

# Climate change and healthy ageing: An assessment of the impact of climate hazards on older people

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**Background** Climate change not only directly impacts older people's longevity but also healthy ageing, which is the process of maintaining physical and mental capacities while optimising functional abilities. The urgency to address both population ageing and climate change necessitates a rethink and assessment of the impact of climate change on older people. This includes identifying what can be done to anticipate, mitigate and adapt to climate change and engage older persons.

**Methods** A review of climate change and healthy ageing forms the basis of evidence in this report. We developed a comprehensive search to assess current literature, combining terms related to ageing and climate change across four major data sets and assessing articles published up to the end of 2021.

**Results** We summarised the current and future impact of climate change on older people and developed a framework identifying climate change impacts on older persons, recognising social and environmental determinants of healthy ageing. Major hazards and some key exposure pathways include extreme temperatures, wildfire, drought, flooding, storm and sea level rise, air quality, climate-sensitive infectious diseases, food and water insecurities, health and social care system displacement, migration, and relocation. Strategies to address climate change require interventions to improve systems and infrastructure to reduce vulnerability and increase resilience. As a heterogeneous group, older people's perceptions of climate change should be integrated into climate activism. Increasing climate change literacy among older people and enabling them to promote intergenerational dialogue will drive the development and implementation of equitable solutions. Pathways may operate via direct or indirect exposures, requiring longitudinal studies that enable assessment of exposures and outcomes at multiple time points, and analyses of cumulative impacts of hazards across the life course.

**Conclusions** The lack of systematic reviews and primary research on the impact of most climate hazards, except for heat, on older people is apparent. Future research should include outcomes beyond mortality and morbidity and assess how older people interact with their environment by focusing on their capacities and optimising abilities for being and doing what they value.

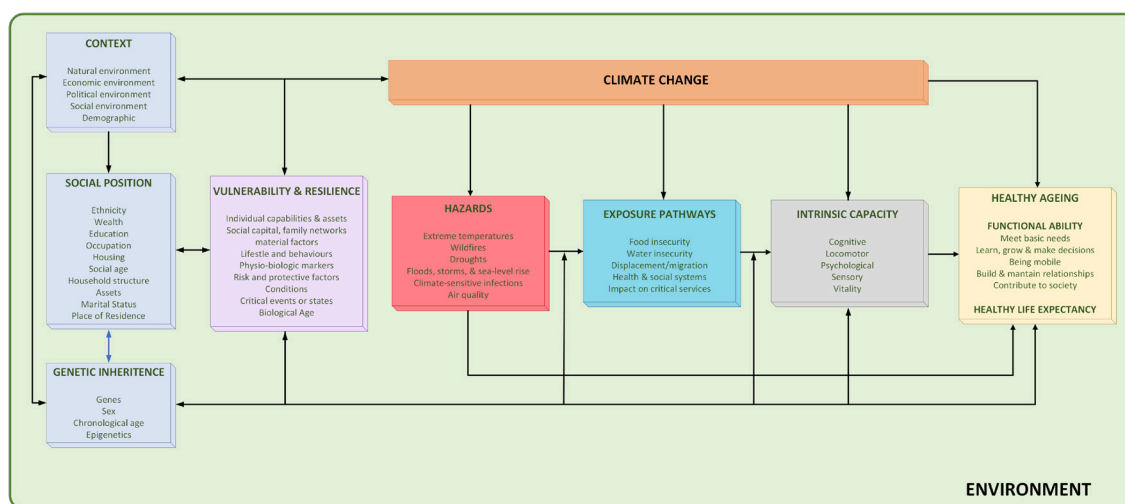
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Extreme heat, natural disasters (including floods, typhoons, and hurricanes) and changing patterns of infection due to climate change are predicted to lead to an additional 250 000 deaths a year worldwide from 2030 to 2050 [1]. Defined as the 'greatest threat to societies and global health of the 21st century', climate change is characterised by a long-term shift in weather patterns at a global level [2]. Climate

change is the result of human activities, such as the burning of coal, gas, and oil, which produce carbon and nitrous oxide that linger in the atmosphere, or changes in land use as well as agricultural practices, such as deforestation, and increased livestock farming [1]. Those drivers are not only modifying the environments in which we live but also have direct repercussions on our lives and health.

Climate change is an existential threat to humans, necessitating urgent and comprehensive action [3]. The combined global challenges of climate change and population ageing exemplify the paramount issues of this century, requiring simultaneous consideration and action, with both having significant impacts on health [4,5]. Climate change impacts every life, but older people are disproportionately affected by these changes [6]. This is due to a heightened vulnerability of older individuals, which stems from physiological, social, and contextual factors raising their risk of adverse health effects due to climate change [7] (Figure 1). For example, during Hurricane Katrina, 71% of the fatalities were older people, despite them only being 15% of the population [8]. A recent study assessing floods across 761 communities worldwide also found stronger associations between floods and mortality risk in sites with larger proportions of older people, combined to those that had a smaller older population [9]. Higher mortality risk among older people, compared to younger, have also been identified in the case of heat [10], with a 45-year study in Scotland reporting the oldest age group (85+) as the most affected by extreme cold and heat exposure, particularly for cardiovascular mortality [11]. As reported later in this paper, increased mortality is not the only outcome that highlights the increased vulnerability of older people. Despite this, as a group, older persons have often been neglected in studies on the impact of climate change. This is a major oversight for older persons living in all regions and countries, not only in high-income countries: already two-thirds of older people live in middle-income countries. Moreover, the proportion of older persons globally is increasing; by 2030, one in six people will be 60 years of age or older globally, and by 2050, one in five will represent over two billion older people [1,12].



**Figure 1.** Framework of the impact of climate change on older people.

Global policies are taking note and can be used as a platform to address the needs and rights of all older people. In December 2020, the United Nations (UN) launched the Decade of Healthy Ageing for 2021–2030, uniting various stakeholders to enhance the well-being of older people in line with the Sustainable Development Goals (SDG) – with healthy ageing defined as ‘the process of developing and maintain the functional ability that enables well-being in older age’ [12]. This is an opportunity to rethink and assess the impact of climate change on older people, as all UN Member States have endorsed that the environment plays a crucial role in promoting healthy ageing [13,14]. Climate change impacts older individuals and the process to optimise healthy ageing affects not only longevity but people’s abilities to be and do what they value [10,11]. This includes people’s ‘intrinsic capacities’ and a person’s interaction with their local environment including the natural environment. The interaction between the person and their environment enables or hinders people to function in families, communities or society with supportive environments optimising a person’s ‘functional ability’ at any level of ‘intrinsic capacity’ [7,12]. Together, these shape how individual older people experience well-being.

The overall aim of this paper is to assess the state of the evidence on the impact of climate change on older people. By constructing this conceptual framework, we aim to create a foundation for discerning adaptation

strategies, policies, and actions that can mitigate the present and future consequences of climate change on older people and healthy ageing. Specifically, we aim to: 1) assess the impact of different climate hazards on older people and identify the exposure pathways; 2) develop a conceptual framework to summarise the impact of climate change on older people; 3) identify vulnerabilities at an individual and societal level that put older people at a higher risk of being impacted by climate change.

## METHODS

The evidence discussed in this report was identified by using a combination of search strategies (**Box 1**), which helped us in developing a theoretical framework.

### Box 1. Methodology of screening and identifying relevant articles

The searches were carried out up to December 2021 and by screening the first 50 records on Google Scholar. After deduplication, 2577 articles underwent title and abstract screening (this includes the articles from Google and Google Scholar) for the primary paper screening. For the screening of reviews, a total of 3242 articles were initially screened after deduplication. Reference lists of these papers were also reviewed, and relevant articles were selected. Given the lack of evidence specific to older people, we did not limit those searches to older people.

#### Step 1: Rapid review

*Data sets:* Medline, EMBASE, PSYCINFO, GLOBAL HEALTH (up to 2021), Google Scholar (first 50 records), Google (first 50 records)\*\*

*Search terms:* Climate change and (older OR older adults OR agein\* OR agin\* OR aged)

#### Step 2: Reviews of reviews

*Data sets:* Medline (filter: 2011-2022) and Google Scholar (first 50 records)\* & \*\*

*Search terms:*

1 - climate AND review AND wildfire\* (n=100 results in medline)

2 - climate AND review AND drought\* (n=810 results in medline)

3 - (climate change\* OR global warming) AND (infectious disease\* OR communicable OR tropical disease\* OR zoonotic OR vector?born\* OR water?born\* OR food?born\*) AND (review) (n=950 in medline)

4 - (climate change\* OR global warming) AND (review) AND (flood\* OR sea?level OR typhoon\* OR hurricane\*) (n=519 in medline)

5 - (Heat OR heat wave\* OR warm\*) AND (health OR health risk\*) AND (climate chang\* OR global warming) AND (review) (n=763 in medline)

#### Step 3: Screening of other grey literature sources.

On top of searching Google, we also screened for potentially relevant reports from key organisations including IPCC, WHO, United Nations, Help Age International, etc.

\* Separate searches conducted for heat, droughts, wildfires, flooding, sea-level rises, and climate-sensitive infectious diseases

\*\* Not limited to only older people as there would be few reviews that focused specifically on the impact of hazards in later life. However, we were primarily only interested in papers that focused on older people or where the evidence was transferrable to later life, defined as:

1. Studies/articles referring to older people using a pre-defined cut-off age.

2. Studies that reported a mean age of 60 years or above

3. Studies reporting specific estimates stratified by age groups, including an older age group.

## RESULTS

Below, we introduce the main hazards and some key exposure pathways identified from the search.

