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Allianz Research

Climate change and the double impact of aging

Executive Summary

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- **Climate change will compound the rise in health expenditure already expected due to aging societies.** With the total number of people aged 60 and older in the EU 27 member states and Norway and Switzerland set to increase to 152mn, from around 130mn today, health costs per capita are likely to rise by +8.5% until 2035. But this could be exacerbated by climate change, which affects older persons disproportionally. Climate change has already caused 157,000 premature deaths in the European countries we analyze between 2000 and 2023.
- **The direct effects of climate change include increased injuries due to extreme weather events such as floods, storms and cyclones, forest fires or heat waves.** The heatwave exposure of persons aged 65 has almost doubled in the decade to 2020, even before the recent spate of record-hot years. Furthermore, while warmer waters in the North of Europe foster the spread of bacteria, the South will be affected by an increase in vector-borne diseases transmitted by mosquitoes such as malaria, dengue fever or the West Nile virus, due to rising air temperatures.
- **The rising prevalence of heatwaves alone could increase the health costs per capita between 2% (Ireland) and 5% (Greece) until 2035.** On average, the cost would be around 4.9% higher than today. However, in combination with population aging, health costs are set to increase between +7% (Denmark) and +14% (Poland) (EU average: 12%).
- **But there are also less-visible indirect and long-term effects to consider.** Heat-related stress and deteriorating sleep quality as well as natural catastrophes could contribute to mental health conditions. At the same time, reduced outdoor activities due to extreme temperatures could result in a further rise in the prevalence of overweight and obesity. Mental health issues and obesity are also risk factors for developing dementia at higher ages. These indirect costs of climate change might add 3% to the per capita health costs in the long run.
- **Adaptation measures need to be implemented, fast.** Urban planning plays a key role here: green spaces, reflective materials and structural modifications can contribute to reducing heat in cities. Relying on air conditioning, on the other hand, is a double-edged sword as it contributes to climate change emissions and aggravates the heat-island effect in cities. Against this background, alternative measures such as the greening of cities are better suited and should be the top priority.

Aging and health costs

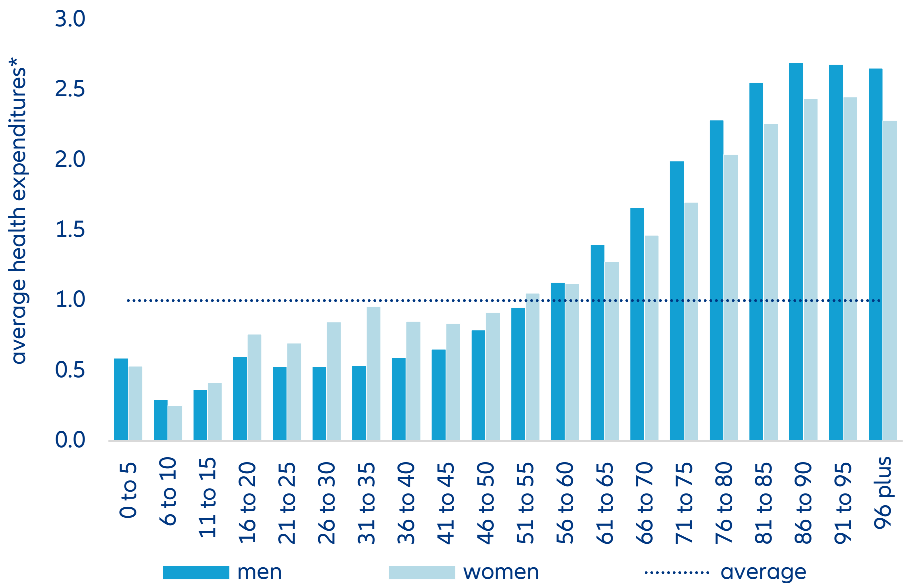
So far, politicians have been mainly concerned with the financial impact of population aging on (public) health systems, since health expenditures per capita increase with age. The total number of people aged 60 and older in the EU27 member states and neighboring EFTA countries Norway and Switzerland is set to increase from around 130mn today to 152mn in 2035.

To assess the impact of aging on the development of health costs in these 29 countries, we abstracted from medical advancements and inflation and assumed that health costs per capita in the respective age groups remained constant. As an approximation for the distribution of health costs by age group, we used the latest available data of the national statistical office of Switzerland. The average health costs per capita ex costs for care and administration were taken from the Eurostat database. To take into account the fact that in some countries the increase in future total health expenditures might be dampened by population decline, we show the developments in per capita terms.

In general, health expenditures increase exponentially in higher ages. In Switzerland, for example, health expenditures are above the total average in the age group 56 and older, albeit to increasing extents. In the age group 56 to 60, health expenditures are around 12% above the total average, while in the age group 61 to 65 they are already more than 30% higher and in the age group 81 and older they are more than twice the average (Figure 1).

