Climate Change and Global Health

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Building Health Resilience

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Abstract

Anthropogenic climate change threatens to diminish global health gains achieved over the past century. This chapter describes the myriad of ways environmental, economic and societal determinants of health are impacted if greenhouse gas emissions continue unabated. It highlights that since collective resources such as water, air and food are impacted, the negative health consequences of climate change are felt universally. This indicates that the climate crisis is a health crisis. A global policy review of the Paris Agreement, Sustainable Development Goals and the Sendai Framework indicate, however, that there remains limited development and integration of climate-resilient health systems in the climate action discourse. Given the unprecedented and potentially irreversible impacts to all life

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on the planet, urgent actions and investments are needed from the world's leaders to build global health resilience, by developing climate-resilient health systems that critically safeguard both population and planetary health.

Keywords

Climate change · Health determinants · Health resilience · Planetary health · Sustainable development

Introduction

Anthropogenic climate change threatens to diminish global health and societal gains accumulated over the past century (Watts et al. 2015). The human population is healthier than it has ever been before, as global life expectancy rises, and rates of poverty and child mortality decline (Horton and Lo 2015). However, these public health achievements have occurred at the planet's expense: rapid economic and population growth have resulted in an unprecedented increase in carbon dioxide emissions, ocean acidification, deforestation, and energy, water, and fertilizer use (IPCC 2014a; Whitmee et al. 2015). Of particular concern are the record concentrations of carbon dioxide and other greenhouse gas (GHG) emissions in the planet's atmosphere, which trap energy and accelerate climate change (Parker et al. 2010; Harris 2014).

The Intergovernmental Panel on Climate Change (IPCC 2018) defines climate change as variability in Earth's average weather and meteorology over an extended period of time. Earth's climate is determined by the balance of incoming and outgoing radiation, which is facilitated by atmospheric GHGs. Variations in atmospheric conditions such as average temperature, precipitation, and wind patterns result in climatic changes. Although the Earth's climate changes naturally over time, human activities since the industrial era have accelerated this process. Consequently, atmospheric GHGs have reached the highest levels experienced in 800,000 years, resulting in rising global temperatures and sea levels, changing weather patterns, and more extreme natural disasters (IPCC 2014b; UN 2020).

If anthropogenic climate change is not appropriately addressed, an estimated 40% of the global population will be living in areas under severe water stress by 2050, and approximately five million more deaths will be attributable to climate change (Whitmee et al. 2015). Moreover, the International Labour Organization (ILO 2019) forecasts that the equivalent productivity of 80 million full-time jobs will be lost by 2030 due to heat-related stress. Reduced labor productivity will decrease human capital accumulation, and impact national gross domestic products (GDPs) and social welfare in the short-term, with lasting impacts on the global economy in the long-term. It is important to note that the negative impacts of climate change will disproportionately affect the economies and public health of low-income countries, which largely are not responsible for anthropogenic climate change. Latin America, Africa, and Southeast Asia are anticipated to suffer the largest per capita income

reductions from decreased agricultural yields and disrupted economies, while Africa and the Middle East will disproportionately experience higher heat-related mortality rates (SIEPR 2019). In addition, recent studies suggest that 99% of economic loss due to climate change in low-income countries is uninsured, and the capacity of disease vectors are expected to increase (Watts et al. 2018b). The combination of the severe health-related and economic consequences of climate change can cripple low-income households for generations, while increasing the pressure on already under-resourced health facilities.

This chapter describes the profound direct and indirect impacts of anthropogenic climate change on human health in terms of physical, societal, and mental health and well-being. It discusses the illnesses linked to extreme temperatures, extreme weather events (including floods, droughts and food and water insecurity) and water-related diseases. Several social and mental health concerns are also examined, with emphasis on the impact to vulnerable populations. Furthermore, the chapter discusses current global policy initiatives which address the threats and impacts of climate change. The chapter concludes by highlighting key gaps in these initiatives from a global health perspective, such as the urgent need to invest in climate-resilient health systems to safeguard both population and planetary health.

Health Impacts of Climate Change

Extreme Temperatures

The year 2019 experienced record-breaking global temperatures. According to the World Meteorological Organization (WMO 2020), 2019 – which had a global mean temperature that was 1.1 °C warmer than pre-industrial times – was the second warmest year on record. Alarmingly, what may seem like an abnormal heat spell was part of a global warming trend: the WMO (WMO 2020) reported that the past 5 years (2015–2019) and the past decade (2010–2019) were the warmest on record, and that each successive decade since 1980 has been warmer than the preceding one.