### Impact of climate change on older people: Conceptual framework

Climate change impacts older people's capacities and abilities in diverse ways through a complex network of interconnected pathways. We have conceptualised a framework – a theory of change – on the impact of climate change on older people (**Figure 1**). This is a further development of the initial framework for healthy ageing that was created by Sadana et al. [15] integrating a social and environmental determinants of health model and the International Classification of Functional, Disability and Health (ICF). This approach emphasises the broader environmental context, encompassing climate dynamics, and involving systematic organ-

isation and evaluation to promote healthy ageing. Rooted in the biopsychosocial model, the ICF facilitates the precise assessment of interventions at individual and societal levels, considering the influence of climate and environmental determinants on health outcomes [16]. Terms that are used throughout are based on the definitions of the Intergovernmental Panel on Climate Change (IPCC) [17], the World Health Organization (WHO) Baseline Report for the Decade of Healthy Ageing [18] and WHO's strategy on health, environment and climate change [19] (Box 2).

#### Box 2. Key terminologies

**Healthy ageing** is defined as 'the process of developing and maintaining the functional ability that enables well-being in older age.' There are three main components of healthy ageing: functional ability, intrinsic capacity, and environment [18].

**Intrinsic capacity** represents every mental and physical capacity that a person can resort to. It includes several domains, including cognition, locomotor capacity (physical movement), psychological capacity, sensory capacity (hearing and vision), and vitality (energy and equilibrium) [18].

**Environments** are where people live and conduct their lives. They include natural and built environments, but also communities and broader societies and all factors within them [18].

**Functional ability** is the combination of the intrinsic capacity of a person, the environment they live and their interaction with the environment. It 'enables people to be and to do what they have a reason to value' [18]. It includes several domains: a) meeting basic needs to ensure an adequate standard of living; b) learning, growing, and making decisions; c) being mobile; d) building and maintaining relationships; and e) contributing to societies.

**Healthy life expectancy** is an indicator reflecting the years spent in good health, which combines morbidity (disease, illness or injury) and mortality (death) [20]. It is an important outcome indicator that has been endorsed in the Decade of Healthy Ageing, and is also WHO's overall indicator to measure impact of its work on population health [18].

**Hazard** has been defined as 'the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provisions, ecosystems and environmental resources' [20].

**Exposure** is defined as 'the presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social or cultural assets in places that could be adversely affected.' In this section we mainly talk about exposure pathways to highlight factors that coexist with each other and with hazards and that can positively or negatively influence outcomes [20].

**Impact** has been defined as 'adverse outcomes on natural and human systems, where risks result from the interactions of climate-related hazards, exposure, and vulnerability.' Impacts can affect humans, natural, social and built environments [21].

**Vulnerability** is defined as 'the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt' [20].

Certain hazards can compound each other, while others result from preceding hazards, for instance, droughts arising from extreme temperature and rainfall patterns. For simplicity, we have categorised all hazards together and have concentrated solely on primary hazards with the potential to impact older individuals, acknowledging the existence of other hazards. The ramifications of climate change on healthy ageing can manifest through intricate, either direct or indirect, exposure pathways. These hazards exert their influence on older individuals by directly shaping their healthy life expectancy and by affecting fundamental aspects of healthy ageing, including intrinsic capacity, functional ability, and the environment.

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It is also imperative to underscore that the older population is heterogeneous, displaying substantial diversity within it. Consequently, not all older adults are equally vulnerable and characteristics (e.g. place of residence, social position, national and political environment, etc.) across subgroups should be considered when developing policies.

## Major hazards

### *Extreme temperatures*

Globally, ambient temperatures have risen by more than 1°C compared to pre-industrial levels, a change primarily driven by human activities, deteriorating air quality, and the accumulation of greenhouse gases that enhance the greenhouse effect [19,22]. These temperature shifts have profound implications for human health, especially among older individuals (Figure S1 in the **Online Supplementary Document**). Thermoregulatory abilities diminish with age, making older adults more susceptible to extreme temperatures [23]. Additionally, the ability to perceive temperature changes decreases with age, compounding the risk of hypo- or hyperthermia with continued exposure to extreme temperatures [24]. Consequently, there has been a rise in morbidity and mortality linked to extreme heat, a trend expected to continue in the coming years. High temperatures can lead to increased overall morbidity and mortality in several ways. For instance, heart failure can result from heatstroke [25,26]. Dehydration, often exacerbated by inadequate access to clean water, has been linked to increased incidence of acute kidney injury and renal failure. Heatwaves also worsen respiratory health, as evidenced by reports of increased respiratory-related hospital admissions during heatwaves in Europe and North America [27]. Many older people have pre-existing medical conditions such as cardiovascular disease, diabetes, and asthma, which put them at high risk for heat-related morbidity and mortality. Moreover, heat waves limit mobility and outdoor activities for older individuals, exacerbating sedentary lifestyles and chronic conditions [28]. Furthermore, coping with extreme heat often necessitates adjusting indoor temperatures, including the use of air conditioning if available. This can result in increased electricity bills and contribute to higher CO<sub>2</sub> emissions, accelerating climate change. For many older individuals without family support, these expenses can be financially burdensome, heightening their vulnerability to the adverse effects of extreme temperatures.

### **Wildfires**

Wildfires pose a high threat to humans and are increasing in frequency (Figure S2 in the **Online Supplementary Document**) [29]. Wildfires disproportionately impact older people in several ways. Wildfires can affect the environments where older people reside, bringing several respiratory complications for older people. A meta-analysis using data from 19 European and North American countries by Huang and colleagues reported that several particulate matter (PM), some of which are associated with wildfires, were significantly related to lung cancer [30]. Children, older people, and those with underlying conditions seem to be at a higher risk compared to other adult populations. A study from Brazil reported that short-term exposure to wildfire related PM<sub>2.5</sub> is associated with increased risks of all-cause, respiratory, and cardiovascular hospital admissions. Children (zero to four years), and older people (≥80 years) had the highest relative risks of hospitalisation per 10 µg per cubic meter (µg/m<sup>3</sup>) increase in wildfire-related PM<sub>2.5</sub>, 4.88% (95% confidence interval (CI)=4.47–5.28), and 3.70% (95% CI=3.20–4.20) respectively, with adults aged between 30 and 39 only having 0.83% (95% CI=0.44–1.23) [31]. It has been suggested that this could be the result of weaker immune systems and pre-existing health conditions, such as asthma, which could increase the susceptibility to the respiratory impact of wildfires [32]. Due to air pollution, wildfires have effects on older people's cardiovascular health. Evidence from Australia shows that cardiovascular mortality rates increased during days when wildfires appeared [29]. Older people are also more likely to use emergency services due to cardiac arrest and become hospitalised due to ischaemic heart disease shortly after wildfires, compared to younger people [33]. Wildfires can also have a negative psychological impact on older people. Wildfires usually destroy houses, lifestyles, the former living environment and communities of older people, preventing ageing in place [34]. Older people may require more time or special support in case of evacuations, and power shortages and increased risk of electrocution from fallen lines may also affect health care facilities and older people's households located in rural areas [29].

### **Drought**

Droughts have been defined as extreme climate events in which the reduction of water, precipitation and an increase in air temperature are observed [35]. The increased duration of droughts will have various negative implications for the global population, especially for older people (Figure S3 in the **Online Supplementary Document**). Droughts particularly affect the environment of older people living in rural areas. In northern Ghana, for example, droughts were reported to reduce the fertility of the soil, reduce harvest quantities, and destroy property and livestock [36]. These effects of droughts can devastate older farmers from low- and middle-income countries (LMICs) due to their economic effects and can also increase the risks of malnutrition [37]. Charnley and colleagues also found that droughts in the African continent may cre-

ate ideal environments for the proliferation of *Vibrio cholerae*, the bacteria responsible for cholera disease, which can be highly detrimental to the health of older people, who have a higher risk of developing waterborne diseases [38].

### Flooding, storms, and sea level rise

Hydro-meteorological disasters affect the ageing population in a multitude of ways (Figure S4 in the **Online Supplementary Document**). A recent assessment of the needs of older people after the 2022 Pakistan floods highlighted a stark picture, with many older people left in need of cash, food, housing, medicines, and hygiene items [39]. Similarly, a case study from the USA reported a disproportional increase in emergency department visits and hospitalisations among older people in the week following Hurricane Sandy [40]. Hydro-meteorological disasters contribute to morbidity and mortality in older people through both direct and indirect means. Directly, reasons for death may include drowning, serious blunt trauma, and electrocution [41]. In addition to being vulnerable to direct impacts from water and flooding, older people are further at risk for other indirect health consequences. Floods have been linked to increased rates of fatal and non-fatal acute cardiovascular events, including myocardial infarction, Takotsubo syndrome (acute stress-induced cardiomyopathy), and cerebrovascular accidents, to which older people are particularly susceptible [41,42]. Hydro-meteorological disasters can also lead to an increased risk of numerous infectious diseases [43], and disasters can also impact mental health among the older population [44].

