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The risk of a lifetime: mapping the impact of climate change on life and health risks

Contents

Executive summary

We expect the health and mortality impacts of climate change to play out gradually with an incremental impact on life and health risks, although the potential for shock events such as pandemics remains.

Climate change affects human health through many channels, the biggest drivers of which are expected to be extreme heat, air pollution, and increased exposure to infectious disease spread by non-human vectors. Consequently, increased morbidity of non-communicable diseases, especially cardiovascular diseases, respiratory illnesses and cancer, and increased spread and emergence of tropical infectious diseases, is expected. This will likely impact clinically vulnerable individuals with pre-existing comorbidities, or groups such as the elderly, and the disabled, the most. Ageing populations could push mortality rates higher. The extent of an individual's exposure to risk factors and access to mitigation tools will also determine their overall risk.

The effects of these are expected to be gradual and incremental over the time horizon we consider. Certain trends, such as extreme heat and the pace of technological change to mitigate climate risks, can be estimated with some accuracy. However, the trajectories of air pollution and infectious diseases are much more uncertain, with a wide range of possible outcomes. Future mortality from vector-borne disease, for example, will be heavily influenced by the emergence of new pathogens from human-animal interactions. Mitigation tools such as cooling, hydration and air filtration can greatly reduce health risks, but risk interdependence is a key consideration given the reliance on electricity, which could increase warming and air pollution through fossil fuel usage.

Given the complexities and uncertainties associated with climate change, attempts to quantify mortality impacts are highly speculative and subject to very wide confidence intervals. However, to provide a directional vector of expected population mortality, we analysed published studies from academia and climate change specialists forecasting heat- and cold-related deaths at a general population level worldwide. These studies indicate that the climate trends expected this century could lead to excess mortality:

- A moderate climate change pathway (RCP 4.5) could result in global excess mortality of 0.75% annually by 2050, rising to 1% excess mortality by 2100. Extreme heat is the biggest contributor, but air pollution would also be a significant factor.
- Limiting global warming to the Paris Agreement target of less than 2°C (RCP 2.6) would cause minimal change in global excess mortality by 2050, driven by lower air pollution under this scenario. By 2100, excess mortality of 0.75% would be expected.
- A pessimistic scenario of unmitigated climate change (RCP 8.5) could result in 1.5% excess mortality annually by 2050, rising to 5.25% annually by 2100. These impacts would be unequally distributed, potentially increasing socio-economic disparities.

For life and health (L&H) insurance, the key focus of climate change risk is how exposure to prevailing climate and environmental conditions affects health over a person's lifetime. The impact of climate change may be successfully reduced in decades to come, but the health impacts from heat or polluted air are accruing now and are unlikely to be reversible. L&H insurers are expected to exert strong underwriting discipline and allow for adjustment of rates as incremental risks develop. Increased incidence of infectious disease poses a specific threat given the universal nature of the risk exposure to a population. Consumers more exposed to climate risk at present are often those less served by L&H insurance, but a growing middle class in emerging markets hints at potential shifts in buying behaviour and growth in demand for insurance as consumers seek to close the protection gap. Insurers have an opportunity to inform and incentivise policyholders on how to adapt to changing climatic conditions. Sparse data hinders understanding of the impacts and interdependencies, so the industry would benefit from closing the data gap.

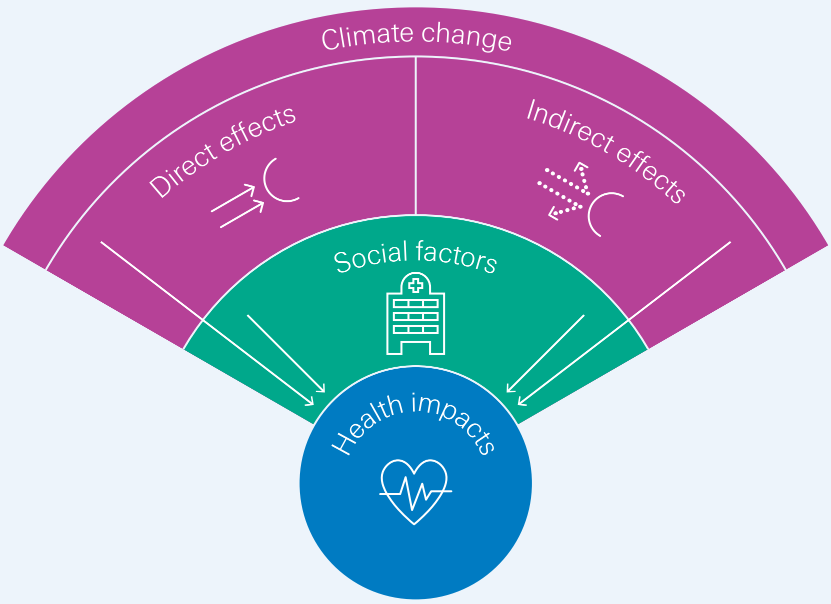
Climate change and health: a lifelong risk

Climate change is driving long-term change to our planet and creating direct and indirect effects that impact human life and health. Direct effects include more frequent and intense extreme weather events that can lead to mortality, injury, community displacement and the spread of water-borne and vector-borne pathogens.[1] Indirect effects include air pollution, degradation of the environment and a resulting scarcity of food and water, and ecological change that drives disease-carrying organisms into contact with humans. Recurring extreme weather events can weaken an area's agricultural and economic resilience, leading to disproportionately greater impacts from smaller threats, creating a vicious circle of environmental damage. Disparities in socioeconomic development, rapid urbanisation without adequate planning, and value accumulation in exposed locations may exacerbate the issues (Figure 1).

We identify three climate change-induced impact drivers that we expect will affect health the most: extreme heat, air pollution and vector-borne diseases (Figure 2). The most significant anticipated health effects from these are heightened risk of non-communicable diseases, primarily cardiovascular diseases (CVD), respiratory illnesses

[1] *Extreme weather in a changing climate: how can we be more resilient?*, Swiss Re, 27 July 2021.

Figure 1
How climate change impacts human health



Climate change		Social factors	Health impacts affected by age, sex and comorbidities
Direct effects	**Indirect effects**		
▪ Extreme heat ▪ Floods/storms/hurricanes ▪ Wildfires ▪ Droughts ▪ Deforestation	▪ Air pollution ▪ Thawing permafrost ▪ Water quality/food shortage ▪ Ecological change	▪ Socioeconomic status ▪ Public health infrastructure ▪ Mobility and conflict status	▪ Cardiovascular diseases ▪ Respiratory diseases ▪ Aeroallergens ▪ Mental health ▪ Infectious/vector-borne diseases ▪ Injuries ▪ Gastrointestinal diseases

Source: Swiss Re Institute

and cancers; and increased frequency and spread of vector-borne diseases. Being exposed to all three of these impact drivers can have compounding effects. Mortality from cardiovascular disease has been found to be 21% more likely when people are exposed to both extreme heat and particulate matter, compared with a 5–6% increase in risk of death from each climactic condition separately.[2]

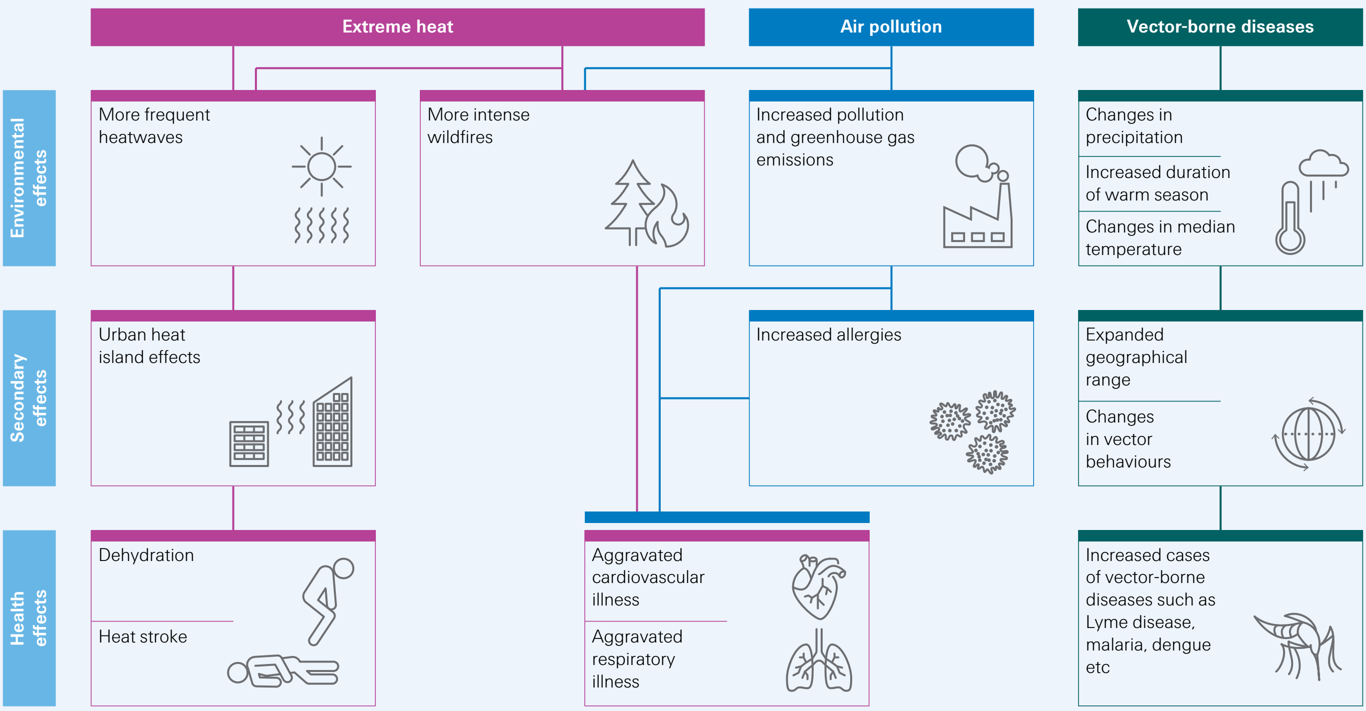
Mental health impacts are another potential threat (Figure 3). A changing climate, accompanied by extreme weather events and disasters, can exacerbate or compound pre-existing mental health diagnoses, or potentially trigger new, acute or chronic conditions. Growing medical research highlights that under a changing climate of extremes (in both frequency and duration), conditions including major depressive disorder (MDD), post-traumatic stress disorder (PTSD), anxiety, depression, substance abuse and suicide ideation are on the rise.[3]