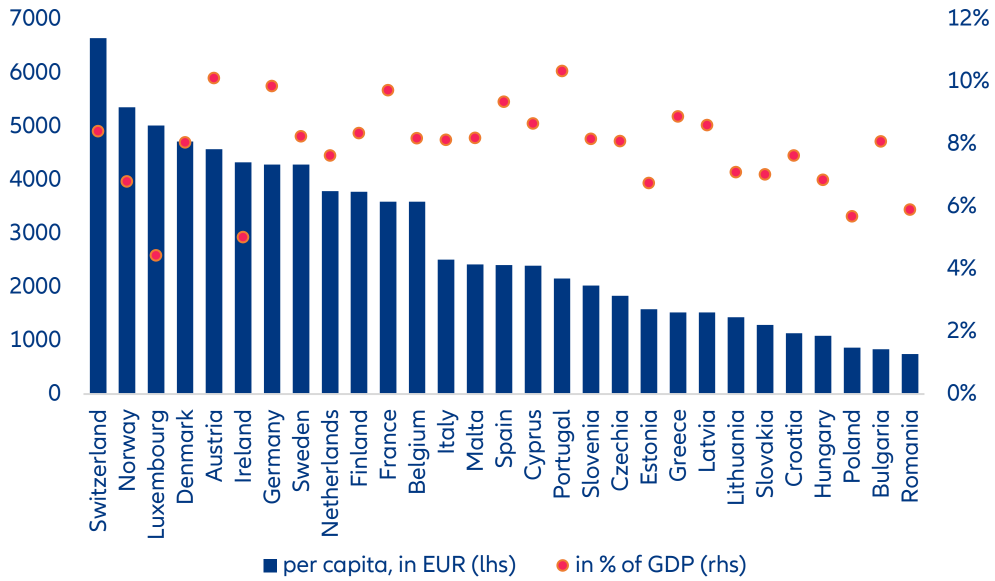
Of course, healthcare expenditures differ markedly between the countries, depending on the overall development level, as well as the generosity and structure of health systems. In the analyzed countries, annual healthcare expenditures per capita in 2021 ranged from EUR746 in Romania to EUR6,650 in Switzerland, with total health expenditures corresponding to between 4.4% of GDP in Luxembourg to 10.3% of GDP in Portugal (Figure 2).

Figure 1: Health expenditures increase with age



*excluding long-term care and administrative expenditures
Source: Federal Statistical Office of Switzerland.

Figure 2: Marked differences in health expenditures*

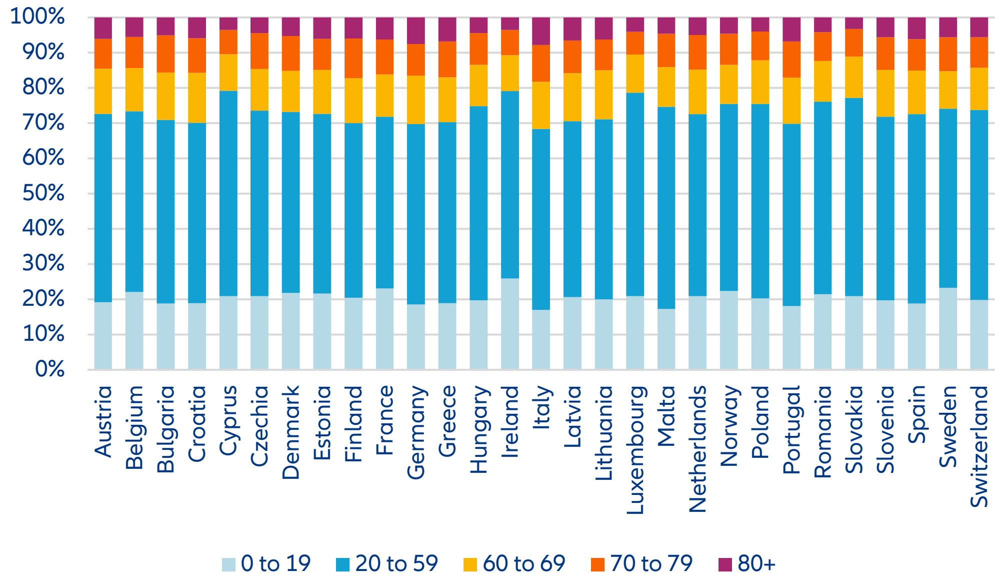


*excluding long-term care and administrative expenditures
Source: Eurostat.

Given the cost structure, the development of health expenditures depends markedly on the shift in the age structures and especially on the development of the population in very high ages, i.e. 80 and older. Already today, between 21% (Cyprus) and 32% (Italy) of the populations are aged 60 and older, while the share of those aged 80 and older ranges from 3% in Slovenia to 8% in Italy (Figure 3).

