efficiency due to decreased overall sweat production, particularly from the core of the body [79, 80]. This problem is exacerbated by the fact that elders are less able to redirect blood flow away from the deep splanchnic vasculature to the skin to facilitate cooling [81, 82]. Second, aging is associated with weaker contractile force of the heart in response to heat, meaning that older hearts are less capable of maintaining sufficient cardiac output in response to drops in blood pressure and left ventricular preload (say, from dehydration) than younger hearts [81]. Lastly, there is a reduction in surface thermoreceptor density in older adults, meaning that the heat releasing autoregulatory mechanisms of the body are less likely to be triggered with advancing age [83, 84].

This sensitivity to heat and fluid loss is particularly intensified in older adults with CVD. One reason is the effect of certain medications commonly used to treat these conditions. Diuretics, frequently employed to maintain optimal

cardiac preload in patients with heart failure and chronic kidney disease, increase vulnerability to dehydration by reducing total resting blood volume. Beta blockers, utilized for managing hypertension, coronary disease, cardiomyopathies, and arrhythmias, further reduce the ability of the heart to augment its rate and stroke volume in response to increased circulatory demand [85, 86]. Furthermore, patients living with disorders that limit myocardial contractility such as heart failure or obstructive coronary atherosclerosis, are more likely to develop cardiac ischemia at peak stress from heat exertion, increasing the risk of precipitating cardiogenic shock or myocardial infarction [23].

These factors make it understandable why the majority of deaths from heat waves are actually not due to the direct effects of heat (i.e., heat stroke, heat exhaustion) but rather from cardiovascular and cerebrovascular complications from the extreme strain placed upon the aging heart. For example, of the 692 excess deaths from the 1995 Chicago heat wave, only 4.7% were directly attributable to heat stroke, while 93.7% of excess deaths listed underlying CVD as a contributing factor [87]. Similarly, it is believed that over half (and possibly nearly two-thirds) of the mortalities from the 1995 and 1997 Milwaukee heat waves were directly precipitated by cardiovascular causes [88]. These findings are made mechanistically plausible by the fact that elevated cardiac troponin levels in blood samples of overheated patients are an independent prognostic marker of poor outcome from heat illness, particularly among the older individuals [89, 90].

## Extreme Weather Events and Rising Sea Levels

Among the most striking effects of climate change are the intensification of seasonal environmental phenomena, chief among them severe weather anomalies such as hurricanes, tornadoes, severe thunderstorms, and winter storms or blizzards [17, 18]. These aberrant events carry the capacity for immense physical destruction to buildings, roads, and power lines, thus crippling healthcare delivery systems. Elders with CVD, who are particularly dependent on pharmacies, clinics, and hospitals, can find themselves cut off from these resources during these crises [91]. Furthermore, the immense emotional trauma inflicted by such natural disasters has been associated with surges in acute CVD complications. New Orleans area hospitals experienced a nearly threefold increase in myocardial infarction admissions immediately following Hurricane Katrina, with the rise in cases persisting for years following the catastrophe [92–95].

Interestingly, although heat waves have been linked to increased cardiovascular sequelae among older people, so have extreme cold weather events, and in general, global

cooling patterns are correlated with a significant number of CVD mortalities [96, 97]. It has been long recognized that major snowstorms are followed by ischemic heart disease–attributable deaths and cardiac admissions [97, 98]. Further investigation is necessary to understand the mechanism of these findings, although it is hypothesized that the reduced circulatory reserve of older adults amplifies their susceptibility to the myocardial and metabolic demands imposed by physical activity in cold weather conditions and snow.

Another very prominent environmental concern stemming from climate change is that of melting polar ice caps and subsequently elevated global sea levels [17, 18]. In conjunction with the worsened storm seasons noted above, rising sea levels have augmented the severity and frequency of flooding in coastal zones, which again hold major implications for less-mobile elders [99]. Flooding not only physically disrupts cardiovascular care infrastructure, it also increases the risk of vector-borne diarrheal diseases, which will affect older populations, who are more vulnerable to cardiac stresses from dehydration and more likely to be on diuretic medications, more severely [100, 101].