Extreme heat tremendously impacts global health in numerous ways. The direct impacts to human health caused by dramatic changes in temperature include short-term dizziness, muscle cramps, dehydration, fever, heat rashes, heat exhaustion and (potentially fatal) heatstroke. Long-term exposure to high temperatures can cause acute cardiovascular, respiratory, and cerebrovascular responses, increasing overall rates of mortality (Heal and Park 2016). The number of hot days is positively correlated with mortality rate (Smith et al. 2015). Warmer temperatures also favor the production and release of airborne allergens such as fungal spores and plant pollen, leading to an increase in cases of allergies.

Mortality rates due to temperature stress are significantly higher in low-income countries and populations, as these populations are generally less able to undertake adaptive measures in the face of increasing temperatures, leading to more devastating public health effects (Heal and Park 2016). However, high-income populations are not immune from the large-scale health risks – especially those residing in

high-density built urban environments. An urban heat island effect can occur in urban environments where high concentrations of heat-retaining surfaces such as asphalt and tar rods sustain higher daily temperatures. Additionally, heat waves worsen urban air pollution, which can further exacerbate cardiovascular and respiratory diseases (WMO 2020).

Health risks of extreme temperatures also increase with physical activity levels (Smith et al. 2015). The ILO (ILO 2019) has estimated a 2.2% loss of total working hours worldwide by 2030 due to heat stress, with the agricultural and construction sectors expected to account for 70% of global working hours lost, and Africa's workforce being disproportionately affected.

Extreme Weather Events

Higher ambient temperatures will intensify patterns of evaporation and precipitation, leading to increased frequency and more intense extreme weather events globally (Patz and Khaliq 2002). An extreme weather event is an above average climate outcome for a given location and time of year (e.g., drought of heavy rainfall) over a persistent length of time (e.g., a season) (IPCC 2018). Put differently, extreme events have weather patterns that go above or below previously observed values (Wu et al. 2016). Increases in floods, droughts, and other extreme weather events are expected to have devastating effects on human health (Smith et al. 2015). There are expected to be 2.3 billion flood exposure events and 1.4 billion drought exposure events within the next century. The next sections describe the causes and health impacts of this increase in floods and droughts (Watts et al. 2015).

Floods

The majority of climate change scenarios predict increased precipitation globally, which forewarns flood risk. Floods are the most frequently occurring natural disaster, and have increased in frequency due to climate change (Smith et al. 2015). Increased flooding is caused by atmospheric changes and glacial melting due to global warming. Earth's atmosphere retains more moisture as global temperatures increase, which increase the volume and intensity of storms. There is also high confidence that increases in heat waves and glacial and permafrost melting will lead to increased flooding in relevant regions (Dokken et al. 2012).

Flooding directly affects health through drowning injuries, hypothermia, and trauma (Smith et al. 2015). The indirect effects of floods include increases in dermatitis and infectious diseases (such as cholera and leptospirosis) caused by the exposure to contaminated water, vector-borne disease due to seasonal and geographic distribution shifts, and respiratory diseases through overcrowding and overgrowth of mold in flooded homes (WHO 2015). Additionally, levels of diarrheal diseases, scabies, conjunctivitis, and trachoma may increase as sewerage systems overflow and safe water, sanitation, and hygiene (WASH) facilities become inaccessible (Wu et al. 2016; Andrade et al. 2018). Release of dangerous chemicals from storage sites and waste disposal sites into flood waters also pose

immediate risk of illness to those who encounter contaminated water (Patz and Khaliq 2002).

At present, 15% of all deaths related to natural disasters are due to floods (Watts et al. 2018a). This number likely under-represents flood-related health impacts because natural disasters are not attributed as causes of death in medical or legal records (UNISDR 2017). A flood-related death, for instance, is commonly registered as a drowning victim. The lack of attribution masks the severity of flood events and what populations might be especially vulnerable. It is expected that more people in Asia, Africa, and Central and South America will be vulnerable to flooding because of increased precipitation patterns (Smith et al. 2015). Populations residing in low-lying coastal communities are especially vulnerable, as well as individuals living in rural areas with limited access to healthcare services (Smith et al. 2015).