Mapping vulnerability to the impacts of climate change
The impacts of climate change on life and health are not being distributed equally. Of the mortality attributed to climate change in the period of 2000–2017, 130 deaths per million occurred in low-income countries, 75 per million in lower-middle income countries and 92 per million in upper-middle income countries. The highest income countries had a mortality rate of only 18 per million.[4]

Inequality in a person's vulnerability to climate change is linked to their **exposure, sensitivity,** and **adaptive capability.** Exposure refers to how exposed an individual is to the elements, such as having to be outdoors during extreme heat; sensitivity refers to underlying health conditions and age, which can be worsened by a less hospitable

[2] M. Rahman, R.McConnell et al, "The Effects of Co-Exposure to Extremes of Heat and Particulate Air Pollution on Mortality in California: Implications for Climate Change", American Journal of Respiratory and Critical Care Medicine, 21 June 2022.
[3] K. Hayes, G. Blashki et al, "Climate change and mental health: risks, impacts and priority actions", International Journal of Mental Health Systems, 2018.
[4] *Climate Change, Insurance and Vulnerable Populations,* International Actuarial Association, October 2019.

Figure 2
The three key risk drivers and their impact on human health



Source: American Public Health Association, Swiss Re Institute climate and natural environment; and adaptive capacity refers to a person's ability to adjust to a changing climate by removing or mitigating the risk.[5] All of these are heavily influenced by social factors including wealth and access to healthcare.

Exposure most affects people in countries where working outdoors or in extreme conditions is widespread. Communities living in poverty, near contaminated waste sites or industrial areas, or in rural areas with limited health facilities, are likely to be most affected by the changing climate.

People with the highest **sensitivity** to climate change are typically clinically vulnerable individuals with pre-existing health conditions and comorbidities, the elderly, children, the disabled, and pregnant. The global demographic transition to an older population will only increase the size of these groups.[6] Many of those with pre-existing health conditions could be at risk of cardiovascular and respiratory aggravation due to climate change, with elevated temperatures and increased air pollution being notable risk factors.

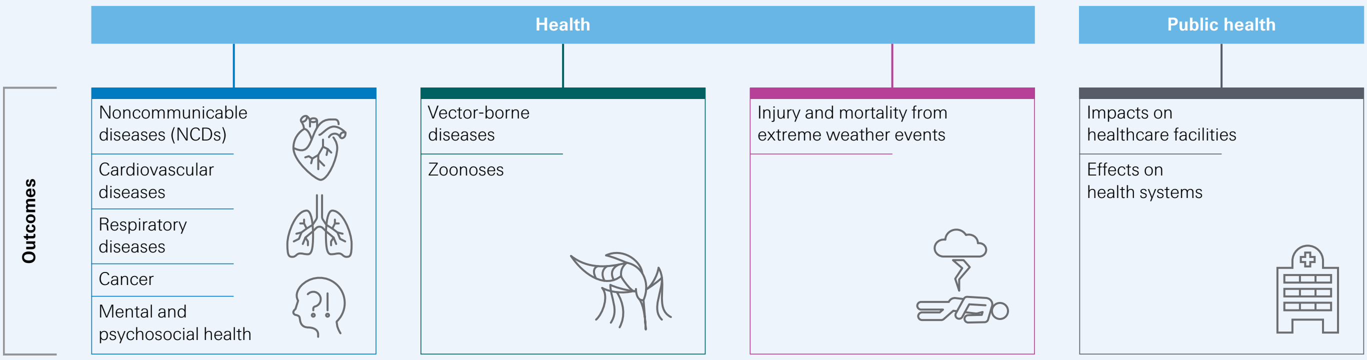
Adaptive capability is typically highest in more affluent countries and population segments, which can alleviate much of the personal health risk of climate change, for example by being able to stay indoors during peak heat and pollution, or by being able to buy air filtration and cooling systems.

Future climate scenarios
Climates of the future are unpredictable with a great degree of reliance on behavioural and societal adaptations. Scientists have devised several scenarios to illustrate the complex network of potential future climate change outcomes. The RCPs (Figure 4) are a series of plausible future pathways based on greenhouse gas emissions and their impact on factors including global surface temperature and sea levels, incorporating the impact of planned interventions to reduce emissions. The RCP scale is based on the forecasted future outcome of several metrics by the year 2100, with a lower number representing a more optimistic scenario.[7]

With increasing global interest in, and commitments to, limiting and reversing climate change, experts predict that the more moderate RCP 4.5 scenario would be the baseline as an end state in 2100.[8] The RCP 8.5 scenario assumes very high levels of emissions with little attempt to curb existing practices.[9]

[5] *Climate Change and Human Health*, US Environmental Protection Agency (EPA), updated 30 August 2022.
[6] T. Carleton, A. Jina, "Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits", Climate Impact Lab, 21 April 2022.
[7] D. Furphy, "What on earth is an RCP", Medium, 2013.
[8] Z. Hausfather, G. Peters "Emissions – the 'business as usual' story is misleading", Nature Comment, 2020.
[9] C. Schwalm, S. Glendon, P.Duffy, "RCP 8.5 tracks cumulative CO2 emissions", PNAS, 3 August 2020.

Figure 3
The key direct and indirect climate-sensitive health risks



Source: World Health Organization, Swiss Re Institute

For L&H, climate risk depends on the trajectory as much as the end state
The evolution of climate risk has been on the radar of climatologists and natural catastrophe modellers, who have closely monitored the incidence and severity of extreme events to effectively assess their risk profile, to weather the proverbial storm. This, combined with the view that more optimistic RCP scenarios would prevail in 2100, has driven climate change impact considerations for risks arising from extreme events at the turn of the century.

For L&H risks, we are still at an early stage of exploring and accounting for climate-driven causes of mortality and morbidity. The focus for mortality and morbidity risks is on the likely impact of extended exposure and long-term health deterioration from now until the end of the century, rather than the risk of acute, shock events.

This will mean considering not only the climate under different scenarios at a single future date, but also how impacts accrue over a person's lifetime from the climate and environmental conditions that prevail throughout the transition to a lower emissions environment.

For the purposes of this publication, we consider the RCP 2.6 scenario, which is in accordance with the 2015 Paris Agreement target; a moderate climate change scenario of RCP 4.5; and an RCP 8.5 scenario to illustrate the most severe effects of climate change on L&H. If wider government and societal actions are taken to reduce emissions by moving towards renewable energy earlier, the impacts is expected to be less extreme.

Figure 4
Representative concentration pathways (RCPs)

Scenario	Effort to curb emissions	Energy generation	New technology	Transport	Temperature in 2081–2100 [1]	Extreme weather increase
RCP 8.5	Low	Coal-fired power		Car, trucks	3.0–6.2 °C	Large
RCP 6.0	Medium	Mix		Mix	2.3–3.6 °C	Moderate
RCP 4.5	Medium	Renewable		Mix	1.8–3.3 °C	Moderate
RCP 2.6	High	Renewable	Emssions capture	Bicycles, public transport	0.9–2.3 °C	Small

Notes: [1] Average increase relative to 1986–2005.
Source: CoastAdapt, Australian Government Department of the Environment and Energy, Swiss Re Institute

Key risk driver 1: extreme heat

Extreme temperatures – hot and cold - represent a serious risk to life and health. They contribute to an estimated five million excess deaths worldwide, annually, representing 9.4% of total global mortality.[10] Whilst this number has been overwhelmingly dominated by cold-related deaths over the last 20 years, heat may be a bigger issue for the decades ahead, with the balance forecast to tip in that direction. Global warming is the leading cause of increasing heatwaves, with the global average temperature increasing at a rate of 0.15°C to 0.20°C per decade.

Temperature-related mortality is highest in the regions most geographically exposed to extreme heat, but the trend is being seen globally. US heatwaves have occurred with greater frequency, longer durations and higher intensities, since the 1960s.[11] Approximately 700 annual deaths are attributable to heat exposure in the US, which is thought to be an underestimation of the true number.[12] In the UK, government forecasts predict 7,000 annual deaths by 2050 if climate change does not substantially reduce.[13]

However, the health risk from extreme heat is also the one that we perhaps have the greatest ability to mitigate. Creating cooler environments with access to ample hydration to live and work in, both indoors and out, can almost entirely neutralise the risk of extreme heat to the human body.

Heatstroke, defined as a core body temperature greater than 40°C, poses a threat to life. This condition typically requires prompt medical attention. The risk to individuals depends on the duration of exposure, an individual's underlying health, and where they live and work. People with chronic respiratory or cardiac conditions are at greater risk of

[10] Q. Zhao et al, "Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modelling study", The Lancet Planetary Health, 2021.
[11] *Climate Change Indicators: Heat Waves*, US EPA, updated 1 August 2022.
[12] S. A. M. Khatana, R. M. Werner, "Association of Extreme Heat With All-Cause Mortality in the Contiguous US, 2008–2017," JAMA Network Open, 19 May 2022.
[13] *Heat-related deaths set to treble by 2050 unless Govt acts*, Environmental Audit Committee, UK Parliament, 26 July 2018.

heat-related complications or death, in addition to those with cognitive impairment, which can skew the perception of heat. Heat-related risks are heightened among outdoor workers, and individuals who are physically active in outdoor sports.