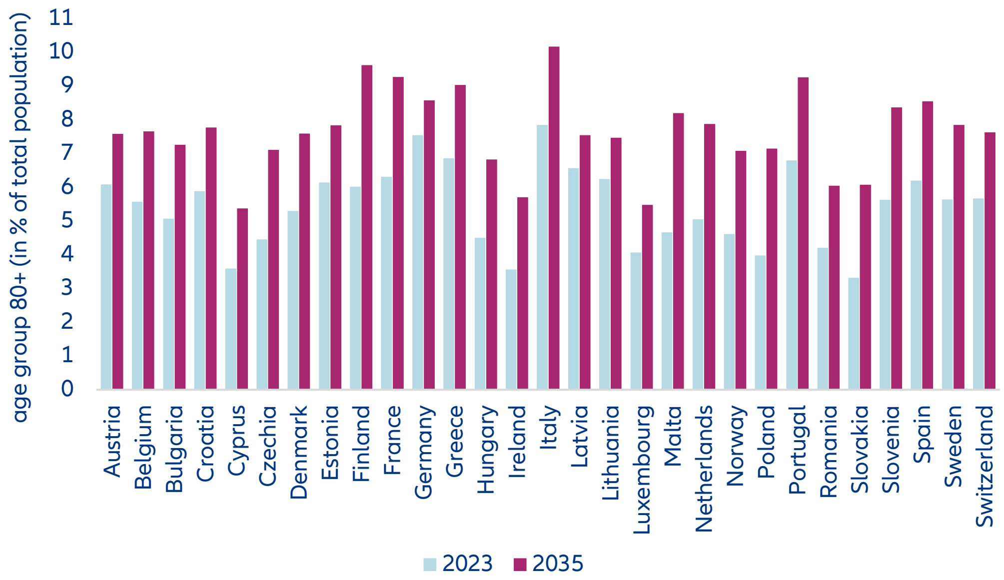
Within the next 10 years, the number of people aged 80 and older is set to increase by +33% from 28.1mn today to 37.0mn in 2035, with the shares by then ranging between 5.4% in Cyprus and 10.2% in Italy, and the strongest increases expected in Poland and Slovakia (Figure 4).

Figure 3: Age structure, by country



Source: UN Population Division (2022).

Figure 4: The EU's population is aging



Source: UN Population Division (2022).

Given these assumptions, health expenditures per capita would increase between 3.8% in Denmark and 10.3% in Spain due to the shifts in age structure alone (Figure 5).

The impact of aging on (public) health spending could be dampened if the onset of age-related diseases such as cardiovascular disease, type 2 diabetes or dementia could be postponed to higher ages by promoting healthier lifestyles, including healthier diets and more physical exercise for example. Until the outbreak of the Covid-19 pandemic this aim seemed to be within reach: In the EU, the average number of life years expected to be spent in good health had increased from 60.9 years in 2013 to 64.2 years at birth in the case of men and from 61.1 to 65.2 years in the case of women. The average 65-year-old men could look forward to 10.2 years in good health and his female peer to an average 10.4 year. However, since the outbreak of the Covid-19 pandemic healthy life expectancy has been declining, with the latest data for 2022 showing a setback to levels comparable to the situation in 2015 (Figure 6).

Figure 5: Aging increases health costs*

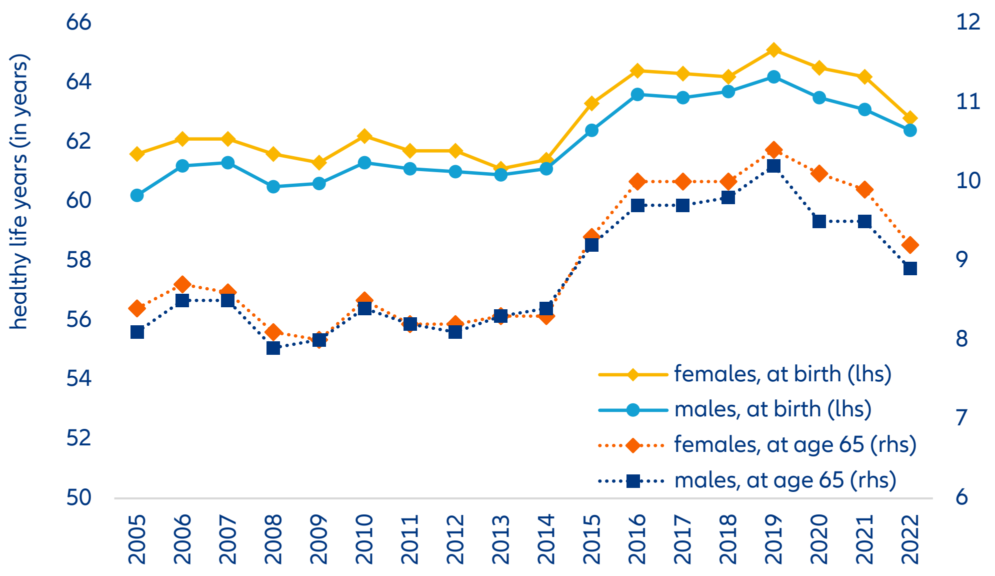
*excluding long-term care and administrative costs

Sources: Eurostat, Federal Statistical Office of Switzerland, UN Population Division (2022), Allianz Research.