Perhaps most insidiously, however, rising sea levels in these regions are encroaching on underground wells and other sources of groundwater for human consumption [102, 103]. The resultant increase in drinking water salinity carries population-level implications for sodium ingestion–related hypertension [104, 105]. Additionally, the contaminated water is projected to reduce crop yield in the millions of acres of coastal farms (particularly for subsistence farmers in alluvial floodplains), jeopardizing the long-term availability of fresh produce critical for good cardiovascular health [106–108].

## Pandemic and Epidemic Infectious Diseases

The devastation caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and its resultant coronavirus disease 2019 (COVID-19) have made the consequences of human environmental impacts on global health stark, given the likely zoonotic origin of the contagion [109–111]. Nevertheless, COVID-19 is not the first infectious pathogen to make the jump from animal to human, and will not be the last to do so. Indeed, the preceding decades have been characterized by potential pandemic warning signs posed not just by coronaviruses, but also by influenza viruses and paramyxoviruses with well-established animal vectors [109, 112–115].

Climate change has elevated the risk of pandemic infections in a number of ways, including increased human-animal contact (thus escalating the possibility of zoonotic disease transmission) by shifting wildlife habitats towards

human settlements, and by the warming of tropics making new regions suitable for inhabitation by disease vectors such as arboviruses and their insect hosts [109, 110, 116]. Furthermore, warm winters have been associated with “rebound” flu seasons of unusual severity, leading researchers to postulate that global warming may result in longer, harsher influenza seasons when they do occur [109, 117]. This is particularly concerning for older adults, as advanced age and pre-existing heart disease are both independent predictors for all-cause and cardiovascular mortality from influenza in this group [118–120]. Much of this may be due to immunosenescence, an age-related phenomenon consisting of deterioration of both the innate and adaptive immune responses, which lead to increased susceptibility to infection, poor response to vaccination, and a pro-atherosclerotic autoinflammatory state [121, 122].

COVID-19, in particular, has laid bare the vulnerabilities of our healthcare system to pandemic-associated disruptions for both older individuals and patients living with chronic CVD. Nursing homes and long-term care facilities were among the first outbreak zones to record massive casualties from the coronavirus, and CVD treatment infrastructure such as cardiac catheterization laboratories were among the first to be shut down due to quarantine and exposure protocols [123]. Indeed, even critical emergency care for ST-elevation myocardial infarctions were compromised, with some institutions reporting significant delays in lifesaving procedural door-to-balloon time therapies [124]. Fears of contracting the disease have led to postponing of even important operations and cardiovascular screening studies, both during the initial pandemic outbreak as well as during subsequent surges, with major implications for the timely management of these debilitating conditions [125–127].

## Vulnerable Populations

Although older adults living with heart disease are a generally vulnerable population, certain subgroups are likely to disproportionately suffer from the cardiovascular impacts of climate change. Multiple analyses have demonstrated both advanced age and low socioeconomic status to be independent determinants of poor cardiovascular outcome from air pollution, wildfires, heat waves, and natural disasters [20, 27, 32, 69, 128]. This may be attributable to greater baseline ambient pollution exposure, higher baseline prevalence of cardiovascular comorbidities and disease severity, and reduced financial access to specialty healthcare. Indeed, indigent elders are more likely to live near highways, and to have been engaged in jobs with occupational air pollution exposure [129–132]. Per US census data, both older individuals and the impoverished are more likely to live in regions vulnerable to wildfire [69].

Additionally, epidemiologic analyses have revealed that the structural racism experienced by Black and Native American communities lead to higher risk of exposure to environmental pollutants, natural disasters, and their associated mortality [19, 69, 74, 87, 133, 134]. Indigenous populations globally, many of whom depend on subsistence agriculture and farming, will be further impacted by the loss of generational farmlands and fisheries needed for a heart-healthy diet, while tribal elders suffer unduly during disaster evacuations due to the cultural shocks of displacement [133, 135–137].