Droughts

Globally, there is a high likelihood that the tropics and high-latitude areas will get wetter, and mid-latitude areas will get drier if anthropogenic climate change persists (Mankin et al. 2019). Below-normal precipitation in areas or regions indicates drought conditions, with climate change contributing to drought in several ways. Warmer temperatures can enhance evaporation from soil, making periods with low precipitation drier than they would be in cooler conditions. Droughts persist through a positive feedback loop, where higher temperatures interact with barren terrain, to decrease rainfall, which can further suppress rainfall in an already dry area.

Drought is viewed as an indirect health impact due to limited direct attributions (Lee et al. 2020). Prolonged drought is one of the most dangerous environmental determinants of premature mortality, with a recent Lancet publication highlighting linkages to unsafe WASH resources, reduced crop yields, and food insecurity (Watts et al. 2019). Dehydration and malnutrition increasingly occur during periods of drought due to water scarcity and food security (Patz and Khaliq 2002; Dokken et al. 2012). Increased stress due to drought has also been associated with increased human susceptibility to infectious diseases (Wu et al. 2016), including meningitis (Dokken et al. 2012). Increases in droughts can furthermore increase or decrease the prevalence of mosquito-borne infectious diseases such as malaria, depending on local conditions.

Droughts (in combination with heat waves) are also correlated with increased wildfire risks. The direct effects of wildfire on human health include burns and smoke inhalation, while the release of particulate matter and other toxic substances can cause and aggravate existing respiratory illnesses (Patz and Khaliq 2002; Dokken et al. 2012; Smith et al. 2015). Drought and high winds may also produce windborne dust and mobilize other materials such as pollen and spores, transporting pollution and allergens to new regions (Smith et al. 2015).

Increased frequency of annual drought is expected in South America, Africa, and Southeast Asia (Watts et al. 2018a), requiring extensive measures to diminish the significant public health impacts (Box 1). This is especially concerning for areas that already face severe water scarcity and food insecurity, as climate change will translate to millions more vulnerable people struggling to survive due to drought-induced famines.

Box 1: Case Study – Extreme Drought in Brazil
From 2012 to 2015, the Northeast of Brazil experienced unprecedented drought conditions. Northeast Brazil is home to a population of approximately 53 million, and it is the most densely populated dry land region on Earth. Both urban and rural populations – especially farming communities – were deeply impacted by the abnormally long period of nominal rainfall. These conditions, in combination with the dense population distribution, resulted in states of emergency being declared in over half of the region's districts. The decrease in agricultural output, along with reductions in freshwater availability and quality impacted water and food security. Many populations residing in urban areas experienced shortages in drinking water and energy supply, while rural populations reliant on agricultural production suffered from reduced yields and an economic loss of approximately 6 billion USD. Projections for this area indicate that this drying trend will endure, with anticipated dramatic temperature increases being accompanied by further reductions in precipitation. The positive impacts of established policy measures in response to previous droughts in the area are expected to be significantly diminished by the impact of climate change, warranting more extreme adaptive measures (Marengo et al. 2017).

Water-Related Diseases

Water is a key component in a number of climate change health impacts. In addition to dehydration due to heat stress or drought, and flood-related drowning, infectious and vector-borne diseases, and poisoning due to the consumption of water contaminated with marine toxins are potential outcome of climate change, especially in marine or coastal zones (Patz and Khaliq 2002). For example, warm water and nitrogenous waste favor blooms of dinoflagellates in marine conditions, resulting in red times which can cause paralytic, diarrheic, and amnesiac shellfish poisoning. Cholera outbreaks are also correlated with monsoon seasons, sea-surface temperatures, and rainfalls, as well as increases in zooplankton populations.

Water-related diseases are expected to become more prevalent globally if climate change continues to affect water security (Box 2). Furthermore, changes in climactic variables also impact the survival, reproduction, and distribution of disease pathogens and hosts, many of which are associated with water. Temperature increases can shorten the incubation period of pathogens such as viruses, bacterium, parasite germ, and fungi, and extended heatwaves algal blooms or vector capacity of small water bodies. Warmer temperatures in addition to increased humidity will especially change vector habitat patterns. A vector is a living animal or plant in which a pathogen resides, which can transmit it to other living organisms. Vectors such as mosquitos associated with water-related diseases have shifted seasonally or expanded geographically as temperatures rise (Wu et al. 2016), increasing the scope of susceptibility to these diseases, which were previously region-specific.