Heatstroke is essentially the failure of the body's own cooling mechanism. In high temperatures, the body maintains normal core temperature by diverting blood flow towards the skin, and increasing production of sweat.[14,15] Both encourage heat loss to the outside environment. However, over prolonged periods heat results in dehydration and depletion of electrolytes, if these are not sufficiently replenished. This is particularly dangerous for people at risk of kidney damage and disease, with limited access to food and water, and in labour-intensive jobs. Individuals on medications which interfere with salt and water balance and circulatory function, are also at risk.

Dehydration and loss of electrolytes in turn compromise the body's thermoregulation. In extreme cases, this can result in a systemic inflammatory response, potential multi-organ failure, central nervous system dysfunction and abnormal blood clotting, which disrupts blood flow.

Maintaining core body temperature for extended periods of extreme heat also requires the heart to work harder. This puts strain on the cardiovascular system, increasing the risk of cardiovascular impairment.[16] During heat exposure, the elderly and those with pre-existing chronic cardiovascular disease may not be able to compensate for the increased circulatory demand needed to maintain a normal core body temperature and are therefore particularly vulnerable.[17] Heatwaves in Europe have also led to very high surface level ozone pollution, which can significantly impact respiratory and cardiovascular illnesses, and increase incidence of skin cancers.[18,19]

The 2003 heatwave in Paris, France, is a key example of how harmful extreme heat can be. The region reported a record-breaking 42°C temperature that summer, and an excess death rate of 141%, with a 250% increase in out-of-hospital cardiac arrests.[20,21]

Similar outcomes are documented in the US. Deaths recorded as caused by both cardiovascular disease and heat exposure have been consistently higher in the hottest summers, especially in those aged 65 and over.[22] The highest summer death rate was recorded in 2006 – one of the hottest years on record in 48 states.

The wet-bulb effect: when humidity adds to extreme heat
The severity of environment-induced heat stress on health depends on the humidity as well as the temperature. Humid air does not have the capacity to retain additional moisture and slows evaporation to cool the body. The wet-bulb temperature scale is used to assess how quickly the body can cool by sweating in hot and humid conditions, including the point at which there is a risk to life. Wet-bulb temperature is expressed as the lowest achievable temperature for moisture to evaporate: the higher the web-bulb temperature, the less easily the body can cool, ultimately leading to death.[23]

[14] M. Gostimirovic, R. Novakovic et al., "The influence of climate change on human cardiovascular function", Arch Environ Occup Health, 23 March 2020.
[15] J. Murugesu, "Why are heatwaves dangerous and how does extreme heat affect the body?", New Scientist, 15 July 2022.
[16] *Heat is hard on the heart; simple precautions can ease the strain*, Harvard Health, 5 November 2019.
[17] "The influence of climate change on human cardiovascular function", op. cit.
[18] *Copernicus scientists warn of very high ozone pollution as heatwave continues across Europe*, newsflash, The Copernicus Programme, 19 July 2022.
[19] E.V. Parker. " The influence of climate change on skin cancer incidence – A review of the evidence ", International Journal of Women's Dermatology, 2021.
[20] F. Canouï-Poitrine, E. Cadot, "Excess deaths during the August 2003 heat wave in Paris, France", Rev Epidemiol Sante Publique, April 2006.
[21] J. P. Empana, P. Sauval et al, "Increase in out-of-hospital cardiac arrest attended by the medical mobile intensive care units, but not myocardial infarction, during the 2003 heat wave in Paris, France", Crit Care Med, December 2009.
[22] *Climate Change Indicators: Heat-Related Deaths*, US EPA, updated 2 August 2022.
[23] The increasing frequency of fatal wet-bulb temperatures, The Economist, 13 May 2022.

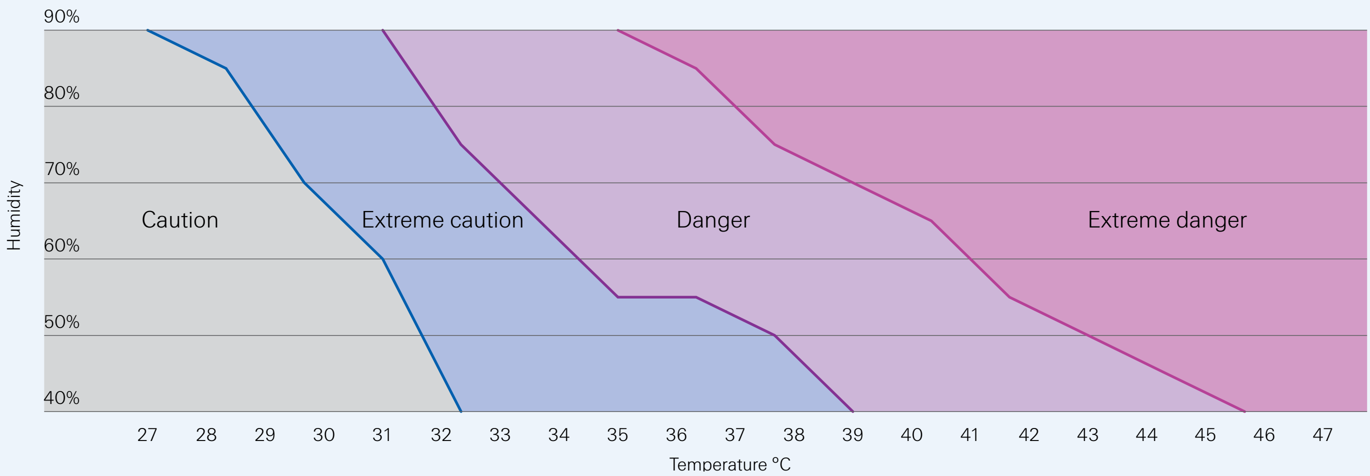
NASA's Jet Propulsion Laboratory estimates that the highest wet-bulb temperature humans can tolerate is 35°C (at 100% humidity) for six hours. Once this threshold has been exceeded, "no amount of sweating or other adaptive behaviour is enough to lower your body to a safe temperature." Even a very healthy, young individual with unlimited drinking water and shade is at risk under these conditions (Figure 5).[24]

Due to climate change, global wet-bulb temperatures are on the rise and some regions are experiencing these conditions more frequently than in past decades. The most vulnerable are the elderly, outdoor workers and those with co-morbidities. AC, which cools and removes humidity, is a boon to health in these climates, allowing people to survive, and eventually thrive, in climates that would otherwise prove challenging.

Cold-related deaths to shift to heat-related mortality
Historically, cold-related mortality due to inherent clinical vulnerability, deaths from winter respiratory viruses and accidents in bad weather, has far outweighed deaths from heat. Over the course of this century deaths as a consequence of extreme cold are expected to sharply decline, as heat-related mortality creeps up. In regions with strong seasonal temperature variations and cold winters, these variations may become less pronounced if winters become milder. This could cause fewer direct deaths from accidents, as well as more limited spread of seasonal respiratory infections. Eventually, this decline in deaths may be halted as temperatures increase, leading to an overall increase in deaths. In regions such as Africa or South America, where winter is not a seasonal threat, impacts may be far more negative, as a rise in heat-related deaths will not be offset by lower mortality from cold temperatures.

[24] A. Buis, "Too Hot to Handle: How Climate Change May Make Some Places Too Hot to Live", NASA, 9 March 2022.

Figure 5
The combination of temperature and relative humidity approximates the impact of wet bulb temperature on health



Source: *Heat Index Chart*, United States National Weather Service (US NOAA), reproduced by Swiss Re Institute

Key risk driver 2: air pollution

Extensive research shows that long- and short-term exposure to fine particle air pollution, also known as fine particulate matter (PM), is harmful to humans. The most significant sources of air pollution are **anthropogenic emissions and wildfires**, which emit pollutants that can travel large distances, exposing people across a wide area to respiratory irritants that can harm the lungs and heart.

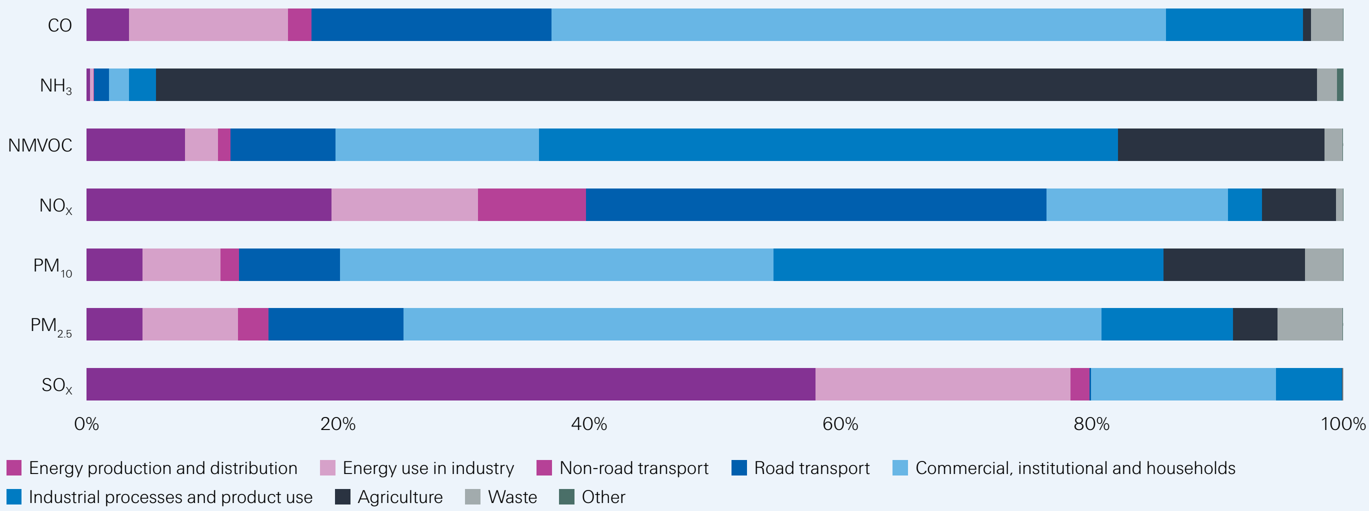
Climate change is projected to increase the occurrence and severity of wildfires, with detrimental effects on air quality.[25] In Australia, the worst wildfire season of 2019–20 degraded air quality for 80% of its citizens and exposed them to hazardous pollution for months after.[26] California experienced its worst wildfire season in 2020 with at least 30 deaths, more than four million acres of land burnt and an estimated economic cost of USD 19 billion.[27] While rebuilding efforts started almost immediately, the decline in air quality remains, with the fires responsible for 23% of the state's emissions in 2020, pushing back air pollution gains by a decade.[28] As wildfires increasingly touch residential areas, they are also burning more homes and buildings, releasing more toxic chemicals and increasing the longer-term risk to health.