These factors are further intensified for older people living in low- and middle-income countries, where rapid industrialization has led to intensification of unhealthy average air quality, particularly in urban centers [34, 138]. The annual average PM<sub>2.5</sub> exposure levels in China and Bangladesh are currently over 50 and 70  $\mu\text{g}/\text{m}^3$ , respectively, which well exceed the recently updated World Health Organization guideline recommended annual average concentration of 5  $\mu\text{g}/\text{m}^3$  [34, 139, 140••]. Many older women in poor countries are often tasked with cooking on traditional biomass-burning stoves [32, 35, 138]. This source of household air pollution, especially in inadequately ventilated homes, is a potent and concentrated source of cardiotoxic particulate matter linked to significant CVD morbidity [16, 31, 32, 35]. By 2050, it is estimated that 80% of people over the age of 60 in the world will live in low- and middle-income countries, nations whose health systems are still emerging from overcoming infectious epidemic diseases, and are having to fight both these transmissible illnesses and the rising tide of cardiovascular disorders simultaneously [3, 141].

## Future Directions

Although the ongoing threat of further climate change leaves the future uncertain, there are measures that policymakers, researchers, and healthcare providers can take to mitigate the risks that our warming globe poses to the heart health of our elders. First, we must be steadfast in our advocacy for carbon emission reductions and environmentally sustainable practices from governments and corporations. On a more individual level, though yet sparse, there is emerging data that personal protective tools such as facemasks, portable air purifiers, and air conditioners can reduce the burden of airborne pollutants and heat stress [34, 36, 142]. Healthcare providers should thus screen older patients, particularly the frail, indigent, and those with multiple pre-existing cardiac comorbidities, for harmful environmental exposures such as chronic air pollution and acute heat/fire risks. If present (or for those living in regions of the world with seasonal wildfires and heat waves), clinicians should advise such patients on personal

risk mitigation strategies as noted above. Emergency preparedness authorities and clinicians should also counsel high-risk older adults on disaster contingency planning preceding storm, heat, and fire seasons, including having medications and critical personal belongings prepared for evacuation. Indeed, both the US Centers for Disease Control and Environmental Protection Agency recommend that older individuals and those living with chronic cardiovascular conditions should have an emergency plan with medications and personal protective equipment ready, while avoiding excessive activity during such events [143, 144]. Currently, two-thirds of Americans over the age of 65 report having no such plan in the event of a disaster [66].

Researchers in the fields of Earth systems studies, public health, and cardiovascular science should also focus further investigations on the unique physiologic aspects of the aging process that increase the susceptibility of older adults to environmental insults. These should be paired with examinations of the socioeconomic and demographic trends that synergistically amplify this relationship. Additionally, high-quality randomized clinical trials are needed to determine the efficacy of personal-level protective equipment and policy-level risk mitigation strategies on reducing acute cardiovascular decompensation risk among elders during extreme weather events.

That said, it is critical that older individuals be involved in the development of strategies to mitigate these challenges. Despite the physical limitations imposed by age, many have developed mental resiliency that society can leverage. These include community leadership, family cohesiveness, the ability to mobilize social capital, and longitudinal perspective from living through previous disasters [66, 140••]. Indeed, older survivors of Hurricane Katrina cited having withstood prior hurricanes (in addition to the full extent of life's hardships) as sources of strength during their most trying times [145]. Most importantly, many older adults espouse the phenomenon of “legacy thinking”, where they are able to utilize their transgenerational knowledge to campaign for and prioritize the needs of their children and grandchildren during times of crisis [146]. Future directions in policy and clinical decision-making can incorporate these foundations of resilience into creating a socio-medical-environmental culture that better protects the cardiovascular wellbeing of our elders as well as the planet they live in.

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## Compliance with Ethical Standards

**Conflict of Interest** Dr. Odden reports personal fees from Cricket Health, Inc., outside the submitted work. The other authors declare that they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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