Box 2: Case Study – Increased Prevalence of Dengue in Nepal (WHO 2020, Pandey and Costello 2019)

Dengue is a mosquito-borne viral disease that induces flu-like symptoms, potentially resulting in mortality (WHO 2020a). Dengue was first recorded in Nepal in 2004, and cases of have rapidly increased each year since then. A study done by Pandey and Costello (2019) found that in 2018, 3425 cases of dengue were reported in Nepal, but extended precipitation and flooding associated with a prolonged monsoon season in 2019 increased the duration of ideal temperatures for mosquito breeding, resulting in over 10,000 cases of dengue. It is estimated that temperatures in Nepal will increase by up to 2 °C by 2030, and up to 6.4 °C by 2090, further prompting the spread of dengue (Pandey and Costello, 2019). Mosquito-borne diseases such as Zika virus and yellow fever may follow a similar increasing trend as climate change increases opportunities for vector breeding (Pandey and Costello 2019).

Social Determinants of Health

In growing recognition of climate change's myriad effects on human systems, there has been increasing impetus to unpack social determinants such as the economic and social conditions that can influence health statuses. For example, in addition to extreme heat's physical impacts to human health, the ILO (ILO 2019) has highlighted that heat stress will be a barrier to the achievement of the United Nations' Sustainable Development Goals (SDGs) relating to poverty, health, decent work and economic growth due to significant global productivity losses. Africa's labor force is expected to be disproportionately affected by heat-related productivity loss, as 18% of the global working population is expected to reside on the continent by 2030 and half of this population will work in the agriculture sector (ILO 2019). Furthermore, limited agricultural yield will result in restricted incomes, as food prices rise due to decreased supply and increased demand, affecting nutrition in lower socioeconomic areas (Smith et al. 2015; ILO 2019). This indicates the potential conflict between health protection and economic productivity in the near future, with increased risks for disenfranchisement and mental well-being concerns among laborer obliged to work in physiologically unsafe conditions at the risk of losing income and employment (Smith et al. 2015; WHO 2015).

In addition to economic repercussions, geography is a significant determinant that links health to one's environment. As noted earlier, urban residents are vulnerable to heat island conditions and higher levels of air pollution (WMO 2020). Floods in cities – especially with open sewers or overwhelmed sewage systems – increase the risk of water-related disease pathogens such as leptospirosis and cholera. Populations in rural and remote areas largely dependent on functioning natural environments and productive agricultural economies are vulnerable to extreme climate change events. This is because floods and droughts lead to ecosystem

degradation, which can cause crop failure, malnutrition, and starvation, as well as an increase in the likelihood for population displacement and resource conflict (Smith et al. 2015; Serdeczny et al. 2017).

Overall, fatality rates and economic losses for extreme weather events as a proportion of GDP are significantly higher in low- and middle-income countries (LMICs). From 1970 to 2008, 95% of deaths from natural disasters were in developing nations (IPCC 2012). As LMICs are anticipated to have greater economic and population growth in the coming decades, populations in affected countries will be exposed to higher concentrations of contaminants in water, air, and sediment, which is especially problematic among those whose unique immune, endocrine, and neurological systems make them especially susceptible to environmental pollutants (Suk et al. 2016).

When considering age, older individuals face a higher risk in the face of storms, floods, and heatwaves, as they are less mobile and are more likely to suffer from health conditions that limit the body's ability to responds to stressors such as heat and air pollution (Smith et al. 2015). Child health is the most affected by the accumulative impacts of climate change, as children are especially at risk for undernutrition and diarrheal diseases. Furthermore, the impacts of undernutrition in children are more devastating, and are associated with a range of adverse health effects, such as life-long stunting, wasting, and even death when experienced by extremely young children (Watts et al. 2018a).

Mental Health

Measuring climate change's impact on mental health and well-being is challenging largely because mental health is influenced by a diverse range of factors that are highly subjective across different social and economic circumstances. Despite these challenges, experts recognize that climate change can affect mental health in the short- and long-term by causing anxiety-related responses such as post-traumatic stress, chronic psychological distress, and depression disorders (Watts et al. 2015). Mental illness also can be observed during, immediately after, or years after the impacts of climate change are felt. For slow developing events such as prolonged droughts, for instance, impacts include elevated levels of depression and increased incidence of suicide (Smith et al. 2015; Watts et al. 2015). Vulnerable populations are especially at risk – specifically Indigenous groups and low socio-economic populations living in low-resource settings. Anecdotal evidence indicates that following floods and drought events, farmers who have lost their land and livelihoods struggle with mental health as well as urban dwellers who lost their homes (Lee et al. 2020).