Air pollutants are typically described by their size, with the smallest usually referred to as $PM_{2.5}$ (Figure 6). Noticeable as a yellow-brown haze in higher concentrations on bright days, $PM_{2.5}$ is a visible reminder of an otherwise invisible threat to health. $PM_{2.5}$ is so small it can pass through the lungs into the bloodstream and vital organs. Other key pollutants are carbon monoxide (CO), ammonia (NH_3), non-methane volatile organic compounds (NMVOCs), nitrogen oxides (NO_x), PM_{10} and sulphur oxides (SO_x). All of which have a negative impact on air quality and health.

Air pollution has a major impact on human life. Exposure can be acute, meaning high exposure over a relatively short period, or chronic, meaning typically lower exposure for

[25] *Climate Change 2022: Impacts, Adaptation and Vulnerability*, AR6 Working Group II, IPCC, 2022.
[26] *The Limits of Livability – The emerging threat of smoke impacts on health from forest fires and climate change*, The Global Climate and Health Alliance, 2021.
[27] T. Briscoe, "Pollution from California's 2020 wildfires likely offset decades of air quality gains", Los Angeles Times, 17 June 2022.
[28] *One year of wildfires undid decades of California's emissions policy*, The Economist, 19 October 2022.

Figure 6
Emissions sources of the main air pollutants in Europe



Note: The main air pollutants illustrated are: carbon monoxide (CO), ammonia (NH_3), non-methane volatile organic compounds (NMVOCs), nitrogen oxides (NO_x), PM_{10}, $PM_{2.5}$ and sulphur oxides (SO_x). The aggregated sector emission contribution for each pollutant is given in percentages.
Source: *Emissions of the main air pollutants in Europe*, European Environment Agency (EEA), 18 November 2021. Swiss Re Institute

a far longer-term period, with different impacts on health. It is estimated that 307 000 premature deaths were attributable to $PM_{2.5}$ across the 27 countries of the European Union in 2019, while chronic nitrogen dioxide (NO_2) and acute ozone exposure were linked to over 40 000 and 16 000 premature deaths, respectively, in that year.[29]

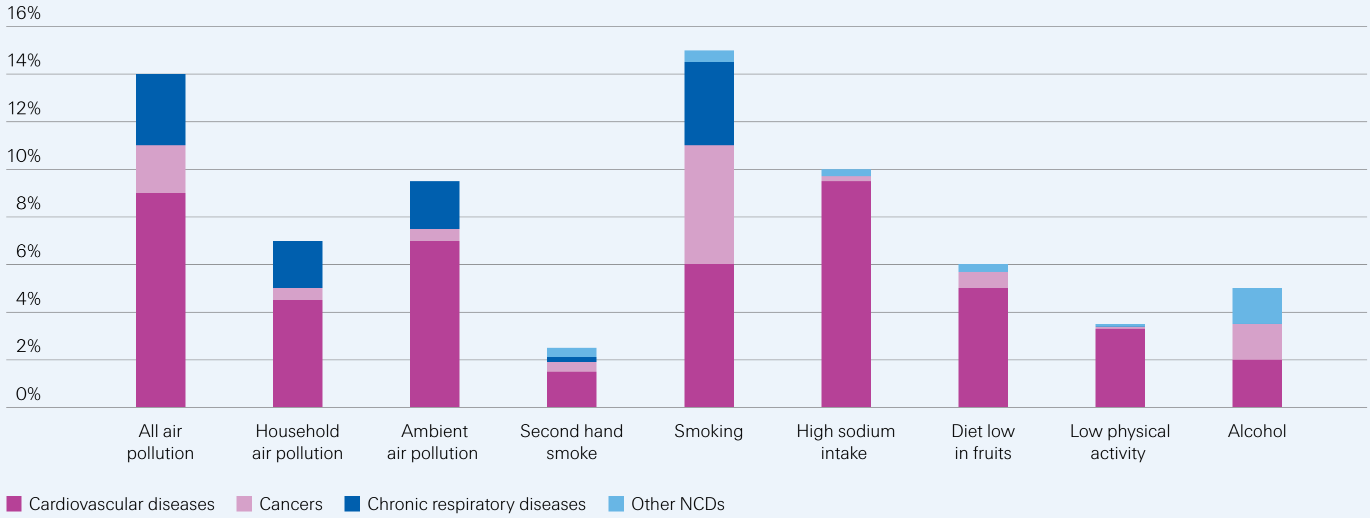
Air pollution is second only to smoking as a risk factor for non-communicable disease globally.[30] Short- and long-term exposure is linked to CVD such as strokes and heart disease; cancers and respiratory conditions, including chronic obstructive pulmonary diseases; aggravated asthma; and lower respiratory tract infections, including acute respiratory infections (Figure 7). Air pollution is also associated with poor birth outcomes.[31]

Exposure to fine particulate matter in the air causes an increased risk of cardiovascular events and cardiovascular disease-related mortality and morbidity.[32] A significant increase in cardiovascular disease (0.5–1.5%) was reported for every 5–6 μg/m³ increase in $PM_{2.5}$, and that acute exposure to PM air pollution drastically worsened mortality risk, with a 69% increase in cardiovascular disease-related deaths. Acute exposure also resulted in a higher death rate from CVD than respiratory disease.[33]

The International Agency for Research on Cancer (IARC) has classified air pollution and $PM_{2.5}$ as leading carcinogens. Multiple studies have documented a correlation between air pollution exposure and lung cancer risk incidence and mortality per 10 μg /m³ increase in $PM_{2.5}$. People exposed to both cigarette smoking and outdoor $PM_{2.5}$ had a greater cumulative risk of dying from lung cancer than would be expected from the sum of the individual exposure risks.[34]

[29] *Health impacts of air pollution in Europe*, European Environment Agency, 2021.
[30] A. Pruess-Ustuen, "Environmental risks and non-communicable diseases", British Medical Journal, 2019.
[31] B-J. Lee, B. Kim, K. Lee, "Air Pollution Exposure and Cardiovascular Disease", Toxicol Res., June 2014.
[32] R. D. Brook, S. Rajagopalan et al, "Particulate Matter Air Pollution and Cardiovascular Disease", American Heart Association, June 2010.
[33] D. R. Gold, A. Litonjua et al, "Ambient pollution and heart rate variability", Circulation, March 2000.
[34] M. C. Turner, A. Cohen, "Interactions Between Cigarette Smoking and Fine Particulate Matter in the Risk of Lung Cancer Mortality in Cancer Prevention Study II", American Journal of Epidemiology, 15 December 2014.

Figure 7
Key risk factors for NCDs



Note: For each risk factor, the attributable fraction of NCDs (%) are grouped by disease.
Source: A. Prüss-Ustünn et al., op. cit., Swiss Re Institute

The WHO also identifies secondary health conditions arising from $PM_{2.5}$, such as an increased risk of obesity, Type 2 diabetes, dementia, and systemic inflammation of organs.[35]

Children, pregnant women, the elderly and those with pre-existing heart and lung diseases are particularly vulnerable to these conditions and more likely to experience worse outcomes. People of lower socioeconomic status are typically more vulnerable to the health impacts of air pollution due to factors such as limited access to healthcare and inability to mitigate exposure level and duration.[36] Proximity to industrial sources of air pollution, poor nutrition and stress, among other factors, can contribute to greater, adverse health impacts.

However, effects are not just limited to life-threatening conditions. Pollen and other airborne allergens can lead to deteriorating respiratory health. Pollen concentrations are highly sensitive to temperature changes, therefore climate change is expected to change pollen concentrations, pollen types and exposure times. This could weaken ongoing respiratory health, as seen in North America over recent pollen seasons.[37]

Other airborne concerns such as fungal spores are also expected to change their emission, dispersion, transport and deposition, with changing patterns in precipitation

[35] *Health effects of particulate matter*, WHO, 2013.
[36] *The psychological, economic, and social costs of air pollution*, MITSloan, 2020.
[37] *Climate & Health* webpage, Asthma and Allergy Foundation of America.

and wind directions.[38] More extreme floods and severe storms could also lead to more damp conditions and resultant exposure to mould spores, triggering allergic reactions and other lung-related conditions that could undermine quality of life and lead to disabilities.[39]

Air pollution exceeds legal limits in much of the world – but reductions can help
Asia is the world's largest emitter of air pollutants and greenhouse gases, linked to its growing population and demand for energy for industrialisation.[40] Although recent improvements in cities like Beijing and Shanghai are having an impact, air quality levels remain far lower in China than recommended under international standards[41]. Exposure to outdoor air pollution at dangerous levels is a health hazard, especially to those in densely populated urban areas.