### Air quality

Air pollutants, such as ozone, black carbon, and sulphates, can lead to a change in climate. At the same time, increasingly warmer days, precipitation, and wind pattern changes can lead to the entrapment of air pollutants, such as ozone and particulate matter (e.g. soot, dust, dirt) in the lower atmosphere [45]. Older people are highly susceptible to the effects of poor-quality air (Figure S5 in the **Online Supplementary Document**). Studies have shown that small PM clearance reduces with increasing age, which is particularly problematic given that PM has been associated with both acute and chronic health effects, including asthma incidence and aggravation, chronic obstructive pulmonary disease (COPD), cancer, cardiovascular disease, and pneumonia [46]. A meta-analysis of the health risks associated with short-term exposure to PM showed that older people have a higher risk of death (0.64%) compared to younger populations per 10 µg/m<sup>3</sup> increase of PM. This included data from different European countries, North America (Canada, Mexico, and the USA), South America (Brazil and Chile) and Asia (China, India, and South Korea) [47].

### Climate-sensitive infectious diseases

While the global burden of disease has shifted from communicable to non-communicable causes in the last century, infectious diseases remain an important source of morbidity and mortality in older people, accounting for 5–6% of disability-adjusted life years (DALY) in 2019 and underlined by the COVID-19 pandemic [48]. Older people are both more prone to certain infections and likely to be diagnosed late due to age-related immunosuppression, being malnourished, or having other health conditions [37,49]. The WHO estimates that climate change will be responsible for over 60 000 additional deaths from malaria and dengue in 2030, as well as 48 000 additional deaths from diarrhoeal illnesses globally [14].

Climate-sensitive infectious diseases (CSIDs) are infections that are vulnerable to changing climatic factors such as increased temperatures and precipitation (Figure S6 in the **Online Supplementary**). One meta-analysis found that a 1°C increase in global temperatures was associated with overall infectious morbidity among older people, but more evidence is needed to establish the magnitude of the effect [25]. Vector and waterborne diseases are the most likely to be impacted by climate change [50]. Malaria, for example, is a major vector-borne disease. Malaria in older people is associated with a higher risk of neurological damage and death in older adults. Dengue, another vector-borne disease on the rise with climate change, is associated with haemorrhagic fever and end-organ damage. Older people could, therefore, be at proportionately greater risk as climate change increases their overall incidence [51,52]. Waterborne gastrointestinal infections are a particularly important cause of illness in older people due to age-related immunosuppression, decreased thermoregulatory ability, and sensitivity to dehydration [53]. In terms of foodborne CSIDs, *salmonella* and *campylobacter* have peak incidences in older people, who are also more likely to be hospitalised and die after illness compared to younger populations [54]. Norovirus is a key illness for older people who are more likely to have prolonged hospitalisation and death caused by norovirus, with a fatality rate higher than >200% that of young children [55].

## Food and water insecurities

Food insecurities are driven by a multitude of factors: warmer weather can lead to poorer crops and greater food spoilage. This is problematic as many older people living in LMICs continue working until later in life and often work as farmers or rely on subsistence agriculture [56]. It has been estimated that up to 28% of smallholder farmers globally are aged over 55. Many older people live on fixed incomes and will not be able to afford rapid price increases. It has also been reported that when food is scarce, households are more likely to allocate limited food supplies to younger members of the family compared to older members [57,58]. All these issues could lead to malnutrition disproportionately affecting older women. High temperatures are also associated with reduced food safety and can increase pathogens in food and seafood, once again disproportionately affecting older people due to pre-existing co-morbidities and reduced immune systems [59]. A recent review of the literature has linked water insecurity with diarrhoeal incidence, chronic kidney disease, increased blood pressure, reduced cognitive performance and dehydration [60]. Older people are increasingly vulnerable to these changes, as they are already underserved by existing facilities and services [61]. Dehydration in later life is burdensome, and several studies have shown that there is a strong association between being dehydrated and having negative health outcomes, including mortality, frailty, cardiovascular disease, cognitive problems, oral health and poorer hospital outcomes [60].

## Health and social care systems

Climate change is having and will have a large impact on health and social care systems. Many of the hazards described above will result in acutely increased hospitalisations after extreme events and the use of already stretched and overburdened health systems. Low- and middle-income countries will be disproportionately affected by this increase in burden due to poverty, malnutrition, lack of resources to address health needs, and poor underlying infrastructure. Displacement from home will also disrupt access to health and social care systems, with a report from the UK highlighting a substantial impact of evacuation efforts on well-being and health [62]. Social care for older people often relies on both formal and informal caregiving. Both are being affected by climate change. Urban migration of younger generations in areas impacted by climate change could result in reduced support ratios and informal caregiving for those older people who are left behind and in need of informal care support [63]. This lack of intergenerational support structures may lead to increasing loneliness among older people, further exacerbating the threats to healthy ageing [64].

## Displacement, migration, and relocation

Climate change-related displacement and migration refers to the movement of individuals and communities due to changing climate conditions that threaten life, livelihood, or well-being [61,65,66]. Migration is often a last resort adaptation to climate change. However, a person's ability to migrate is limited by mobility and resources. Older people, who are more likely to have socioeconomic vulnerabilities, locomotor limitations, underlying health conditions, and greater social care needs, are often the least able to relocate in approaching climate threats [65,67]. Case studies in Bangladesh, Nepal, and Pakistan have shown that older people are among the vulnerable subgroups often left behind in climate migration [68]. In cases of successful relocation, older people may be more vulnerable to other exposure pathways and risks of climate change, such as food insecurity or loss of access to critical services. Migrant groups generally have worse health outcomes due to dangers in transit and disrupted health and social care [69,70]. Evacuations pose special risks to older people who are frail, medically complex, or live in group care settings, as needed medications, medical equipment, and medical records may not be accessible [63].

## Vulnerabilities and resilience

While climate change affects all older individuals to some extent, it has a more pronounced impact on specific subpopulations of older people, attributable to their characteristics and broader determinants of health. When these factors are anticipated to result in deleterious consequences, they are designated as 'vulnerabilities' and, when positive or building up reserve, as 'resilience'. These vulnerabilities often overlap and coexist, working together dynamically and synergistically to perpetuate unequal health outcomes related to climate change.

Older people comprise a diverse population with varying experiences of risk factors on individual, social, and contextual levels. Vulnerabilities among older people can be seen as the result of how risk factors, sensitivity, and coping capacity interact when confronting climate threats [71]. There is evidence highlighting that factors affecting healthy ageing, such as social determinants of health, are evolving and older persons' vul-

nerabilities have increased due to climate change impacts [19]. For example, several studies have identified a key role in socio-economic markers of position, such as education and wealth, as key drivers of inequalities in healthy ageing [72,73]. At the same time, climate change is amplifying existing inequalities by exacerbating vulnerabilities in people with lower incomes. This group of people often have lower awareness of climate change, with more limited resources to access knowledge on and implement adaptation strategies. Older people with low socio-economic positioning often live in poorer housing conditions and have less access to health services which include preventive, promotion, treatment, rehabilitation, and palliative care [74,75]. In the event of a climate crisis, this can lead to greater relative losses compared to younger or more affluent segments of the population. Thus, a vicious cycle occurs, whereby poverty increases older adults' vulnerability to climate hazards, which in turn exacerbates economic inequalities [76,77]. In this paper, one objective is to explore specific vulnerabilities and offer relevant examples when possible. In essence, the climate crisis exacerbates pre-existing health disparities, as identified in some examples in **Table 1**.

**Table 1.** Vulnerabilities of older people and interactions

Major factors	Interaction factors	Examples
Sociodemographic characteristics	Gender	Women are at increased vulnerability to climate events with age if they outlive their male peers [77–79]
	Education	Lower education status is closely linked to lower socio-economic status, which is further related to poorer health outcomes in older people [80,81]
	Occupation	Occupational heat stress in construction work, mining, factory work, etc., can pose a serious health threat, leading to higher mortality and morbidity [82,83]
	Ethnicity	Barriers to access health care, health inequalities and discrimination for minority ethnic groups can further exacerbate vulnerabilities to the effects of climate change, particularly in older people from ethnic minorities [84,85]
	Poverty	Poverty limits people's access to adequate health care services and access to knowledge, which can be detrimental to older adults' functional ability and healthy longevity [5,86]
Health factors	COVID-19	In England, an excess of (~88%) of total cumulative all cause excess mortality from the COVID-19 pandemic occurred among individuals the 65+ age group [87,88]
	General health and comorbidities	With climate change, older people with pre-existing health conditions and with lower intrinsic capacity levels are at much higher risk of negative consequences than the general population [87,89]
	Cognition and mental health	During heatwaves, people living with dementia are at an increased risk of hospitalisation, and those with pre-existing mental health conditions, such as psychoses and substance misuse, may also be at an increased risk of heat-related mortality [90,91]
Social and contextual factors	Social links/connectedness	A review from Nepal has demonstrated that the migration of active and educated individuals to urban areas has left older people with fewer adaptive resources and social support, increasing their susceptibility to the adverse impact of climate change [81,92]
	Built environment and housing	In Portugal, larger wildfire-burned areas tend to be more inland and associated with where ageing communities live and poorer housing infrastructure [93,94]
	Geographical location	Many climate-sensitive infectious diseases are likely to spread in Central and South America, South Asia, and Africa, imposing a burden on the already fragmented health care infrastructure in low HDI regions [95]
	Political situation, economic factors, armed conflicts	Political and demographic changes alongside socio-political instability, which lead to migration and displacement, disproportionately impact the lives of older people [63,96]

COVID-19 – coronavirus disease 2019, HDI – human development index

## DISCUSSION

### Implication for mitigation and adaptation

Despite increasing global awareness of the interplay between climate change and public health, current efforts fall short of achieving a sustainable recovery and safeguarding people from the mounting health risks associated with climate change [97]. As the majority of mitigation approaches focus on reducing the drivers of climate change (i.e. greenhouse gases) and are therefore not specific to older people, in this section, we will primarily discuss potential adaptation strategies.