At the country level, the average number of healthy life years of newborn boys reached from 53.1 years in Latvia to 70.1 years in Malta, while the span was smaller among girls with the average expected number of healthy life years ranging between 54.6 years in Denmark and 70.3 years in Malta in 2022 (Figure 7).

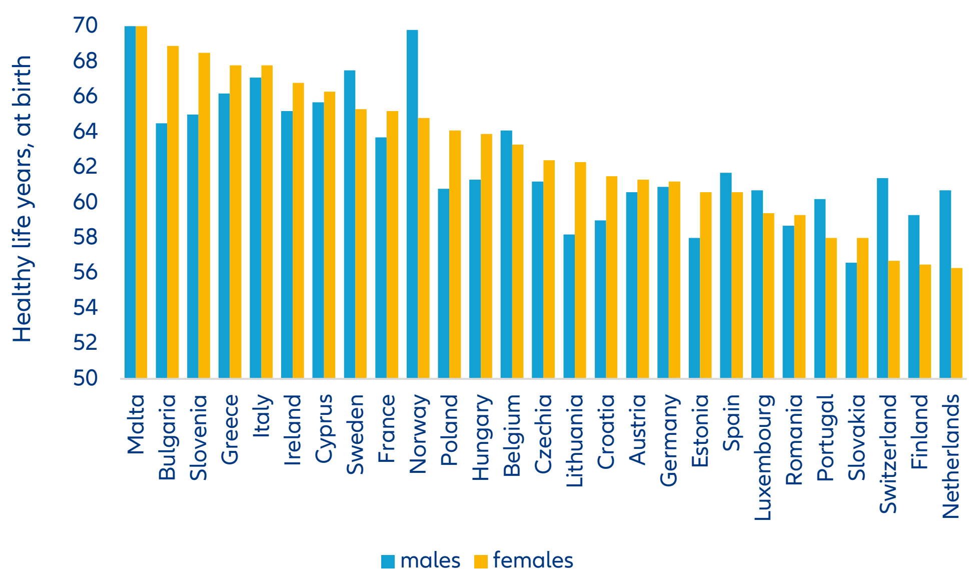
In the meantime, the latest data show a recovery of the average life expectancy in many EU countries. However, climate change threatens to stop or even reverse this trend. Not only because older persons are more vulnerable than younger people, and are thus disproportionally affected by climate change, but also because climate change may trigger behavioral changes in today' s younger population.

Figure 6: Development of the number healthy life years, at birth (in years)



Source: Eurostat.

Figure 7: Differences in healthy life expectancy within the EU, 2022

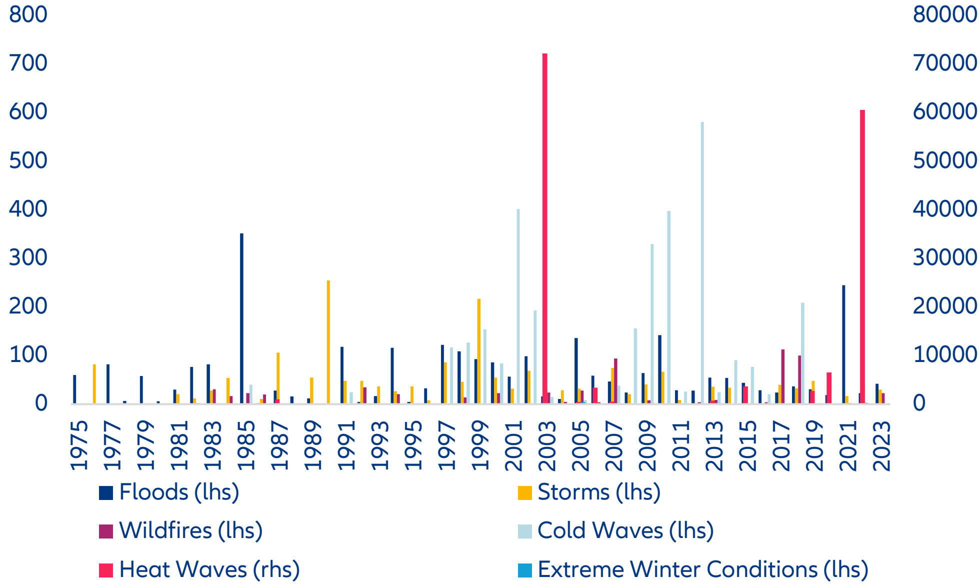


Source: Eurostat.