A study in the Lancet (2015) estimated that India and China combined contribute 50% of the global estimates of mortality and disability-adjusted life-years attributable to ambient PM pollution[42]. Research from the Energy Policy Institute at the University of Chicago (EPIC) suggested that people in India, who are often exposed to greatly elevated temperatures and air pollution levels, would live an average of four years longer if the country met the WHO guidelines.[43] Asian countries therefore have great opportunities to improve their populations' health and extend lifespans by lowering emissions, thereby reducing air pollutants, while simultaneously contributing to the global climate risk mitigation effort.

Pollution levels in many areas of the US also exceed national air quality standards for at least one of the six commonly listed pollutants. Levels of particle pollution and ground-level ozone pollution in the US are lower than in the past, but current levels do exceed safety thresholds across the country and can travel vast distances when carried by the wind. As of 2020, it has been estimated that over 50 million people in US live in counties where $PM_{2.5}$ concentrations were above national ambient quality limits.[44].

However, efforts to curb emissions can generate positive impacts. The EU reduced its emissions by 28% between 1990 and 2019.[45] It reported 33% fewer premature deaths in the EU-27 from exposure to fine PM in 2019 compared with 2005.[46] Fine PM will also likely be reduced if CO_2 emissions are curbed through a reduction of fossil fuel use to hit climate change limits.

Indirectly, the first wave of the COVID-19 pandemic in 2020 was an unintended pilot study of the improvements possible from a decline in air pollution. A recent study noted an unexplained decrease in a subset of heart attacks (STEMI) in the US during the pandemic, in conjunction with reduced levels of $PM_{2.5}$-related air pollution; the temporary reduction of this known risk factor may have contributed to an acute decline in these heart attacks.[47] While other studies are needed to validate these findings in other countries, it is an indication of the deep links between our health and the wider environment.

[38] *Does Climate Change Impact Allergic Disease?*, American Academy of Allergy, Asthma and Immunology, reviewed 28 September 2020.
[39] W. R. L. Anderegg, J. T. Abatzoglou et al, "Anthropogenic climate change is worsening North American pollen seasons", PNAS, 8 February 2021.
[40] *Climate risk and response in Asia*, McKinsey, 2020.
[41] H. Kan, B. Chen, C. Hong, "Health Impact of Outdoor Air Pollution in China: Current Knowledge and Future Research Needs", Environmental Health Perspectives, May 2009.
[42] A. Cohen, M. Brauer et al, "Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015", The Lancet, 2015.
[43] *AQLI Tool Shows Pollution's Impact in India*, EPIC India, 2020.
[44] F. Huang, B. Pan et al, "Relationship between exposure to $PM_{2.5}$ and lung cancer incidence and mortality: A meta-analysis", Oncotarget, 21 April 2021.
[45] M. Romanello, K. van Daalen et al, "Tracking progress on health and climate change in Europe", The Lancet, 22 September 2021.
[46] *Health impacts of air pollution in Europe*, op. cit.
[47] *Air Pollution: Current and Future Challenges*, US EPA, updated 30 March 2022.

Key risk driver 3: vector-borne disease

Vector-borne diseases represent a risk to half of the world's population. These diseases, which are carried by an animal (the "vector") that infects another species, at present affect around one billion people each year and are responsible for about one-sixth of annual global morbidity and mortality, or more than 700 000 deaths annually.[48] Vector-borne diseases include malaria and West Nile virus, which are carried by mosquitos, Lyme disease, which is transmitted by ticks, and bubonic plague, transmitted by rodents and fleas, among many others.

Climate change is modifying the transmission of these diseases, particularly those spread by mosquitoes and other insect vectors. Global warming is altering their geographical distribution, creating favourable breeding conditions in locations that were previously inhospitable (Figure 8). This expansion of habitats means the range of certain vector-borne diseases, formerly confined to tropical regions and areas of high temperature, is broadening and progressively expanding into temperate and subtropical climates[49]. This expansion of the distribution of disease vectors is expected to continue.[50]

In the US, reported cases of mosquito, tick and flea-related illnesses doubled between 2004 and 2018, to 760,000 annually. Nine new mosquito- or tick-transmitted pathogens were reported in the same period.[51]

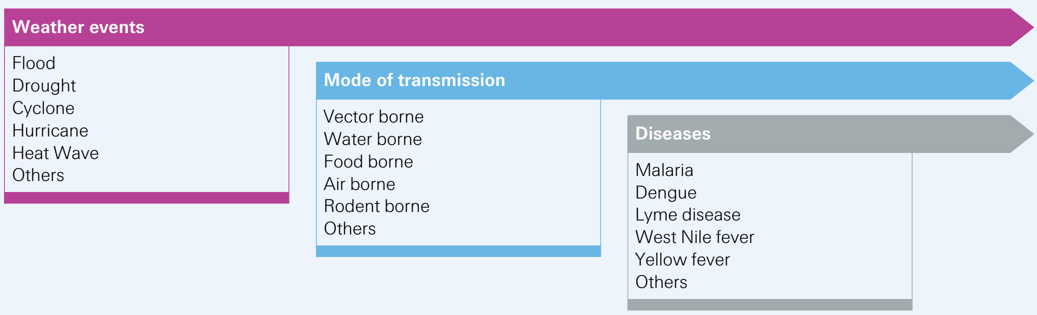
Vector-borne diseases have historically been most prevalent in developing countries with less resilient healthcare infrastructure and in countries that struggle with healthcare provision. These diseases can lead to a high number of deaths, adding strain to already burdened healthcare systems, increasing overall health inequities.

The spread of vector-borne diseases into densely populated urban regions in Europe and North America has the potential to substantially impact healthcare systems, due to poor local adaptations and a limited understanding of how to prevent, identify and treat these conditions.

Much global interest has been paid to monitoring, controlling the spread of, and reducing infection of diseases like malaria or zika, but there is little experience outside of the most heavily impacted regions on how to deal with serious vector-borne illnesses.

[48] *Vector-borne diseases*, WHO, 2 March 2020.
[49] W. L. Filho, L. Ternova et al, "Climate Change and Zoonoses: A Review of Concepts, Definitions, and Bibliometrics", International Journal of Environmental Research and Public Health, 14 January 2022
[50] *Climate change and infectious diseases*, National Center for Emerging and Zoonotic Infectious Diseases, CDC, 2 August 2022.
[51] *Illnesses from Mosquito, Tick, and Flea Bites Increasing in the US*, CDC, 28 November 2018.

Figure 8
Vector-borne diseases: explaining the link between climate, transmission and disease



Source: Swiss Re Institute

Climate change increases the likelihood of vector borne diseases
Precipitation and humidity, as well as warming, are leading factors in the reproduction and transmission cycles of vector-borne diseases, particularly where mosquitos are the vector since mosquitos require a body of still water to reproduce. Survival and reproductive patterns are impacted by the environment, and a movement towards warmer and wetter winters across Europe and North America could turn seasonal peaks of insect activity into year-long cycles. The pathogens themselves have their own reproduction patterns, and higher global temperatures will likely result in a net increase in infections, as fewer cold periods will present fewer opportunities to kill infections.

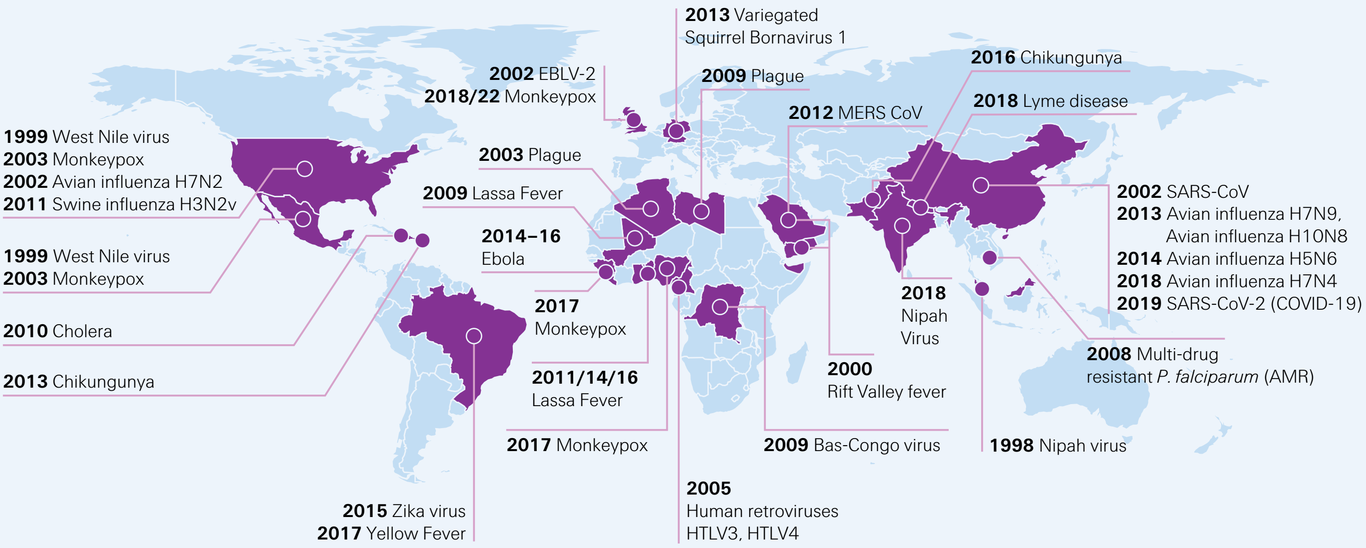
By 2070, climate change is predicted to drive 3,870 species of wild mammals into new territories, altering their geographical ranges and habitats. This development is forecasted to lead to more than 300,000 new cross-species encounters across the globe, with hotspots in tropical Africa and southeast Asia, and the added potential for 15,000 novel virus-sharing events between 2011 and 2040.[52]

Zoonotic disease and the potential for new endemic or pandemic diseases
A zoonotic disease is an infectious disease caused by a pathogen that arises through cross-species transmission, such as avian influenza from poultry. Animal-to-human transmission (spillover) from wildlife appears to be accelerating, partially due to environmental change (Figure 9). Certain species are more likely to be hosts for zoonotic disease due to more resilient immune systems that allow them to tolerate rather than die from the infections. Among mammals, bats are responsible for the greatest proportion of these diseases. Coupled with their ability to fly long distances, this makes them a significant vector for zoonotic transfer.[53]

Zoonotic pathogens and parasites tend to be maintained in animal reservoirs and regularly or sporadically spill over to cause disease in humans, which may sometimes lead to sustained human-to-human or vector-borne epidemics (eg, severe acute respiratory syndrome coronaviruses (SARS-CoV), Ebola,) but more commonly to

[52] R.E. Baker, J.E. Metcalf "Heating and stirring the global viral soup". Nature, 2022.
[53] C. J. Carlson, G. F. Albery et al, "Climate change increases cross-species viral transmission risk", Nature, 28 April 2022.