WHO conducted a consultation with older adults to identify research questions addressing healthy ageing involving more than 1500 people in 77 countries [1] and documented many related to climate, extreme environmental events, pollution hazards, and the impact on housing, indoor and outdoor infrastructure, as well as the increased need for information and new technologies [98]. Several documents on this topic,



including some guidelines from different organisations, already exist. Although these are not specific recommendations for older people, their integration could still be important to lessen the impact of climate change on this group. These include the WHO Global Strategy on Health, Environment, and Climate Change [19], WHO's Housing and Health Guidelines [99], the Compendium on Health and Environment [100], the Lancet's Countdown on Health and Climate Change series [101], the Sustainable Development Goals [102], the UNFCCC reports [103] and the Paris Agreement itself [103].

Mitigating vulnerabilities, especially those to which older individuals are more predisposed, and enhancing resilience, constitute pivotal strategies to bolster preparedness and curtail the adverse effects of climate change on healthy ageing. Some important strategies suggested by different international bodies and scientists across the globe are listed in **Table 2**.

**Table 2.** Strategies for mitigation and adaptation

Key areas	Recommended strategies
Building intrinsic capacity and functional ability	Intrinsic capacity and functional ability can be built and optimised throughout the life course, with policy actions developed to shape those determinants of healthy ageing [102]
	Developing interventions following the WHO Integrated Care for Older People (ICOPE) guidelines adapted to contexts which are more prone to climate change [103,104]
	Increase accessibility to health services to older populations and increase the budget allocated to tackle health deteriorations in climate events [105]
Improving systems, communities, and infrastructures	
<i>Housing</i>	To protect older residents, houses and living facilities should ensure adequate ventilation and insulation [106] In heat-prone areas, buildings should utilise reflective surfaces and avoid heat-trapping materials like concrete to minimise heat absorption [107] Age-friendly housing codes with wider doorways and large staircases or stairlifts to support everyday mobility and facilitate quick evacuation during disasters [63]
<i>Cities and surrounding infrastructure</i>	Increased greenspaces to protect against extreme temperatures, mitigate pollution, provide shade, and offer aesthetic spaces for multiple types of activities for older people [108,109] Ensure walking paths are smooth surfaced, and well-lit to mitigate falls and safety concerns [109] In areas prone to heatwaves, heat shelters around the community should offer both physical safety and areas for social connection [56]
<i>Transport and mobility</i>	Ensure strong transport networks for timely evacuation and aid delivery, particularly for older people [56] In flood-prone areas, roads could be fitted on either side with bioswales, which are mulched and vegetated channels that facilitate water runoffs [110]
<i>Energy and resource poverty</i>	Local governments/municipalities to introduce new technologies like solar panels to provide low-emission, clean-energy power to homes [111] Provide information, technological training, or finances to older people to access renewable energy, which may help mitigate climate change and secure energy sources [56]
<i>Agriculture, food, and water security</i>	Utilise and support older people's knowledge on how to deal with agricultural losses during extreme climatic events, such as planting different crops and changing farming techniques [56] Provide information and economic aid to more vulnerable older people to ensure food security [112] Provide information and training on recycling water, practicing adequate water storage techniques, and restricting excessive water use within the community [113]
<i>Health and social systems</i>	Adaption and contextualising of WHO 'Operational framework for building climate resilient health systems' for older people [114] Develop institutional policies and enhance the knowledge of health practitioners to facilitate the discussion of climate change with patients [115] Introduction of new technology, telehealth, remote monitoring, precision health, and artificial intelligence [116]
<i>Pathogen control</i>	Execute wider municipal programmes to control pathogen proliferation and improve sanitation to mediate the risk of CSID in older people [56] Public health programmes should be implemented in areas vulnerable to climate-sensitive vectors, educate older people and providers, and encourage behavioural changes Maintaining the quality and supply of community water sources is important for older people who are vulnerable to gastrointestinal illnesses.
<i>Early warning systems and disaster mitigation</i>	Early warning systems should be able to identify and send targeted messages to older people, particularly those with other vulnerabilities, including older persons with declines in hearing and vision Ensure availability and accessibility of communication technologies especially targeted to socially isolated older people [107,111] Early warning systems should use diverse and accessible communication avenues (e.g. public radio) to maximise reach to older people

## Potential initial action

To create effective and pertinent strategies for climate change prevention and mitigation, all affected communities need to participate, regardless of age, as emphasised by the UN Human Rights Council in 2021 [63]. Understanding the perception of climate change among older individuals is a crucial area to investigate for effective action. In 2010, the Stockholm Environment Institute reported that the baby boomer generation, currently aged 58–76, had the highest carbon footprint in the UK standing at 13.5 CO<sub>2</sub> tonnes per capita [117], with this footprint driven to meet basic needs rather than having luxury lifestyles [118]. It has been argued that older people in the USA have various objections to climate change action, such as the idea that it is too late to reverse climate change [119], although other studies found no major differences in perceptions between younger and older cohorts [120]. One of the first initial actions is to change the perception of older individuals so that they recognise their role as significant drivers and contributors to climate change action.

A recent survey involving 1.4 million participants from 50 countries underscored that the individual's level of education was the most significant influencer of public opinion regarding climate change [121]. To comprehend why older generations are not as actively involved in climate action as younger ones, it is imperative to consider additional barriers (including individual, structural, and societal barriers) beyond lower education levels and a lack of personal exposure to the adverse effects of climate change, which may limit the scope for older individuals' engagement in environmental initiatives.

Engaging in climate action not only fosters healthy ageing but also positively impacts community well-being and environmental preservation. Older people are inherently motivated to contribute to society. The inclination of older populations to assist during crises with substantial environmental consequences or other emergencies, even at the risk of their well-being, is a remarkable characteristic. Scholars have proposed that fostering a sense of generativity and emphasising the importance of leaving a positive legacy when discussing climate change can effectively encourage policies and practices that reduce greenhouse gas emissions and promote behaviour change across all age groups [97,122,123]. The active involvement of older individuals in climate change activism can also yield community benefits, including a reduction in ageism, enhanced intergenerational connections, and the transfer of valuable knowledge. Furthermore, cultural wisdom and steadfast beliefs of older people have proven instrumental in enabling effective coping mechanisms during challenging situations, including disasters [124,125].

Investing in training for older adults in areas like political advocacy (such as letter writing, meeting with legislators, and personal storytelling) may hold significant potential for generating a multiplier effect within their local communities [126,127]. Climate change education, digital literacy programmes, and daily practices aimed at reducing carbon emissions could be integrated into older people's associations (OPAs) throughout East and Southeast Asia, following the model proposed by HelpAge International [97], and possibly expanded to other continents. Empowerment of older people will also lead to more advocacy at a governmental level to create adaptation plans that consider the needs of older people, and that hopefully will translate into increased research funding to address the existing evidence gaps.

Various policies aimed at mitigating climate change, such as those addressing fuel poverty e.g. inability to adequately meet household energy needs [128], renewable technologies, and insulation, prove advantageous for the well-being of older individuals [128,129]. The involvement of older adults in environmental volunteering is a growing initiative. For instance, in Italy, an environmental volunteering programme involving park restoration showed increased life satisfaction, physical activity, and positive feelings among older people after they joined the activities [130].

The political situation of a given country influences the priority given to health, which is crucial for older people. The governmental allocation of funds to health – both addressing its determinants and to the health care system – determines how much health services can focus on the prevention and treatment of chronic illnesses among older people. National governments may not even recognise the need for the development of such strategies in low-income countries; however, international funding allocation and implementation of targeted programmes are timely needs.

## Research gaps

We have presented compelling evidence highlighting the substantial impact of climate change on older people worldwide. However, it is essential to recognise that much of this evidence is indirect, revealing gaps in our understanding of this issue. Notably, individuals who were actively engaged in the environmental movement, including the inaugural Earth Day in 1970, have now transitioned into the older population demographic.

As global leaders age, there is an opportunity for them to leverage their leadership skills and social influence to foster intergenerational solidarity within the climate change movement, amplifying the voices of younger adults, as suggested by the UN Human Rights Council in 2021 [63].

Nevertheless, there is a noticeable lack of research exploring the opinions of older individuals regarding climate change and their motivations and contributions to climate change activism. Although many systematic reviews have been published on the impact of climate hazards on health, only a few focused specifically on older people, with evidence predominantly being systematically assessed for heat and air pollution. For example, Bunker and colleagues and Yu et al. assessed the impact of air temperature on older adults [131,132]. Most epidemiological studies on climate change impacts, with few exceptions, primarily target younger populations, and general adults, or even exclude older individuals entirely. This omission is concerning, given that older individuals likely bear a disproportionate burden of climate-related hazards and as the world population becomes increasingly older. Comprehensive evidence from large-scale longitudinal studies to imply causal inference and explore the cumulative effect of various hazard exposures is absent globally. The establishment of a universally accepted definition of climate hazards would facilitate cross-study comparisons.