Climate change has already taken its toll

In fact, climate change has already been responsible for 157,000 premature deaths in the analyzed European countries between 2000 and 2023, with most of them (151,100) the result of heat waves (Figure 8).

Figure 8: Number of deaths caused by natural disasters



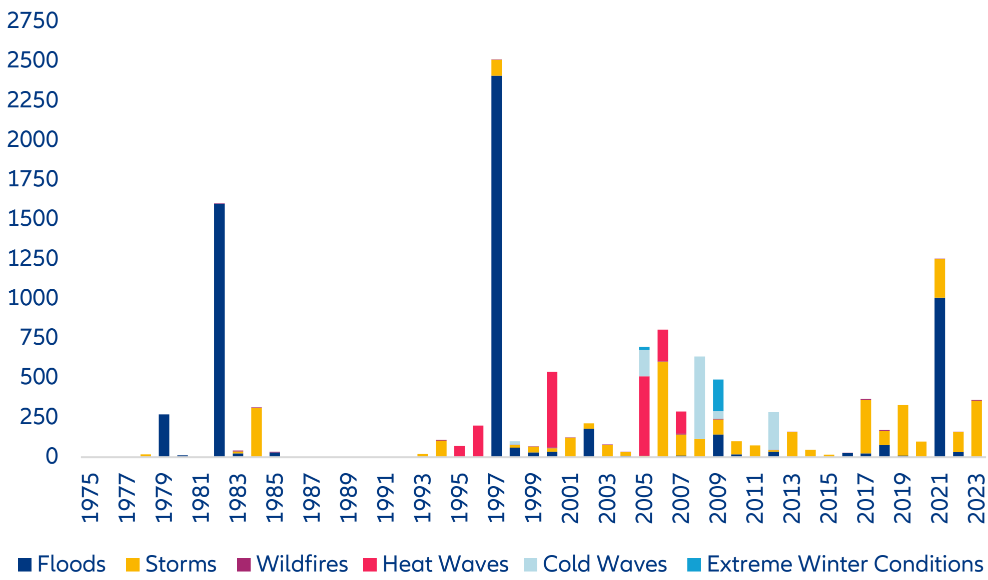
Source: EM-DAT.

For the same period, around 7,400 injuries were reported, with most of them (around 3200) caused by flood events[1] (Figure 9).

In the period between 1975 and 1999 especially, the number of reported deaths and injuries was markedly lower (4,425 and 5,385, respectively)[2]. Indeed, the number of (documented) natural disasters has increased since the turn of the century (Figure 10).

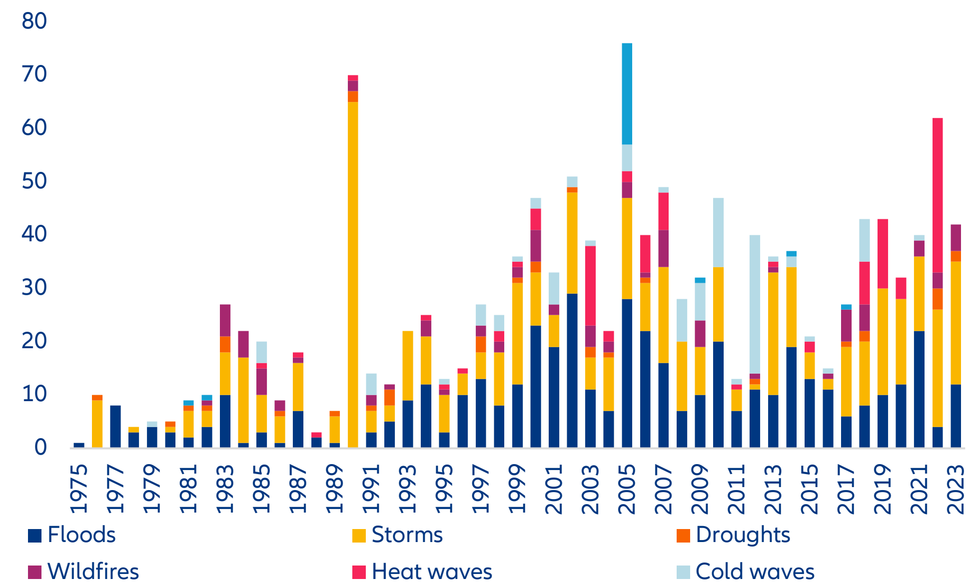
With the likelihood and intensity of heat waves, floods, severe storms, droughts and forest fires expected to increase further, accompanied by worsening air pollution and the spread of infectious and vector-borne diseases previously only found in subtropical regions, healthcare systems need to be prepared to flexibly cope with temporary, often locally or regionally limited, direct effects of climate change on the one hand, and long-term and indirect effects on the other.