Figure 9
Global spread of new and significant emerging disease outbreaks since 1998



Source: Public Health England, Swiss Re Institute endemic or sporadic disease (eg, Lyme disease).[54] Deforestation, climate change and human encroachment into animal territories are changing how isolated these reservoirs can be – by bringing humans and livestock into contact with wildlife.

Approximately 60–75% of human infectious diseases are a consequence of pathogens originating from other species; a well-known example of this is influenza - a group of viruses that spread from animals that are a leading cause of human mortality globally.[55]

Emergence of these diseases has often been in tropical and less economically developed markets, but the significance of their spread through travel, and subsequent ill health in more developed markets in temperate zones, should not be minimised. Although an acute outbreak could have a relatively small impact initially, there could be a notable ongoing mortality risk from a severe vector-borne disease outbreak. The COVID-19 pandemic has shown how the healthcare systems of even the most advanced countries can be overwhelmed by increasing numbers of patients who require sustained treatment.

Food, water and shelter disruptions could intensify the impacts of these risk drivers

Fresh water shortage: The UN projects that global demand for fresh water will exceed supply by 40% in 11 major cities by 2030.[56] Water scarcity will likely exacerbate heat impacts as hydration is key to reducing heat strokes. The inability to convert arid and hot areas into green spaces to reduce temperatures, may also pose longer-term problems for dissipating heat. Water cuts may be necessary to regulate the supply of hydroelectric power, responsible for fuelling electricity. In summers, anticipated lower rainfall coupled with soaring temperatures will significantly reduce water flows, irrigation and reduce dilution of pollutants in rivers.[57]

Food insecurity and scarcity: Climate directly affects agriculture with global crop yields predicted to drop by 3–12% by 2050, rising to 11–25% by the end of the century.[58] Under a high emissions scenario, maize and wheat yields could decline by 24% and 17% respectively by 2030.[59] Extreme weather events can lead to crop failures and distribution challenges. Substantial changes to food prices or changes to global shipping or transport trends may affect food accessibility. Fish stocks are also extremely vulnerable and projected to decline by up to 40% by 2050 under RCP 8.5. This will exacerbate frailty and ability to withstand diseases.[60]

People displacement: More than 216 million people are expected to be displaced within their countries across six regions due to climate change and natural disasters by 2050.[61] This could lead to additional challenges through the spread of tropical diseases and conditions such as multidrug-resistant tuberculosis.[62]

[54] R. Gibb, L. H. V. Franklinos at al, "Ecosystem perspectives are needed to manage zoonotic risks in a changing climate", BMJ, 2020.
[55] J.H. Ellwanger & J.A.B. Chies "Zoonotic spillover: Understanding the basic aspects for better prevention", Genetics and Molecular Biology, 2021.
[56] *The 11 cities most likely to run out of drinking water - like Cape Town*, BBC News, 11 February 2018.
[57] *The impact of climate change on water scarcity*, Scottish Environmental Protection Agency.
[58] I.S. Wing et al, "Global vulnerability of crop yields to climate change", Journal of Environmental Economics and Management, September 2021.
[59] Global Climate Change Impact on Crops Expected Within 10 Years, NASA Study Finds. NASA. November, 2021.
[60] V. W. Y. Lam, E. H. Allison et al, "Climate change, tropical fisheries and prospects for sustainable development", Nature Reviews Earth & Environment, 4 August 2020.
[61] *Groundswell Part 2: Acting on Internal Climate Migration*, World Bank Group, 13 September 2021.
[62] D. A. Boudville, R. Joshi, "Migration and tuberculosis in Europe", Journal of Clinical Tuberculosis and Other Mycobacterial Diseases, February 2020.

Mortality impacts from climate change

Estimating the health and mortality impacts of climate change is subject to a high degree of uncertainty as the exact trajectory of climate change could vary widely depending on actions taken. This is further complicated by interdependencies and non-uniformity across regions, age bands, health status and socio-economic classes. Qualitative impact assessments remain the best method of assessing risks from climate change for L&H insurance companies.

However, with the intention of providing a directional vector, we present estimates of excess mortality based on a critical analysis of available expert reports and studies for the general population under different RCP scenarios through 2050 and 2100.

Methodology
Climate data and inferences on impact to life and health are speckled in literature. Dependent upon the recipient audience, academic papers tend to use a wide range of metrics including various climate models and different scenarios such as the shared socioeconomic pathways (SSPs), RCP and often their own non-standardised metrics, all with a very limited scope covering a country, region or even only a city.

We do not present projections for potential vector-borne diseases because the impact of these is likely to be in the form of periodic disease outbreaks, which is best quantified through traditional pandemic modelling. The focus for this exercise is therefore on mortality driven by heat (and offsets from less cold weather-related mortality) and air pollution. Population and mortality data from World Population Review and United Nations were used to convert estimates presented in various formats to the same basis and calculate the percentage of excess mortality.

For the projections, confidence intervals are largest for air pollution, where magnitudes of differences – even directionally whether air pollution contributes positively or negatively – between various models are observed. Additionally, air pollution might develop independently of temperature trajectories. Confidence intervals for heat-related deaths are the smallest of the three categories, but all factors are more likely.

Global population estimated average annual excess mortality

RCP pathway	2050	2100
RCP 4.5 pathway Consistent with 1.8 to 3.3°C warming by 2100	**0.75%**	**1.00%**
The majority of deaths are attributed to greater exposure to extreme heat. Heat-related deaths may contribute 1.25% excess mortality by 2050, largely in Africa and Asia, the most geographically exposed and populous regions. In other regions, large reductions in deaths from cold, such as from respiratory viruses, are expected as warming reduces the severity of winters. This would offset about 0.5% of the excess mortality.		
RCP 8.5 pathway Consistent with 3°C or more warming by 2100, used as a proxy for unmitigated climate change	**1.50%**	**5.25%**
In this scenario, by 2100, heat and air pollution would together cause nearly 6.75% excess mortality globally per year, but with an additional offset of -1.25% from fewer cold-related deaths.		
RCP 2.6 pathway Consistent with the world meeting the Paris Agreement target of limiting global warming to well below 2°C	**Minimal excess mortality**	**0.75%**

Regional variations

The excess mortality shown in the table above is not expected to apply uniformly across the globe. Wide variations are expected. Northern hemisphere regions such as north America and northern Europe are predicted to see significant reductions in cold-related deaths for most of this century that will outweigh the rise in deaths linked to heat. The regions most exposed to the combined effect of heat and air pollution are expected to also see least benefit from colder parts becoming more temperate. Southern Asia and Africa are estimated to see large upticks in heat-driven mortality by 2050 whether climate change is moderate or unmitigated.

Mitigating climate health risk: strategies and challenges

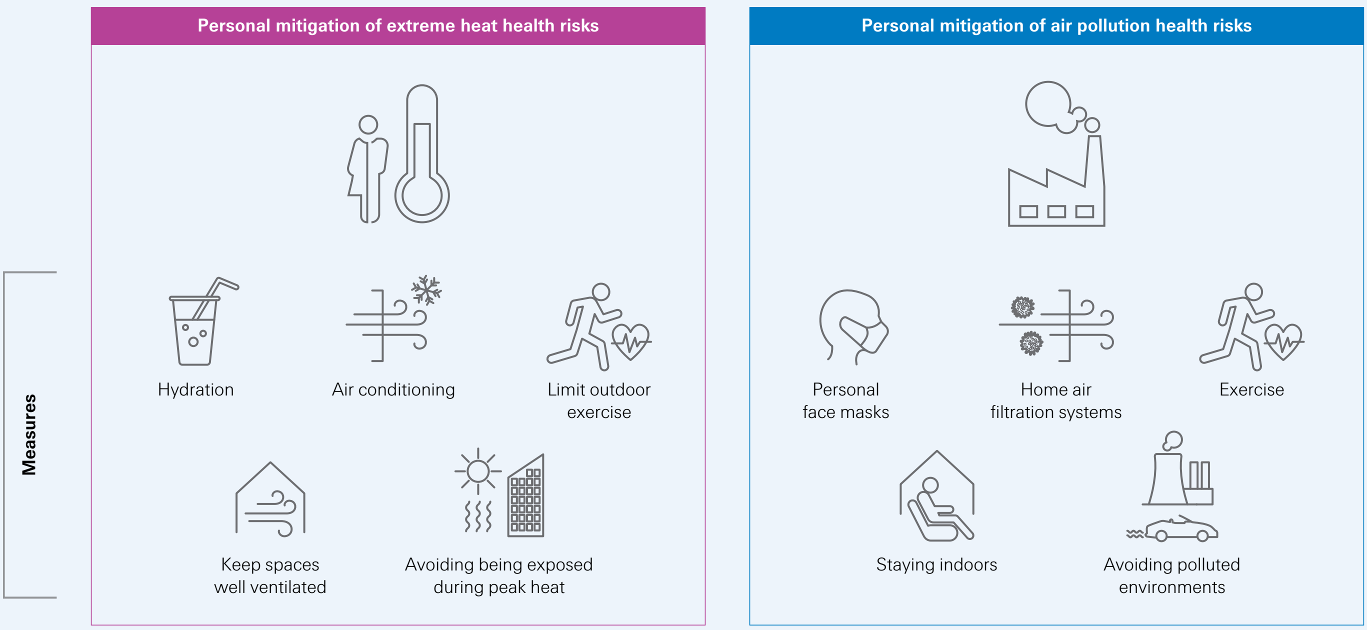
Reducing a person's personal exposure to heat and air pollution through air conditioning, hydration and air filtration is currently the most effective way to mitigate the health risks associated with climate change (Figure 10).