Furthermore, studies involving older individuals often have a narrower scope, primarily focusing on morbidity and mortality rather than the enabling processes to optimise healthy ageing, including people's functional ability and intrinsic capacity, which older individuals themselves often consider more critical than morbidities. It is imperative to integrate research on topics of interest to older individuals [92] and environmental sustainability to ensure the protection of the rights of older people, especially as the effects of the climate change crisis intensify. Additionally, research from low- and middle-income countries and vulnerable communities is lacking, such as from the Small Island States, with most of the evidence originating from North America, Australia, and Western Europe, even though the impact of climate change will disproportionately affect the Global South [133].

We have presented evidence highlighting the substantial impact of climate change on older people worldwide. However, it is essential to recognise that much of this evidence is indirect, revealing gaps in our understanding of this issue. One of the major limitations of this narrative review was the compressed timeframe for literature screening and report production. Although this study covers a broad scope encompassing multiple exposures, outcomes, and adaptation strategies relating to older adults, the short time frame affected our ability to present evidence systematically, including an assessment of its strength, risk of bias, and dose-response relationships. Furthermore, it is essential to acknowledge that although we tried to identify as many studies as possible, our systematic searches could have been further expanded by focusing on primary papers and not only systematic reviews when assessing the literature for each hazard identified.

We are hopeful for a shift towards greater inclusivity in climate change research. We advocate for prioritising research in the following areas:

- Studies that explicitly assess the impact of climate change on older people.
- Studies that focus on outcomes beyond mortality and morbidity, including functional ability and intrinsic capacity.
- Studies that assess impact across diverse regions of the world, including a focus on vulnerable groups within those areas.
- Studies that assess exposures and outcomes at multiple time points and the cumulative impacts of being exposed to different hazards.
- Studies that assess the inter-relationships between different hazards and quantify combined impacts on older people.
- Studies that focus on quantifying interactions and risks among groups with multiple vulnerabilities.
- Studies that value and quantify older people's contributions to climate action that are not accounted for in standard economic indices, such as caregiving and volunteering, supporting people and sustaining the environment, as highlighted by the WHO Council on the Economics of Health for All [134].
- Studies that address ways to improve housing to enable older persons to age in place.
- Evaluations of how non-governmental climate action organisations empower and engage older people and promote intergenerational dialogue.
- Studies that identify effective ways to increase climate change literacy of older people.

There is a crucial need to harmonise the concerns of older individuals and environmental sustainability to safeguard the rights of older people, particularly given the escalating impacts of the climate change crisis

[91]. Additionally, we must persist in developing climate change adaptation and mitigation solutions that are both equitable and culturally appropriate, with a specific focus on older people.

## CONCLUSIONS

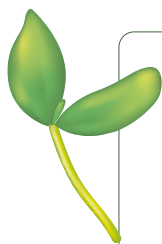
If the increase in temperature is not kept within the levels decided in the Paris Agreement, the implications for our world will be devastating, with effects affecting all spheres of society, every living creature, and the ecosystem. Climate change is already having a large impact on older people's lives, and with a projected increase in the number and proportion of older people worldwide, the scale of those impacts will increase even further.

The potential redirection of financial investments by local government and international organisations toward climate-friendly initiatives, along with the adjustment of food and energy consumption patterns that older people can endorse, represents a potent tool for positive impact investing in climate change initiatives for older individuals. For example, energy-efficient technologies provide dual advantages – cost savings to older people and positive environmental impact. [122,135]. Investment in training older people to be effective environmental activists can maximise their abilities to contribute to society and the value of their actions [56]. For example, in China, there are over half a million older people's associations (OPAs) that let older people take the lead on environmental projects and climate education in both urban and rural communities [97]. Policymakers need to prioritise the most vulnerable, aligning local and global development and climate actions while disseminating public information on risks and solutions. Equitable adaptation strategies that reach all people are also crucial, ensuring that all individuals, regardless of socioeconomic status, have the resources and support to cope with climate-related challenges. For instance, targeted outreach and education programmes can bridge the gap, fostering resilience in communities facing diverse socioeconomic circumstances.

This review highlights specific entry points for policies and actions, emphasising potential leadership roles by either the health sector or other relevant domains globally. The objective is to systematically address determinants and diminish inequities, supporting individuals in achieving and maintaining optimal well-being as they age. Furthermore, the framework delineates essential features that health systems can integrate to amplify equity in the context of healthy ageing and alleviate the enduring repercussions of disparities. Essentially, the framework serves as a compass guide for formulating and executing effective strategies to advance healthy ageing and reduce health disparities.

Although older people are overwhelmingly affected by climate change, existing evidence on this group is limited, and more is needed to understand the multifaceted impacts and the complex network of exposure pathways underlying these effects. What is clear is that older people are not a homogenous group and that specific individual, and contextual characteristics put certain people at a heightened risk. More research, however, is needed to understand the relationship between different vulnerabilities and the implications of having multiple vulnerabilities.

Older people play a crucial role in driving these changes, and there is a growing momentum to increase climate change activism among this demographic, as well as their awareness and understanding of climate change issues. By actively involving older individuals in conversations about climate change and creating age-friendly environments, we not only have the opportunity to mitigate the adverse effects of climate change on healthy ageing but also to transform population ageing into a valuable resource for addressing the most pressing challenge of our time.



**Disclaimer:** This article is a short version of a longer report commissioned by WHO. The views expressed in this article are of the authors and not necessarily of WHO.

**Ethics statement:** This article reflects an evidence synthesis and does not require ethics approval per WHO policy.

**Funding:** The authors gratefully acknowledge funding support received from the World Health Organization Department of Climate Change and Health, the Government of Spain and Velux Stiftung to conduct research and evidence synthesis.

**Authorship contributions:** RS and MP conceived the article and developed the narrative; MP led the review; all authors (MP, NK, SAK, JCC, AP, CS, SX, and RS) contributed to the searches, writing and final review.

**Disclosure of interest:** The authors completed the ICMJE Disclosure of Interest Form (available upon request from the corresponding author) and disclose no relevant interests.

### Additional material

Online Supplementary Document

- 1 World Health Organization. COP24 special report: health and climate change 2018. Geneva: World Health Organization; 2018.
- 2 World Health Assembly 61. Climate change and health: report by the Secretariat;2008.
- 3 Steffen W, Richardson K, Rockström J, Cornell SE, Fetzer I, Bennett EM, et al. Sustainability. Planetary boundaries: guiding human development on a changing planet. *Science*. 2015;347:1259855. Medline:25592418 doi:10.1126/science.1259855
- 4 Harper S. The Convergence of Population Ageing with Climate Change. *J Popul Ageing*. 2019;12:401–3. doi:10.1007/s12062-019-09255-5
- 5 United Nations Economist Network. Report of the UN Economist Network for the UN 75th anniversary: Shaping the trends of our time. United Nations; 2020.
- 6 Zimmer Z, Knodel J. Climate Change, Vulnerability, and Older People. *Encycl Gerontol Popul Aging*. 2021;1022–8.
- 7 Sarkar SM, Dhar BK, Fahlevi M, Ahmed S, Hossain MDJ, Rahman MM, et al. Climate Change and Aging Health in Developing Countries. *Glob Chall*. 2023;7:2200246. Medline:37635700 doi:10.1002/gch2.202200246
- 8 Kriebel-Gasparro A. Climate Change: Effects on the Older Adult. *J Nurse Pract*. 2022;18:372–6. doi:10.1016/j.nurpra.2022.01.007
- 9 Yang Z, Huang W, McKenzie JE, Xu R, Yu P, Ye T, et al. Mortality risks associated with floods in 761 communities worldwide: time series study. *BMJ*. 2023;383:e075081. Medline:37793693 doi:10.1136/bmj-2023-075081
- 10 Son JY, Liu JC, Bell ML. Temperature-related mortality: a systematic review and investigation of effect modifiers. *Environ Res Lett*. 2019;7:073004. doi:10.1088/1748-9326/ab1cdd
- 11 Wan K, Feng Z, Hajat S, Doherty RM. Temperature-related mortality and associated vulnerabilities: evidence from Scotland using extended time-series datasets. *Environ Health*. 2022;21:99. Medline:36284320 doi:10.1186/s12940-022-00912-5
- 12 United Nations. Decade of Healthy Ageing (2021-2030): resolution/adopted by the General Assembly. United Nations; 2020.
- 13 United Nations. Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs. United Nations; 2015.
- 14 World Health Organization. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. Geneva: World Health Organization; 2014.
- 15 Sadana R, Blas E, Budhwani S, Koller T, Paraje G. Healthy Ageing: Raising Awareness of Inequalities, Determinants, and What Could Be Done to Improve Health Equity. *Gerontologist*. 2016;56 Suppl 2:S178–93. Medline:26994259 doi:10.1093/geront/gnw034
- 16 Ustün TB, Chatterji S, Kostansjek N, Bickenbach J. WHO's ICF and Functional Status Information in Health Records. *Health Care Financ Rev*. 2003;24:77–88. Medline:12894636
- 17 Chen Y, Moufouma-Okia W, Masson-Delmotte V, Zhai P, Pirani A. Recent Progress and Emerging Topics on Weather and Climate Extremes Since the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. *Annu Rev Environ Resour*. 2018;43:35–59. doi:10.1146/annurev-environ-102017-030052
- 18 World Health Organization. Decade of healthy ageing: Baseline report. Geneva: World Health Organization; 2020.
- 19 World Health Organization. WHO global strategy on health, environment and climate change: the transformation needed to improve lives and well-being sustainably through healthy environment. Geneva: World Health Organization; 2020.
- 20 Masson-Delmotte V, Zhai P, Pörtner OH, Roberts D, Skea J, Shukla PR, et al. Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. *World Meteorol Organ*. 2018.
- 21 Semanza JC, Paz S. Climate change and infectious disease in Europe: Impact, projection and adaptation. *Lancet Reg Health Eur*. 2021;9:100230. Medline:34664039 doi:10.1016/j.lanep.2021.100230
- 22 Brennan M, O'Shea PM, Mulkerrin EC. Preventative strategies and interventions to improve outcomes during heatwaves. *Age Ageing*. 2020;49:729–32. Medline:32638997 doi:10.1093/ageing/afaa125
- 23 Schneider A, Ruckerl R, Breitner S, Wolf K, Peters A. Thermal comfort, Weather, and Aging. *Curr Environ Health Rep*. 2017;4:21–9. Medline:28110470 doi:10.1007/s40572-017-0129-0
- 24 Johnston FH, Bailie RS, Pilotto LS, Hanigan IC. Ambient biomass smoke and cardio-respiratory hospital admissions in Darwin, Australia. *BMC Public Health*. 2007;7:240. Medline:17854481 doi:10.1186/1471-2458-7-240
- 25 Bunker A, Wildenhain J, Vandenbergh A, Henschke N, Rocklöv J, Hajat S, et al. Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. *EBioMedicine*. 2016;6:258–68. Medline:27211569 doi:10.1016/j.ebiom.2016.02.034
- 26 Vardoulakis S, Dear K, Hajat S, Heaviside C, Eggen B, McMichael AJ. Comparative Assessment of the Effects of Climate Change on Heat- and Cold-Related Mortality in the United Kingdom and Australia. *Environ Health Perspect*. 2014;122:A320. Medline:25222967 doi:10.1289/ehp.1307524
- 27 Oudin Åström D, Schifano P, Asta F, Lallo A, Michelozzi P, Rocklöv J, et al. The effect of heat waves on mortality in susceptible groups: a cohort study of a mediterranean and a northern European City. *Environ Health*. 2015;14:30. Medline:25889290 doi:10.1186/s12940-015-0012-0
- 28 Gildner TE, Levy SB. Intersecting vulnerabilities in human biology: Synergistic interactions between climate change and increasing obesity rates. *Am J Hum Biol*. 2021;33:e23460. Medline:32618027 doi:10.1002/ajhb.23460
- 29 Finlay SE, Moffat A, Gazzard R, Baker D, Murray V. Health Impacts of Wildfires. *PLOS Curr Disasters*. 2012.
- 30 Huang F, Pan B, Wu J, Chen E, Chen L. Relationship between exposure to PM2.5 and lung cancer incidence and mortality: A meta-analysis. *Oncotarget*. 2017;8:43322. Medline:28487493 doi:10.18632/oncotarget.17313
- 31 Ye T, Guo Y, Chen G, Yue X, Xu R, Coêlho MSZS, et al. Risk and burden of hospital admissions associated with wildfire-related PM2.5 in Brazil, 2000–15: a nationwide time-series study. *Lancet Planet Health*. 2021;5:e599–607. Medline:34508681 doi:10.1016/S2542-5196(21)00173-X