Figure 9: Number of injuries caused by natural disasters



Source: EM-DAT.

Figure 10: Natural disasters reported



Source: EM-DAT.

[1] See CRED (2024): EM-DAT.
[2] See CRED (2024): EM-DAT.

Box 1: COP26, NAPs, HNAPs and EU4Health

The authors of the recent Europe report of the Lancet Countdown on health and climate change came to the conclusion that "European health systems remain poorly adapted to climate change-related impacts"[3]

The health sector was for the first time explicitly mentioned in the COP26 by establishing the COP26 Health Programme to "build and develop climate-resilient and sustainable low-carbon health systems".[4] So far, Austria, Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Poland, Spain and the UK have signed respective commitments.[5]

In 2022, 21 European countries had national health and climate change strategies or plans[6], and 10 had conducted a climate change and health vulnerability and adaptation assessment. At the same time, 118 European cities reported that climate change threatens their public health or health services.[7] While the adaption to heatwaves and droughts as well as heavy precipitation and flooding play a major role in all[8] countries' climate adaptation plans, these points are not explicitly considered in all national health plans.

Most national health strategies focused on infectious and vector-borne diseases, increased concentrations of air pollutants, heat impacts on cardiovascular and respiratory diseases and injuries from extreme weather events.[9]

However, the EU4Health program, launched by the EU in response to the Covid-19 pandemic, is designed to improve health systems and boost the EU's ability to respond to health crises. It has a budget of EUR5.1bn for the period 2021-2027, making it the largest health program ever in terms of EU funding. These measures to improve the coordination of health systems between EU member countries including a reserve of medical and healthcare staff could be a starting point for better coordination and cooperation for future emergencies caused by climate change.[10]

[3] Van Daalen, Kim R. et al. (2024): The 2024 Europe report of the Lancet Countdown, p. 13.
[4] Climate-ADAPT (2024): WHO Europe activities on climate change and health.
[5] See WHO (2024): Alliance for transformative action on climate and health.
[6] See European Climate and Health Observatory (2022): Climate change and health: overview of national policies in Europe, p. 3.
[7] See van Daalen, Kim R. et al. (2022): The 2022 Europe report of the Lancet Countdown [...], p. e943.
[8] See European Climate and Health Observatory (2022a), p. 5.
[9] See European Climate and Health Observatory (2022a), p. 6.
[10] See European Commission (2024); EU4Health programme 2021-2027 [...]

The direct effects of climate change

The direct effects of climate change include the rise in injuries due to extreme weather events such as floods, storms and tropical cyclones[11] , forest fires or heatwaves. Young children, older people, persons suffering from chronic diseases and those living in urban areas are the most vulnerable to heat waves. While between 2000 and 2009 the mean average of heatwave exposure of persons aged 65 was 0.65bn person-days, it was already 1.07bn person-days in the decade from 2010 to 2020. As a consequence, the number of people suffering from heat-related symptoms has increased.

At the same time, warming waters could also increase the transmission of pathogenic non-cholerae vibrio, which can cause severe gastrointestinal as well as skin and ear infections, and even lead to necrotizing fasciitis, amputation, sepsis and death. This is particularly a risk for countries around the Baltic Sea with its brackish water, including Denmark and Germany. The length of the coastline affected reached 28,263km in 2022[12]. In contrast, only 4% of the coast of Southern Europe offers suitable conditions for the bacteria, thanks to the higher surface salinity in the Mediterranean. However, the Southern European and Eastern European countries will probably be more affected by an increase in vector-borne diseases transmitted by mosquitoes, such as malaria, dengue fever or the West Nile virus, due to rising temperatures.

An increasing number of (longer) heatwaves also raises the risks of droughts and wildfires. Italy and parts of Spain, for example, have witnessed some of the longest drought periods in decades, while Greece recently faced one of the largest wildfires recorded in the EU, with around 73,000 hectares (730 square kilometers) burnt in 2023, likely deteriorating the slightly declining trend in the number of wildfires in the past. Between 2003 and 2020, Portugal and Greece as well as Bulgaria and Romania reported the highest levels of exposure to wildfire smoke in the EU. With wildfire smoke contributing to the worsening of air quality and increasing air pollution, heatwaves also indirectly contribute to increasing the number of people who suffer from respiratory problems caused or exacerbated by air pollution. Moreover, the earlier and longer flowering seasons of allergenic trees are also affecting the health of those suffering from pollen allergies.

In addition, climate change is increasing the risk of flooding, not only in coastal regions due to rising sea levels, but also around rivers due to heavy rainfall events, as was recently the case in southern Germany. While the focus is usually on those injured by the floods directly, they may also cause a temporary increase of gastrointestinal illnesses[13] or the incidence of diseases transmitted by mosquitoes or parasites in the regions affected.