Figure 1 summarizes the environmental outcomes and public health impacts of global climate change. It highlights that climate change influences the environmental, economic, and societal determinants of health and well-being in a myriad of ways. Since collective resources such as water, air, and food are impacted, the negative consequences of climate change are felt universally. In light of this, a

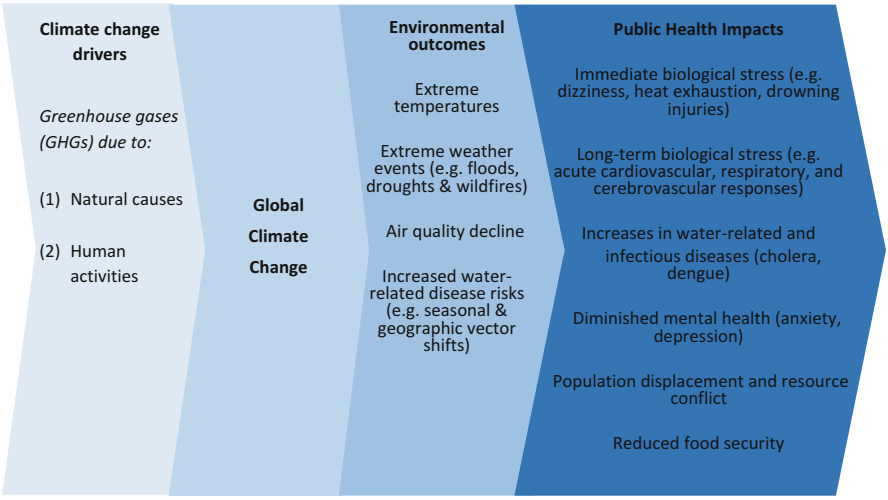

Fig. 1 Climate change environmental and public health impacts

number of pioneering global policy responses have been established to curb and ameliorate the threats of anthropogenic climate change. The next sections detail three key global initiatives: the Paris Agreement, SDG 13 (climate action) and the Sendai Framework.

Global Policy Measures and Gaps

Paris Agreement (2016)

Box 3: The Paris Agreement (UNFCCC 2015)
The Paris Agreement's explicit goals are to strengthen global climate action by: (1) holding the net increase in global average temperature to below 2 °C above pre-industrial levels and limiting temperature increases to 1.5 °C above pre-industrial levels; (2) increasing government ability to adapt to changing conditions, foster climate resilience, and develop low GHG industries in ways that do not threaten food production; and (3) aligning economies with climate-resilient development principles (UNFCCC 2015). Each signatory has agreed to set national goals and establish plans with short-term peak GHG emission goals, followed by a dramatic decline in emissions, with the long-term aim of transforming national economies and building climate-resilient societies.

The Paris Agreement is an accord within the United Nations Framework Convention on Climate Change (UNFCCC) treaty, which was signed by 188 nations in November 2016 to proactively address the threat of climate change through

mitigative, adaptive, and financial measures (Box 3). With regards to health, the Paris Agreement acknowledges in principle the public health co-benefits of decreasing global emissions and preserving carbon sinks, such as the decrease in loss and damage due to extreme weather events, and preserved biodiversity on land and in the oceans. It explicitly ties climate action to a healthier environment and population – from cleaner air and water, to reduced risks of extreme heatwaves and greater food security. However, the agreement does not include corollary targets or indicators to reduce the health impacts of climate change.

Regardless of the political commitments made in the Paris Agreement and scientific warnings, GHG emissions have reached a record high in 2018 (UNEP 2019). The global dependency on carbon remains virtually unchanged since 1990 (Watts et al. 2019), and economies continue to invest more in fossil fuels than climate action (UN 2020). The UN (UN 2020) has recently warned that the targets outlined in the Paris Agreement are far from being met. Considering this limited progress, the authors of the 2019 Lancet Countdown report – an independent and interdisciplinary body of health experts and climate scientists monitoring the health effects of climate change, the Paris Agreement's implementation, and the implications of (in)action – concluded that global warming will undo what enacted climate action measures have achieved, because governments are struggling to cope or are unwilling to respond (Watts et al. 2019).