- 32 Liu JC, Wilson A, Mickley LJ, Ebisu K, Sulprizio MP, Wang Y, et al. Who Among the Elderly Is Most Vulnerable to Exposure to and Health Risks of Fine Particulate Matter From Wildfire Smoke? *Am J Epidemiol*. 2017;186:730. Medline:28525551 doi:10.1093/aje/kwx141
- 33 Haikerwal A, Akram M, Del Monaco A, Smith K, Sim MR, Meyer M, et al. Impact of Fine Particulate Matter (PM<sub>2.5</sub>) Exposure During Wildfires on Cardiovascular Health Outcomes. *J Am Heart Assoc*. 2015;4:e001653. Medline:26178402 doi:10.1161/JAHA.114.001653
- 34 Shih RA, Acosta JD, Chen EK, Carbone EG, Xenakis L, Adamson DM, et al. Improving Disaster Resilience Among Older Adults: Insights from Public Health Departments and Aging-in-Place Efforts. *Rand Health Q*. 2018;8:3. Medline:30083424 doi:10.7249/RR2313
- 35 Sena A, Freitas C, Souza PF, Carneiro F, Alpino T, Pedroso M, et al. Drought in the Semiarid Region of Brazil: Exposure, Vulnerabilities and Health Impacts from the Perspectives of Local Actors. *PLoS Curr*. 2018;10:ecurrents.dis.c226851eb-d64290e619a4d1ed79c8639. Medline:30555749 doi:10.1371/currents.dis.c226851ebd64290e619a4d1ed79c8639
- 36 Acharibasam JW, Anuga SW. Psychological distance of climate change and mental health risks assessment of smallholder farmers in Northern Ghana: Is habituation a threat to climate change? *Clim Risk Manage*. 2018;21:16–25. doi:10.1016/j.crm.2018.04.002
- 37 Lieber M, Chin-Hong P, Kelly K, Dandu M, Weiser SD. A systematic review and meta-analysis assessing the impact of droughts, flooding, and climate variability on malnutrition. *Glob Public Health*. 2022;17:68–82. Medline:33332222 doi:10.1080/17441692.2020.1860247
- 38 Charnley GEC, Kelman I, Murray KA. Drought-related cholera outbreaks in Africa and the implications for climate change: a narrative review. *Pathog Glob Health*. 2022;116:3. Medline:34602024 doi:10.1080/20477724.2021.1981716
- 39 HelpAge International. Pakistan: Older people facing health catastrophe but are being ignored. 2022.
- 40 Gotanda H, Fogel J, Husk G, Levine JM, Peterson M, Baumlin K, et al. Hurricane Sandy: Impact on Emergency Department and Hospital Utilization by Older Adults in Lower Manhattan, New York (USA). *Prehosp Disaster Med*. 2015;30:496–502. Medline:26369433 doi:10.1017/S1049023X15005087
- 41 Veenema TG, Thornton CP, Lavin RP, Bender AK, Seal S, Corley A. Climate Change-Related Water Disasters' Impact on Population Health. *J Nurs Scholarsh*. 2017;49:625–34. Medline:28834176 doi:10.1111/jnu.12328
- 42 Vinet F, Lumbroso D, Defossez S, Boissier L. A comparative analysis of the loss of life during two recent floods in France: the sea surge caused by the storm Xynthia and the flash flood in Var. *Nat Hazards J Int Soc Prev Mitig Nat Hazards*. 2012;61:1179–201. doi:10.1007/s11069-011-9975-5
- 43 Lee J, Perera D, Glickman T, Taing L. Water-related disasters and their health impacts: A global review. *Prog Disaster Sci*. 2020;8:100123. doi:10.1016/j.pdisas.2020.100123
- 44 Mimura N. Sea-level rise caused by climate change and its implications for society. *Proc Jpn Acad, Ser B, Phys Biol Sci*. 2013;89:281. Medline:23883609 doi:10.2183/pjab.89.281
- 45 Archer CL, Brodie JF, Rauscher SA. Global warming will aggravate ozone pollution in the U.S. mid-atlantic. *J Appl Meteorol Climatol*. 2019;58:1267–78. doi:10.1175/JAMC-D-18-0263.1
- 46 Dominski FH, Lorenzetti Branco JH, Buonanno G, Stabile L, Gameiro da Silva M, Andrade A. Effects of air pollution on health: A mapping review of systematic reviews and meta-analyses. *Environ Res*. 2021;201:111487. Medline:34116013 doi:10.1016/j.envres.2021.111487
- 47 Bell ML, Zanobetti A, Dominici F. Evidence on Vulnerability and Susceptibility to Health Risks Associated With Short-Term Exposure to Particulate Matter: A Systematic Review and Meta-Analysis. *Am J Epidemiol*. 2013;178:865. Medline:23887042 doi:10.1093/aje/kwt090
- 48 GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;396:1204–22. Medline:33069326 doi:10.1016/S0140-6736(20)30925-9
- 49 Gavazzi G, Krause KH. Ageing and infection. *Lancet Infect Dis*. 2002;2:659–66. Medline:12409046 doi:10.1016/S1473-3099(02)00437-1
- 50 Paddock CD, Lane RS, Staples JE, Labruna M. Global Health Impacts of Vector-Borne Diseases. *Global Health Impacts of Vector-Borne Diseases*. National Academies Press; 2016.
- 51 Del Prete V, Mateo-Urdiales A, Bueno-Cavanillas A, Ferrara P. Malaria prevention in the older traveller: a systematic review. *J Travel Med*. 2019;26:taz067. Medline:31509199 doi:10.1093/jtm/taz067
- 52 Lin RJ, Lee TH, Leo YS. Dengue in the elderly: a review. *Expert Rev Anti Infect Ther*. 2017;15:729–35. Medline:28730853 doi:10.1080/14787210.2017.1358610
- 53 Mouton CP, Bazaldua OV, Pierce B, Espino DV. Common infections in older adults. *Am Fam Physician*. 2001;63:257–68. Medline:11201692
- 54 Scallan E, Crim SM, Runkle A, Henao OL, Mahon BE, Hoekstra RM, et al. Bacterial Enteric Infections Among Older Adults in the United States: Foodborne Diseases Active Surveillance Network, 1996–2012. *Foodborne Pathog Dis*. 2015;12:492–9. Medline:26067228 doi:10.1089/fpd.2014.1915
- 55 Lindsay L, Wolter J, De Coster I, Van Damme P, Verstraeten T. A decade of norovirus disease risk among older adults in upper-middle and high income countries: a systematic review. *BMC Infect Dis*. 2015;15:425. Medline:26467099 doi:10.1186/s12879-015-1168-5
- 56 HelpAge International. Climate change in an ageing world. Help Position Paper. 2015.
- 57 HelpAge International. The ageing of rural populations: evidence on older farmers in low-and middle-income countries. 2014.