Extreme heat
As formerly cool countries adapt to higher temperatures, air-conditioning installations and usage are likely to rise. In Europe, the International Energy Agency (IEA) estimates that fewer than 10% of European households have residential air-conditioning.[63] The UK is particularly vulnerable as only 1% of UK homes have a fixed cooling system and a further 3–5% have portable systems. By contrast, about 90% of US households have some form of air-conditioning.

Despite surging demand and soaring temperatures, only 15% of households in Southeast Asia are equipped with air-conditioning, with significant disparities based on income – less than 10% of households in Indonesia, Philippines and Vietnam have air-conditioning, compared with ~80% in Singapore and Malaysia. A substantial rise in sales is expected across the region with air-conditioning usage predicted to increase from 40 million to 300 million units between 2017–2040, and account for 30% of peak electricity demand.[64] Across Southeast Asia, demand for energy has increased by 80% since 2000, resulting in 75% usage of fossil fuels to meet this need.[65]

[63] *The Future of Cooling*, International Energy Agency, May 2018.
[64] *The Future of cooling in Southeast Asia*, International Energy Agency, November 2019.
[65] *Southeast Asia Energy Outlook 2019*, International energy Agency, October 2019.

Figure 10
Strategies to mitigate personal exposure to air pollution and heat-related risks



Source: S. G. Al-Kindi et al., "Environmental determinants of cardiovascular disease: lessons learned from air pollution", Nature Reviews Cardiology, 7 May 2020. Swiss Re Institute

Air pollution
A similar challenge exists for mitigating the damaging effects of air pollution. High-efficiency particulate air (HEPA) purifiers have been shown to decrease indoor allergens and reduce PM in the home, with the addition of carbon filters aiding in the removal of gaseous pollutants such as ozone and nitrogen oxides. Modified HEPA filters designed for installation as high-efficiency cabin air filtration systems in school buses, were found to decrease ultrafine particle and black carbon concentrations by over 80%.[66] Standalone filter systems are commercially available, but there are also similar options to combine air filtration with air conditioning units.

Simpler solutions for reducing outdoor exposure or staying indoors during peak periods of pollution can also mitigate personal risk.[67] Governments, health agencies and weather forecasts are beginning to publicise times of day when pollution is higher and this trend is likely to continue, providing essential information for those at risk of air-pollution related conditions.

Vector borne diseases
Governments, together with the private sector, including the insurance industry, can strengthen their infrastructure to reduce the impact of vector borne diseases. Continued surveillance of global disease emergence and transmission will be vital to tracking future outbreaks. For existing diseases, measures such as mosquito nets, repellents, and treating freshwater supply may be widespread, as the breeding grounds and habitats of vectors spread. Urban planning and civil engineering, with a new climate normal in mind, may further help to limit the number of residential and business buildings built in at-risk local areas. Furthermore, treatments and vaccines will need to be made more widely available in regions where they are currently rarely used.

Key public sector-led mitigation measures include building stronger, more resilient health systems, investing in public health programmes such as mass vaccination where applicable, and extending public health insurance protections to ensure people can access treatment.

Offsetting and compounding effects
Mitigating the impact associated with one climate-related health risk driver can have the unintended effect of increasing the risk associated with another driver. For example, air-conditioning requires substantial energy, potentially aggravating climate change-related extreme heat if fossil fuels are used, as anticipated in southeast Asia as energy needs soar. With the current global energy crisis and issues with supply chains, countries may be forced to rely on increased fossil fuel usage in the short term to meet demand, or risk power cuts. It is thus unclear the level of damage that this usage could cause and to what extent the gains from improved air pollution could be reversed.

Additionally, air pollution and temperature increases could change precipitation patterns, with heavier and more stagnant rainfall increasing the potential for breeding grounds for insects such as mosquitos and ticks, which could further spread disease.

There are elements of risk interdependence and connectedness as well: for example, where one risk factor elevates the risk of subsequent factors, as in the case where higher temperatures cause more wildfires, which in turn leads to more air pollution. When combined, higher temperatures and increased air pollution can compound the negative health effects of each in isolation. In contrast, some actions that can be taken to combat climate change can have positive secondary feedback effects, eg a shift to use of electric vehicles can reduce air pollution and, in turn, may reduce related mortality.

Uneven access to mitigation measures
Access to mitigation measures is unequally distributed between and inside countries.[68] The populations of developing countries are the most vulnerable to health-related climate risks. However, due to low incomes, limited savings, and manual work, among

[66] D.E. Schraufnagel et al., "Health Benefits of Air Pollution Reduction", Annals of the American Thoracic Society, 2019.
[67] C. Carlsten et al, "Personal strategies to minimise effects of air pollution on respiratory health: advice for providers, patients and the public", European Respiratory Journal, 2020.
[68] *sigma* 3/2022: insurance and its role in reducing income inequality, Swiss Re Institute, 11 May 2022.

other factors, they are less likely to have the means to adapt to this more hostile environment to minimise health and wellbeing impacts. Those who have been hospitalised and remain at-risk during a heatwave, for example, may not be able to be discharged – taking up hospital space and adding to the healthcare burden. New medical preventions and treatments for temperatures and vector borne disease may be too expensive, or inaccessible for parts of the population.

Even in developed countries, climate change protection could be unaffordable for many, so worsening often-already significant differences in health outcomes and mortality. As countries of all development levels learn to adapt to the changing climate, unequal opportunities and outcomes based on socioeconomic status is to be expected.

Strengthening public policies to address inequalities in access
Given that substantial segments of the global population may have limited regular access to some basic mitigation measures, it will be vital that governments work to reduce the negative effects of climate change on health. In addition to efforts being made across the globe to reach net-zero global carbon emissions, some of the key public sector-led mitigation measures that will aid this include:

- Building stronger public health infrastructure, resilient to peaks of acute medical care and supportive of long-term recovery;
- Investing in public health programmes such as mass vaccination where applicable for vector borne diseases;
- Extending public health insurance protections to ensure people can access treatment when health is impacted by climate change-related events; and
- Partnering with private companies and the insurance industry to combat these effects and provide protection to vulnerable communities.

Upgrading to climate-resilient healthcare infrastructure
Upgrading and adapting existing healthcare infrastructure to develop climate-resilient systems will need to be a top policy priority for the coming years. Extreme weather can disrupt critical services causing electrical power outages, drinking and wastewater contamination, breakdown of roads and transport infrastructure and healthcare pressures, including delayed emergency response times. As many of these systems are interlinked, the failure of one may have knock-on effects on the others; acute climate emergencies are estimated to increase usage of ambulances by 25–35%, which is comparable to major flu epidemics.[69] The loss of power and strained healthcare could lead to a short-term mortality risk, as systems become unable to cope with increased pressure and limited resources. At present, healthcare systems rely greatly on energy production and are responsible for 4.4.% of global greenhouse gas emissions.[70]

To avoid aggravating the climate challenge as we develop better, climate-resilient infrastructure, a transition to cleaner energy is necessary to support future health systems. The UK's National Health Service (NHS) is the world's first health entity to commit to reaching net-zero direct and indirect carbon emissions by 2045.[71]

The L&H insurance industry is a key participant in the health ecosystem and has a key role to play in supporting climate resilience in healthcare infrastructure. L&H insurance may enable policyholders to afford access to healthcare, but insurers do not typically own or manage the health infrastructure itself. Consequently, there is a risk to insurers if a healthcare system itself is impaired by the impact of climate change, such as by extreme heat, wildfire or extreme weather events.

[69] J. Paavola, "Health impacts of climate change and health and social inequalities in the UK", Environmental Health, 2017.
[70] *Health Care's Climate Footprint*, Health Care Without Harm, September 2019.
[71] *Delivering a 'Net Zero' National Health Service*, NHS England, July 2022.

Health risks and insurance

The L&H insurance industry is exposed to climate change risk via the health of the insured population, which is typically very different in characteristics to the general population overall that we analysed in the prior chapter. As has been illustrated, climate change may introduce new health risks or aggravate existing ones. Insurance will be part of the solution to combat these. Some of these aspects are discussed in this section.

Risk outlook: insured lives may be vulnerable but are typically more resilient
Any increase in premature mortality and morbidity is potentially a significant issue for L&H insurers. The unpredictability and uneven impact of climate change may place the assumptions of long-term health improvements at risk. The impact of climate change on L&H cannot therefore be ignored.

In principle, the insured segments – in particular those with private insurance - are expected to be a more climate-resilient group. There are several drivers for this resilience:

- Insured populations are typically more affluent. This means they can be expected to have greater resources to **put towards mitigation and climate adaptability.**
- They are more likely than the general population to be able to **reduce exposure** to the negative impacts of climate change, through better access to drinking water, ability to live in less polluted environments and to stay indoors in peak heat.
- Insured segments are typically healthier with better underlying health metrics, leading healthier lifestyles, and with increased access to healthcare and greater personal focus on prevention rather than treatment. For certain product lines, healthier cohorts are selected through the process of medical underwriting, which lowers insurers' sensitivity to the risk that climate change will exacerbate pre-existing health vulnerabilities.