SDG 13 (2015)

The 2015 Sustainable Development Goals are the UN's blueprint to achieve a more equitable and sustainable future for all by the year 2030. While the 17 goals address a range of global and interconnected challenges, SDG 13 stresses taking urgent climate action to combat climate change and its negative impacts. While SDG 13 has five targets and eight indicators, only one explicitly measures health-related impacts as part of a target to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters. Indicator 13.1.1 tracks the number of deaths, missing persons, and affected persons attributed to climate-related hazards and natural disasters. There is no indicator addressing resilience in health institutions.

In its recent assessment, the UN (UN 2020) reported that global progress is not consistent with achieving SDG 13's targets. Consequently, climate change continues to exacerbate the severity and frequency of natural disasters that have disrupted the lives of more than 39 million people in 2018 (UN 2020). This narrow focus on people affected overlooks how health resilience can be built in both individuals and institutions. The latter ostensibly is addressed in SDG 13's alignment with the Sendai Framework.

Sendai Framework for Disaster Risk Reduction (2015)

The Sendai Framework was the first global framework in the UN's post-2015 agenda that made explicit references to health, development, and climate change to bridge

gaps and build policy coherence between the Paris Agreement and the SDGs (Murray et al. 2017). The Sendai Framework addresses SDG 13's health limitations. It does this by adopting a broader framing of health resilience in terms of developing individual and institutional capacities, the latter of which should be addressed through reduced damage to critical national health infrastructure and limited disruption of basic services (target d) (UNISDR 2015).

To date, only 85 countries have aligned their national disaster risk reduction strategies to the Sendai Framework (UN 2020). This indicates limited uptake of this landmark policy framework. Even with increased uptake, it is questionable whether governments will effectively integrate health resilience planning and development in planning. While health resilience is explicitly promoted as a key principle of the Sendai Framework, the concept itself is not clearly conceived to guide government planning and implementation. For example, building health resilience can include assessments of national and city-level climate change impacts and vulnerabilities; development of health adaptation plans; monitoring and communications of climate and health data; adaptation delivery and implementation to support health emergency detection, preparedness, and responses; and financial resources to support health adaptation activities (Watts et al. 2019). The limited conceptualization in the Sendai Framework is likely due to its greater focus on reducing disaster risks, as well as resilience being an emerging interdisciplinary concept in global health discourse that has yet to be unpacked and explicitly defined (Haldane et al. 2017; Fridell et al. 2019).

Key Global Policy Gaps

The world is currently off track to achieving global climate action goals outlined in the Paris Agreement, SDGs, and the Sendai Framework. The UN has warned that if the climate crisis continues unabated, the catastrophic effects of climate change will be far greater than the implications of the current Covid-19 pandemic (UN 2020). While each of these global initiatives recognizes health as being an important aspect of climate change adaptation, there remains limited integration of climate-resilient health systems in global climate action discourse. For example, the main climate change indicator monitored at a global scale continues to be GHG emissions (Horton and Lo 2015). Global impact indicators only focus on climatological and environmental factors (specifically, mean temperature, atmospheric composition, and direct impacts of land, oceans, and ice) (WMO 2020). This narrow focus on the climatological and environmental impact overlooks the need to account for the capacity of human systems to monitor and address the various climate change threats which affect the social and environmental determinants of health as well.

To accelerate the integration and development of climate-resilient health systems in climate action initiatives, governments need to adopt systemic approaches such as health resilience (WHO 2015; Wulff et al. 2015) and planetary health (Horton and Lo 2015; Whitmee et al. 2015) that tackle the direct, ecosystem-mediated, and

indirect or displaced health effects, while developing the social systems and protecting ecosystems on which we depend. Both health resilience and planetary health are incipient interdisciplinary concepts that have grown in traction in the realization that complex crises such as anthropogenic climate change are population health crises.

Conclusion

As the 2030 SDG deadline approaches, the WHO encouraged world leaders to invest resources in health systems that safeguard lives, livelihoods and economies (WHO 2020b). Given the public health impacts of global warming and pollution, the WHO stated that ensuring health security should not be the sole responsibility of health authorities and highlighted that public health is ultimately a political choice. Leading experts and advocates from a diverse range of disciplines have similarly warned that anthropogenic climate change will continually undermine the determinants of good health and well-being, as well as exacerbate socioeconomic inequality, if it remains unchecked. These impacts highlight that the climate crisis is a health crisis. Given the unprecedented and potentially irreversible impacts to all life on the planet, urgent actions and investments are needed from the world's leaders to build health resilience, by developing climate-resilient health systems that critically safeguard both population and planetary health.

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