- 58 Hines D. Food and nutrition. In: Marks SP, Rajagopal B. Critical issues in human rights and development. Edward Elgar Publishing; 2011;239–60.
- 59 Lake IR, Gillespie IA, Bentham G, Nichols GL, Lane C, Adak GK, et al. A re-evaluation of the impact of temperature and climate change on foodborne illness. *Epidemiol Infect.* 2009;137:1538–47. Medline:19371450 doi:10.1017/S0950268809002477
- 60 Edmonds CJ, Foglia E, Booth P, Fu CHY, Gardner M. Dehydration in older people: A systematic review of the effects of dehydration on health outcomes, healthcare costs and cognitive performance. *Arch Gerontol Geriatr.* 2021;95:104380. Medline:33636649 doi:10.1016/j.archger.2021.104380
- 61 Rosinger AY, Young SL. The toll of household water insecurity on health and human biology: Current understandings and future directions. *Wiley Interdiscip Rev Water.* 2020;7:e1468. doi:10.1002/wat2.1468
- 62 Government of the UK. The National Flood Emergency Framework for England. Contin Cent. 2014.
- 63 United Nations. Analytical study on the promotion and protection of the rights of persons with disabilities in the context of climate change. Report of the Office of the United Nations High Commissioner for Human Rights | OHCHR. United Nations; 2020.
- 64 Thapa DK, Visentin D, Kornhaber R, Cleary M. Migration of adult children and mental health of older parents 'left behind': An integrative review. *PLoS One.* 2018;13:e0205665. Medline:30346972 doi:10.1371/journal.pone.0205665
- 65 The White House. Report on the Impact of climate change on Migration. 2021.
- 66 International Organization for Migration. Migration Research Series No. 31. Migration and Climate Change. Geneva: International Organization for Migration; 2008.
- 67 Wells J. The neglected generation: The impact of displacement on older people. 2012.
- 68 Rigaud K, De Sherbinin A, Jones B, Bergmann J, Clement V, Ober K, et al. Groundswell - Preparing for internal climate migration. World Bank Group. 2018.
- 69 Borg FH, Greibe Andersen J, Karekezi C, Yonga G, Furu P, Kallestrup P, et al. Climate change and health in urban informal settlements in low- and middle-income countries – a scoping review of health impacts and adaptation strategies. *Glob Health Action.* 2021;14:1908064. Medline:33847256 doi:10.1080/16549716.2021.1908064
- 70 Severoni S, Machado RS, Alderslade R. Migration and Health. In: Raviglione MCB, Tediosi F, Villa S, Casamitjana N, Plasencia A, editors. *Global Health Essentials.* Springer; 2023;239–44.
- 71 Schröder-Butterfill E, Mariani R. A framework for understanding old-age vulnerabilities. *Ageing Soc.* 2006;26:9. Medline:23750062 doi:10.1017/S0144686X05004423
- 72 Skoufias E, Rabassa M, Olivieri S, Brahmabhatt M. The Poverty Impacts of Climate Change: A Review of Evidence. 2011.
- 73 O'Neill BC, Jiang L, Kc S, Fuchs R, Pachauri S, Laidlaw EK, et al. The effect of education on determinants of climate change risks. *Nat Sustain.* 2020;3:520–8. doi:10.1038/s41893-020-0512-y
- 74 Wu YT, Daskalopoulou C, Muniz Terrera G, Sanchez Niubo A, Rodríguez-Artalejo F, Ayuso-Mateos JL, et al. Education and wealth inequalities in healthy ageing in eight harmonised cohorts in the ATHLOS consortium: a population-based study. *Lancet Public Health.* 2020;5:e386–e394. Medline:32619540 doi:10.1016/S2468-2667(20)30077-3
- 75 Sadana R, Budhwani S, Blas E, Posarac A, Koller T, Paraje G. Healthy Ageing and Health Equity: Broader Determinants of Health with a Spotlight on Climate Change. In: Michel JP, editor. *Prevention of Chronic Diseases and Age-Related Disability.* Springer; 2019. pp.169-183.
- 76 Hallegatte S, Vogt-Schilb A, Rozenberg J, Bangalore M, Beaudet C. From Poverty to Disaster and Back: a Review of the Literature. *Econ Disasters Clim Change.* 2020;4:223–47. doi:10.1007/s41885-020-00060-5
- 77 Guralnik JM, Balfour JL, Volpato S. The ratio of older women to men: historical perspectives and cross-national comparisons. *Aging (Milano).* 2000;12:65–76. Medline:10902048 doi:10.1007/BF03339893
- 78 Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. Health effects of coastal storms and flooding in urban areas: a review and vulnerability assessment. *J Environ Public Health.* 2013;2013:913064. Medline:23818911 doi:10.1155/2013/913064
- 79 van Steen Y, Ntarladima AM, Grobbee R, Karssenberg D, Vaartjes I. Sex differences in mortality after heat waves: are elderly women at higher risk? *Int Arch Occup Environ Health.* 2019;92:37–48. Medline:30293089 doi:10.1007/s00420-018-1360-1
- 80 Muttarak R, Lutz W. Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change?. *Ecology and Society.* 2014;19:42. doi:10.5751/ES-06476-190142
- 81 Howard A, Aglias K, Bevis M, Blakemore T. How Social Isolation Affects Disaster Preparedness and Response in Australia: Implications for Social Work. *Aust Soc Work.* 2018;71:392–404. doi:10.1080/0312407X.2018.1487461
- 82 Nerbass FB, Pecoits-Filho R, Clark WF, Sontrop JM, McIntyre CW, Moist L. Occupational Heat Stress and Kidney Health: From Farms to Factories. *Kidney Int Rep.* 2017;2:998. Medline:29270511 doi:10.1016/j.ekir.2017.08.012
- 83 Nunfam VF, Adusei-Asante K, Frimpong K, Van Etten EJ, Oosthuizen J. Barriers to occupational heat stress risk adaptation of mining workers in Ghana. *Int J Biometeorol.* 2020;64:1085–101. Medline:32130507 doi:10.1007/s00484-020-01882-4
- 84 Nikolakis W, Grafton Q, Nygaard A. Indigenous communities and climate change: a Recognition, Empowerment and Devolution (RED) framework in the Murray-Darling Basin, Australia. *J Water Clim Chang.* 2016;7:169–83. doi:10.2166/wcc.2015.058
- 85 Hartman C, Squires GD, editors. *There is no such thing as a natural disaster: Race, class, and hurricane Katrina.* New York: Routledge Taylor & Francis Group; 2013.
- 86 The World Bank. *Poverty and Health Report.* 2014. Available: <https://www.worldbank.org/en/topic/health/brief/poverty-health>. Accessed: 17 May 2024.
- 87 Bose-O'Reilly S, Daanen H, Deering K, Gerrett N, Huynen MMTE, Lee J, et al. COVID-19 and heat waves: New challenges for healthcare systems. *Environ Res.* 2021;198:111153. Medline:33857461 doi:10.1016/j.envres.2021.111153