However, as COVID-19 has shown, it is plausible for the insured population to be equally or disproportionately impacted with worse outcomes than the general population. In particular, vector-borne diseases may impact insured lives as much as general populations. These diseases offer fewer opportunities for individuals to reduce their mortality risk and create the potential for healthcare to become temporarily less available, especially if health infrastructure comes under extreme strain, as seen during the peaks of COVID-19. These circumstances could lead to potentially larger negative health outcomes in the insured population than anticipated for other health threats we identify.

Climate change considerations for financial reporting and disclosures
Climate change scenario analysis (and stress testing) have become a regulatory priority to ensure risk awareness, forward-looking assessment and management of climate change risks by financial institutions. In many countries, new climate reporting requirements require or recommend that climate scenario analysis is incorporated into their Own Risk Solvency Assessment (ORSA).

For these disclosures and solvency assessments, consideration of risk factors and mitigation techniques previously noted become relevant, as well as the higher climate resilience of insured groups relative to the general population. Given the high degree of uncertainty on many dimensions and the long time period under consideration, qualitative approaches are more fit for the purpose of assessing these risks.

Climate change impacts and L&H insurance rates
The health impacts of climate change are likely to be slow-moving and play out gradually over this century and beyond. Health risks that are significant today may be reduced through global mitigation efforts. Climate change-driven innovation may also have beneficial secondary effects, for example in the move to electric vehicles from petrol and diesel. This suggests the impact of climate change on life and health insurance portfolios may be incremental rather than a shock. Adverse trends in health and mortality present

today, for example from air pollution, are integrated into current assumptions, so sudden, completely unanticipated impacts in the risk rates are unlikely.

Adjustments to our expectations may be required as L&H specific climate risks are better understood and quantified in terms of long-term impact on mortality and morbidity trends. How climate-driven impacts will play out in conjunction with other key adverse trends, such as the increase in unhealthy behaviours or obesity, or indeed in the context of an ageing population, remains an area of concern.

Insurers can play a role in promoting health resilience against climate change
The insurance industry will be a key partner and participant in global public-private efforts to address climate change health risks worldwide. Global action is necessary to establish strong, climate-resilient public healthcare systems, especially with respect to water and power as environmental decline threatens the availability of these key resources for public health.

Public and private sector stakeholders can partner to gather richer data and expand programming expertise to better map and model the evolving climate, mortality and morbidity trends, and ultimately to enable better decision-making in terms of impact on future health outcomes.

Climate change will likely widen existing financial inequities. Insurers worldwide have a responsibility, as well as an opportunity, to close the protection gap by expanding access and coverage to more vulnerable consumers.[72] Different approaches, such as microinsurance, parametric risk transfer solutions with government agencies and harnessing the opportunities offered by digital technology, can all be part of the solution to better align insurance offerings with consumer needs and overcome barriers to insurance acceptance.

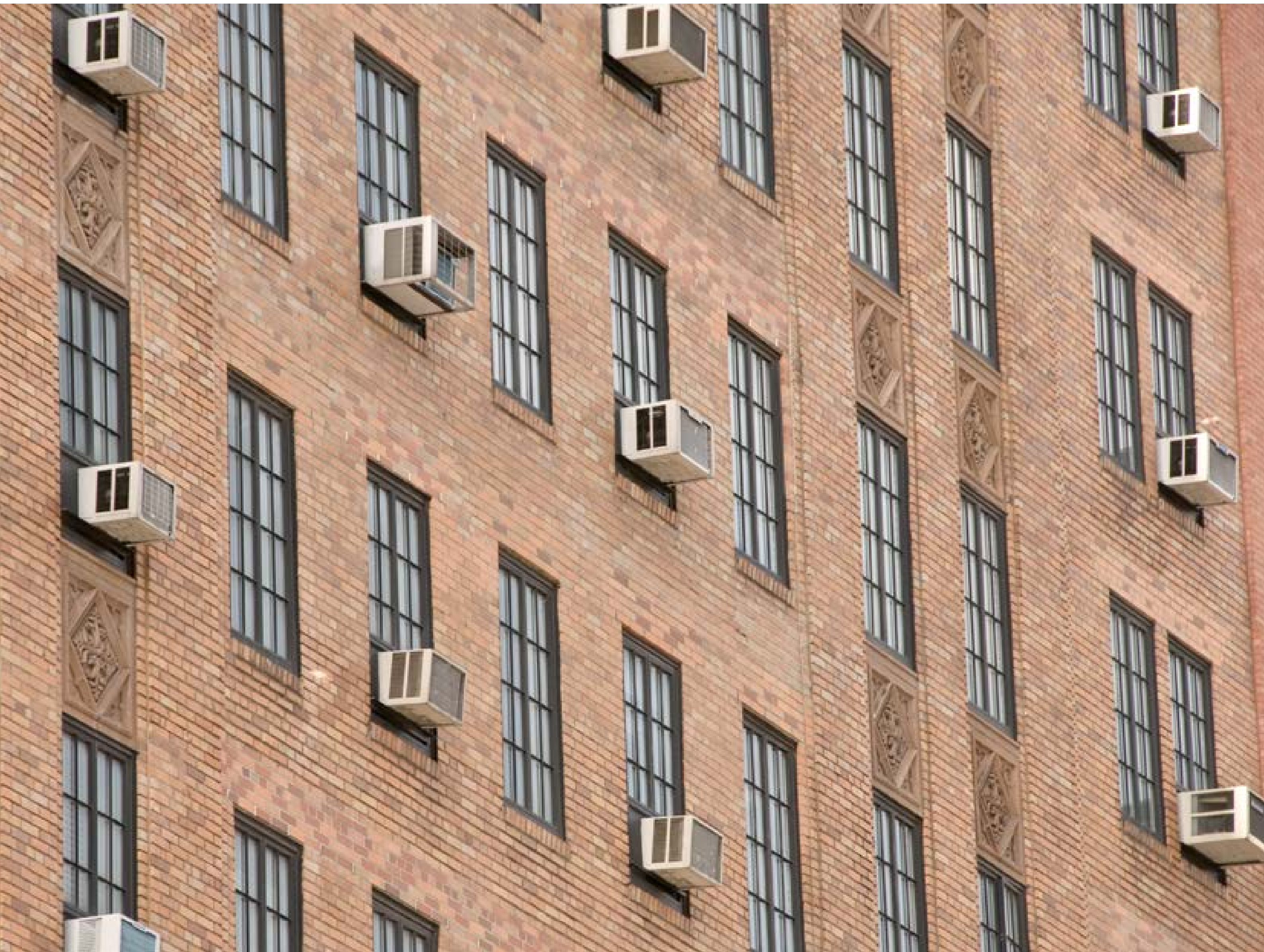
[72] Swiss Re Institute has published extensive research on how the insurance industry can expand access to insurance in emerging and frontier markets. See for example: *sigma* 2/2021 - Emerging markets; *sigma* 2/2016: Insuring the frontier markets; *sigma* 4/2017: Insurance: adding value to development in emerging markets.

Conclusion

Climate change represents a risk to health as extreme weather, heat, air pollution and vector-borne diseases stand to increase globally. Progress made on reducing deaths, for example from conditions such as lung cancer by decreasing emissions-related air pollution, could be reversed. Expansion of vector-borne diseases may cause illness in previously unaffected regions and communities.

However, there are reasons to be optimistic. Many governments are working to reduce carbon emissions, and awareness of societal actions and their impacts on climate change is rising. Strict adherence to agreements to limit emissions and air pollution will limit some of the worst potential outcomes. Technological developments to widen access to renewable energy, as well as offset and reverse carbon emissions, are already underway. Future innovation may accelerate as the commitment to climate action becomes more urgent.

Extreme heat may place millions at risk of heat stroke and heart attacks, but the impact can be minimised by factors such as air-conditioning, hydration and reducing heat exposure. Technology already exists to monitor and remove pollution from indoor air. Anti-mosquito nets and insect repellents are already in use to prevent the spread of malaria and other vector-borne diseases. Recent developments in vaccines and treatments raise hopes for the future. It is important to be cognisant of unintended



consequences of mitigations such as risk to biodiversity by overuse of insect repellents or use of fossil fuels to run AC.

For an insured population, the effects of air pollution, extreme heat and vector borne diseases on mortality are likely to be more modest. We see health insurers playing a growing role in informing and incentivising policyholders on how to adapt to changing climatic conditions. Fragmented, sparse data is a challenge for both policymakers and the L&H insurance community. The ability to forecast risks is only as good as the data available and we aim through this research to contribute to filling the data gap.

Life and health insurers are already actively preparing for the long-term asset impacts. We now see a need for far greater awareness and responses to the threats to balance sheet liabilities in the L&H insurance industry. No matter how climate change will affect mortality and morbidity over the long term, L&H insurers will benefit from proactively acting today for the challenges of tomorrow.

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Swiss Re Management Ltd
Swiss Re Institute
Mythenquai 50/60
8022 Zurich Switzerland

Telephone +41 43 285 2551
Email institute@swissre.com

Authors
Dr Daniel Meier
Dr Prachi Patkee
Dr Adam Strange

Editor
Alison Browning

Managing Editor
Priya Dwarakanath

With thanks for contributions by:
Melissa Gargaro
Dr Minfu He
Dr Thomas Holzheu
Natalie Kelly
Melissa Leitner
Ian Lennox
Dr Christoph Nabholz
Daniel Staib
Lawrence Tsui
Gabriel Webber Ziero
Bernd Wilke

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Media Production, Zurich

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Swiss Re Management Ltd.
Swiss Re Institute
Mythenquai 50/60
P.O. Box
8022 Zurich
Switzerland

Telephone +41 43 285 3095
swissre.com/institute