The latter is also an example of how official statistics might still underestimate the climate change effect on health systems and death rates. The classification of diseases and causes of death have only recently been amended to explicitly state natural disasters or climate change as the specific reason[14]. The above-mentioned potential case of gastrointestinal illnesses, for example, could be diagnosed as diarrhea caused by food poisoning, leaving no hint in the statistics that a flood was the actual trigger.

[11] Storm Daniel (2023): as of Wikipedia "Storm Daniel, also known as Cyclone Daniel, was the deadliest Mediterranean tropical-like cyclone in recorded history, as well as one of the costliest tropical cyclones on record outside of the north Atlantic Ocean. Forming as a low-pressure system around 4 September 2023, the storm hit Greece, Bulgaria and Turkey with extensive flooding." [

[12] See van Daalen et al. (2024), p. 4 and 8.

[13] This could be a result of the consumption of spoiled food due to interruptions in the power supply or the contamination of drinking water, for example. See Butsch, Carsten et al. (2023): Gesundheitliche Auswirkungen von Extremwetterereignissen, p. 44.

[14] See for example Geneva Association (2024): Climate change. What does the future hold for life and health insurance? p. 28.

The indirect or potential long-term effects of climate change

The indirect, long-term effects are less obvious. These could potentially include increases in the prevalence of non-communicable diseases. Stress and deteriorating sleep quality as well as natural catastrophes or other climate-related traumatic events[15] could lead to an increase in the share of the population suffering from mental health conditions (which are still addressed to a lesser degree than physical health impacts[16] in many countries). Furthermore, heatwaves could lead to people reducing their outdoor activities during hotter summers since even light exercise, such as walking, raises the risk of heat stress and heat stroke. This could contribute to a further rise in the prevalence of overweight and obesity.

In southern Europe, the number of hours with heat-related health risks during medium-intensity activities has more than doubled since 1990 to 429 hours per person in 2020. Since mental health issues and obesity are also risk factors for developing dementia in higher ages, the indirect costs of climate change could be even higher in the long run. Furthermore, fighting under-nutrition and especially malnutrition could (re)gain in importance because of crop failures due to droughts and floods, potentially aggravating further the impact of imbalanced diets on health systems.

[15] See Butsch, Carsten et al. (2023): Gesundheitliche Auswirkungen von Extremwetterereignissen, p. 65.

[16] See European Climate and Health Observatory (2022a), p. 3. Exceptions were Austria, Bulgaria, Croatia, Cyprus, Denmark and Malta. Only six out of 34 countries have included mental health in their strategy so far; see European Climate and Health Observatory (2022): Climate change and health: overview of national policies in Europe, p. 4.

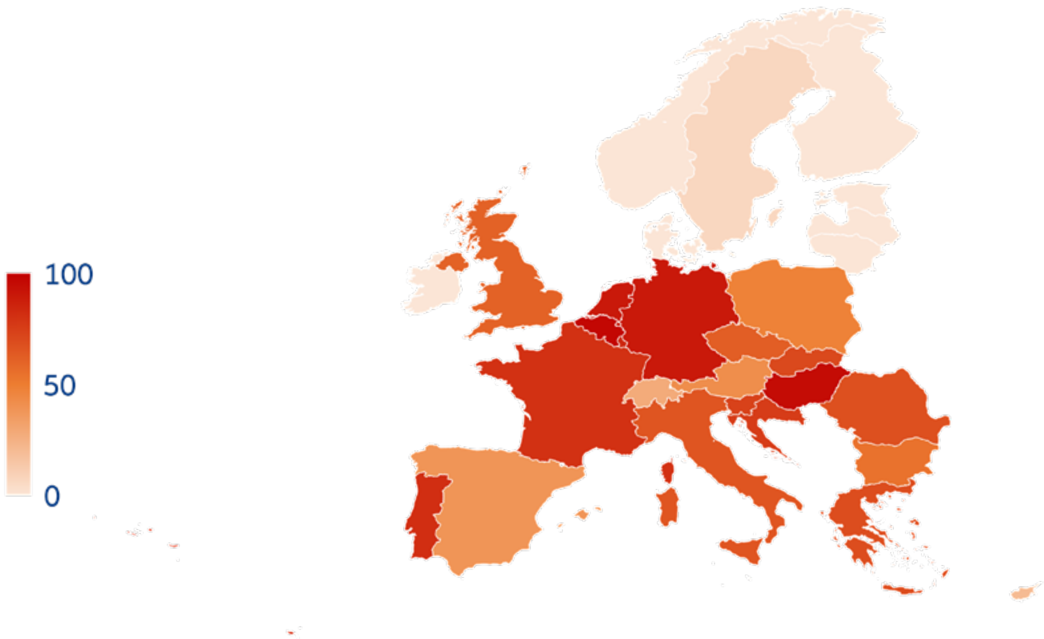
The impact of climate change on health expenditures