- 88 Thompson R, Landeg O, Kar-Purkayastha I, Hajat S, Kovats S, O'connell E. Heatwave Mortality in Summer 2020 in England: An Observational Study. *Int J Environ Res Public Health*. 2022;19:6123. Medline:35627660 doi:10.3390/ijerph19106123
- 89 Semenza JC. Lateral public health: Advancing systemic resilience to climate change. *Lancet Reg Health Eur*. 2021;9:100231. Medline:34642677 doi:10.1016/j.lanep.2021.100231
- 90 Gładka A, Rymaszewska J, Zatoński T. Impact of air pollution on depression and suicide. *Int J Occup Med Environ Health*. 2018;31:711–21. Medline:30281038
- 91 Ayalon L, De Mendonça Lima CA, Banerjee D, Rabheru K, Fitzgerald K. Older persons in climate change-induced hazards and building forward better: International Psychogeriatric Association, World Psychiatric Association-Section of Old Age Psychiatry, and NGO Committee on Ageing in Geneva Position Statement. *Int Psychogeriatr*. 2023;35:589–91. Medline:37655740 doi:10.1017/S1041610223000765
- 92 Tome J, Richmond HL, Rahman M, Karmacharya D, Schwind JS. Climate change and health vulnerability in Nepal: A systematic review of the literature since 2010. *Glob Public Health*. 2022;17:1406–19. Medline:34061709 doi:10.1080/17441692.2021.1924824
- 93 Nicholas PK, Breakey S, Blank P. Roles of Nurse Practitioners: Health Consequences of Climate Change in Vulnerable Older Adults. *J Nurse Pract*. 2020;16:433–7. doi:10.1016/j.nurpra.2020.03.011
- 94 Alcasena F, Ager A, Le Page Y, Bessa P, Loureiro C, Oliveira T. Assessing Wildfire Exposure to Communities and Protected Areas in Portugal. *Fire (Basel)*. 2021;4:82. doi:10.3390/fire4040082
- 95 Romanello M, McGushin A, Di Napoli C, Drummond P, Hughes N, Jamart L, et al. The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *Lancet*. 2021;398:1619–62. Medline:34687662 doi:10.1016/S0140-6736(21)01787-6
- 96 Levy BS, Patz JA. Climate Change, Human Rights, and Social Justice. *Ann Glob Health*. 2015;81:310–22. Medline:26615065 doi:10.1016/j.aogh.2015.08.008
- 97 Pillemer K, Tillema Cope M, Nolte J. Older People and Action on Climate Change: A Powerful But Underutilized Resource.
- 98 Beard JR, Officer A, De Carvalho IA, Sadana R, Pot AM, Michel JP, et al. The World report on ageing and health: A policy framework for healthy ageing. *Lancet*. 2016;387:2145–54. Medline:26520231 doi:10.1016/S0140-6736(15)00516-4
- 99 World Health Organization. WHO Housing and Health Guidelines - Executive Summary. Geneva: World Health Organization; 2018.
- 100 World Health Organization. Compendium of WHO and other UN guidance on health and environment. Geneva: World Health Organization; 2021.
- 101 Watts N, Adger WN, Ayeb-Karlsson S, Bai Y, Byass P, Campbell-Lendrum D, et al. The Lancet Countdown: tracking progress on health and climate change. *Lancet*. 2017;389:1151–64. Medline:27856085 doi:10.1016/S0140-6736(16)32124-9
- 102 United Nations. The 2030 Agenda for Sustainable Development and the UN Decade of Healthy Ageing 2021-2030. United Nations; 2020.
- 103 United Nations. United Nations Framework Convention on Climate Change. The Paris Agreement | UNFCCC. United Nations;2018.
- 104 World Health Organization. Integrated care for older people (ICOPE): guidelines on community-level interventions to manage declines in intrinsic capacity: evidence profile: malnutrition. Geneva: World Health Organization; 2017.
- 105 Nikora RD, McFarlane DR. Closing the Gap in a Generation: Health Equity Through Action on the Social Determinants of Health. *J Health Polit Policy Law*. 2010;35:438–42. doi:10.1215/03616878-2010-010
- 106 Nunes AR. The contribution of assets to adaptation to extreme temperatures among older adults. *PloS One*. 2018;13:e0208121. Medline:30496245 doi:10.1371/journal.pone.0208121
- 107 Brennan M, O'Shea PM, Mulkerrin EC. Preventative strategies and interventions to improve outcomes during heatwaves. *Age Ageing*. 2020;49:729–32. Medline:32638997 doi:10.1093/ageing/afaa125
- 108 Qiu C, Ji JS, Bell ML. Effect modification of greenness on temperature-mortality relationship among older adults: A case-crossover study in China. *Environ Res*. 2021;197:111112. Medline:33838131 doi:10.1016/j.envres.2021.111112
- 109 See L, Rasiyah RL, Laing R, Thompson SC. Considerations in Planning Physical Activity for Older Adults in Hot Climates: A Narrative Review. *Int J Environ Res Public Health*. 2021;18:1–18. Medline:33540584 doi:10.3390/ijerph18031331
- 110 Dvorak AC, Solo-Gabriele HM, Galletti A, Benzecry B, Malone H, Boguszewski V, et al. Possible impacts of sea level rise on disease transmission and potential adaptation strategies, a review. *J Environ Manage*. 2018;217:951–68. Medline:29679917 doi:10.1016/j.jenvman.2018.03.102
- 111 Gutierrez KS, LePrevost CE. Climate Justice in Rural Southeastern United States: A Review of Climate Change Impacts and Effects on Human Health. *Int J Environ Res Public Health*. 2016;13:189. Medline:26848673 doi:10.3390/ijerph13020189
- 112 Di Falco S, Veronesi M, Yesuf M. Does Adaptation to Climate Change Provide Food Security? A Micro-Perspective from Ethiopia. *Am J Agric Econ*. 2011;93:829–46. doi:10.1093/ajae/aar006
- 113 Rankoana SA. Climate change impacts on water resources in a rural community in Limpopo province, South Africa: a community-based adaptation to water insecurity. *Int J Clim Chang Strateg Manag*. 2020;12:587–98. doi:10.1108/IJCCSM-04-2020-0033
- 114 World Health Organization. Operational framework for building climate resilient health systems. Geneva: World Health Organization; 2015.
- 115 Nicholas PK, Breakey S, Blank P. Roles of Nurse Practitioners: Health Consequences of Climate Change in Vulnerable Older Adults. *J Nurse Pract*. 2020;16:433–7. doi:10.1016/j.nurpra.2020.03.011
- 116 Loveys K, Prina M, Axford C, Domènec ÒR, Weng W, Broadbent E, et al. Artificial intelligence for older people receiving long-term care: a systematic review of acceptability and effectiveness studies. *Lancet Healthy Longev*. 2022;3:e286–97. Medline:35515814 doi:10.1016/S2666-7568(22)00034-4



- 117 Haq G, Brown D, Hards S. Older People and Climate Change: the Case for Better Engagement. 2010.
- 118 Zheng H, Wood R, Moran D, Feng K, Tisserant A, Jiang M, et al. Rising carbon inequality and its driving factors from 2005 to 2015. *Glob Environ Change*. 2023;82:102704. doi:10.1016/j.gloenvcha.2023.102704
- 119 Moody HR. Overcoming objections by elders to action on climate change. *Int J Aging Hum Dev*. 2014;80:64–75. Medline:26215299 doi:10.1177/0091415015591110
- 120 Gray SG, Raimi KT, Wilson R, Árvai J. Will Millennials save the world? The effect of age and generational differences on environmental concern. *J Environ Manage*. 2019;242:394–402. Medline:31059952 doi:10.1016/j.jenvman.2019.04.071
- 121 Fylnn C, Yamasumi E, Fisher S, Snow D, Grant Z, Kirby M. Peoples' Climate Vote. United Nations Development Programme and University of Oxford; 2021.
- 122 Frumkin H, Fried L, Moody R. Aging, climate change, and legacy thinking. *Am J Public Health*. 2012;102:1434–8. Medline:22698047 doi:10.2105/AJPH.2012.300663
- 123 Wickersham RH, Zaval L, Pachana NA, Smyer MA. The impact of place and legacy framing on climate action: A lifespan approach. *PLoS One*. 2020;15:e0228963. Medline:32097411 doi:10.1371/journal.pone.0228963
- 124 Timalisina R, Songwathana P. Factors enhancing resilience among older adults experiencing disaster: A systematic review. *Australas Emerg Care*. 2020;23:11–22. Medline:31928971 doi:10.1016/j.auec.2019.12.007
- 125 Kok AAL, van Nes F, Deeg DJH, Widdershoven G, Huisman M. “Tough Times Have Become Good Times”: Resilience in Older Adults With a Low Socioeconomic Position. *Gerontologist*. 2018;58:843–52. Medline:29490029 doi:10.1093/geront/gny007
- 126 King AC, King DK, Banchoff A, Solomonov S, Ben Natan O, Hua J, et al. Employing Participatory Citizen Science Methods to Promote Age-Friendly Environments Worldwide. *Int J Environ Res Public Health*. 2020;17:1541. Medline:32121001 doi:10.3390/ijerph17051541
- 127 Rhoades J, Gruber J, Horton B. Promoting the Resilience of Older Adults Through Participatory Climate Change Adaptation Planning. *J Homel Secur Emerg Manag*. 2019;16:1–14. doi:10.1515/jhsem-2017-0057
- 128 New Philanthropy Capital, Disability Rights UK and Re-engage. How will the climate and nature crises impact older people and Disabled people? 2022.
- 129 Jessel S, Sawyer S, Hernández D. Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. *Front Public Health*. 2019;7:357. Medline:31921733 doi:10.3389/fpubh.2019.00357
- 130 Gagliardi C, Pillemer K, Gambella E, Piccinini F, Fabbietti P. Benefits for Older People Engaged in Environmental Volunteering and Socializing Activities in City Parks: Preliminary Results of a Program in Italy. *Int J Environ Res Public Health*. 2020;17:3772. Medline:32466501 doi:10.3390/ijerph17113772
- 131 Bunker A, Wildenhain J, Vandenberg A, Henschke N, Rocklöv J, Hajat S, et al. Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. *EBioMedicine*. 2016;6:258–68. Medline:27211569 doi:10.1016/j.ebiom.2016.02.034
- 132 Yu W, Mengersen K, Wang X, Ye X, Guo Y, Pan X, et al. Daily average temperature and mortality among the elderly: a meta-analysis and systematic review of epidemiological evidence. *Int J Biometeorol*. 2012;56:569–81. Medline:21975970 doi:10.1007/s00484-011-0497-3
- 133 Ayalon L, Keating N, Pillemer K, Rabheru K. Climate Change and Mental Health of Older Persons: A Human Rights Imperative. *Am J Geriatr Psychiatry*. 2021;29:1038–40. Medline:34294541 doi:10.1016/j.jagp.2021.06.015
- 134 World Health Organization. Health for All: Transforming economies to deliver what matters The WHO Council on the Economics of Health for All. Geneva: World Health Organization; 2023.
- 135 Pelling M, Garschagen M. Put equity first in climate adaptation. *Nature*. 2019;569:327–9. Medline:31089230 doi:10.1038/d41586-019-01497-9