The impact of climate change will differ across regions. While eastern Europe could face more air pollution, southern Europe will have to deal with more heatwaves and heat-related illnesses, wildfires, food insecurity, drought and climate-sensitive infectious diseases, like leishmaniasis. Meanwhile, northern Europe will be equally or more impacted by Vibrio infections and ticks.[17]

However, measured in terms of the share of population that is affected, heatwaves and air pollution are likely to have the highest impact: In 2022, in many countries, more than 90% of the population were exposed to hot days for up to two weeks (Figure 11).[18]

The most vulnerable to heat are children and the elderly, with the latter often suffering from cardiovascular diseases that are aggravated during heat periods. This is reflected in mortality rates, which were substantially higher in the higher age classes than in younger age groups during the recent heatwaves. The mortality rates during the heat wave in 2022, which is estimated to have caused more than 61,000 premature deaths in Europe, were markedly higher in the age groups 65 and older than in the age group 0 to 64. The highest death rates in the age group 80 and older were found in Italy, Spain, Greece, Bulgaria, Croatia and Portugal (Figure 12).

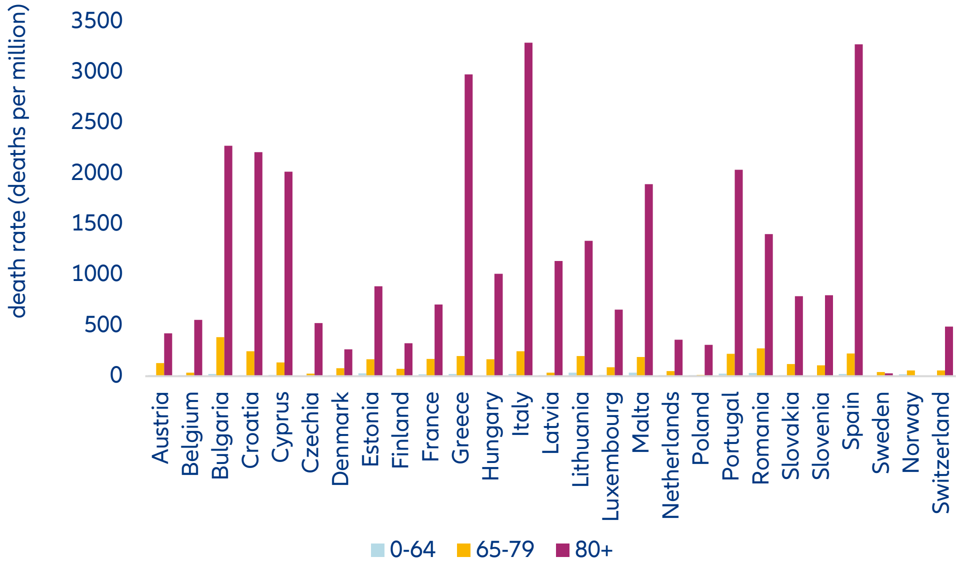
Figure 11: Share of population exposed to hot days for up to two weeks (in % of population)



Source: OECD.

[17] See van Daalen, Kim R. et al. (2023): Approaching unsafe limits [...], p. 1 and van Daalen, Kim et al. (2024): The 2024 Europe Report,[...] p. 10
[18] See OECD (2024): Dataexplorer.

Figure 12: Older people are more vulnerable to heat



Source: Ballester et al. (2023), p. 1862.

The question is, how can we prepare health systems for future heatwaves, especially with respect to an aging population? For Germany, the Bundesärztekammer warned that 25% of the people aged 65 and older have an increased risk for inpatient hospitalization during heatwaves. In the long run, this share could reach 85%.[19] According to the statistical office of Germany,[20] for example, the number of people hospitalized for dehydration increased to more than 100,000 persons during the hot summers of 2018 and 2019. If we assume that the group of patients suffering from dehydration includes mostly elder people, who had to be hospitalized, this would have corresponded to around 1.2% of the age group 75 and older.

People suffering from obesity, cardiovascular diseases[21], respiratory diseases and diabetes also face an elevated risk for heat-related illnesses, regardless of their age, since these factors lower the physiological ability to respond to heat stress. In this context, the rising shares of people suffering from obesity are alarming. According to latest available data, in 2022, 30.7% of the women aged 18 and older and 37.1% of their male peers were obese[22] in Romania. However, there are marked differences between the member countries: France recorded the lowest shares with 9.6% of the female and 9.8% of the male population being obese (Figure 13).

Since the prevalence of obesity increases with age (Figure 14) on the one hand, and there is a higher share of younger people suffering from obesity, thus increasing the vulnerable group on the other, the combination of these two developments might aggravate the impact of heat waves on health systems.

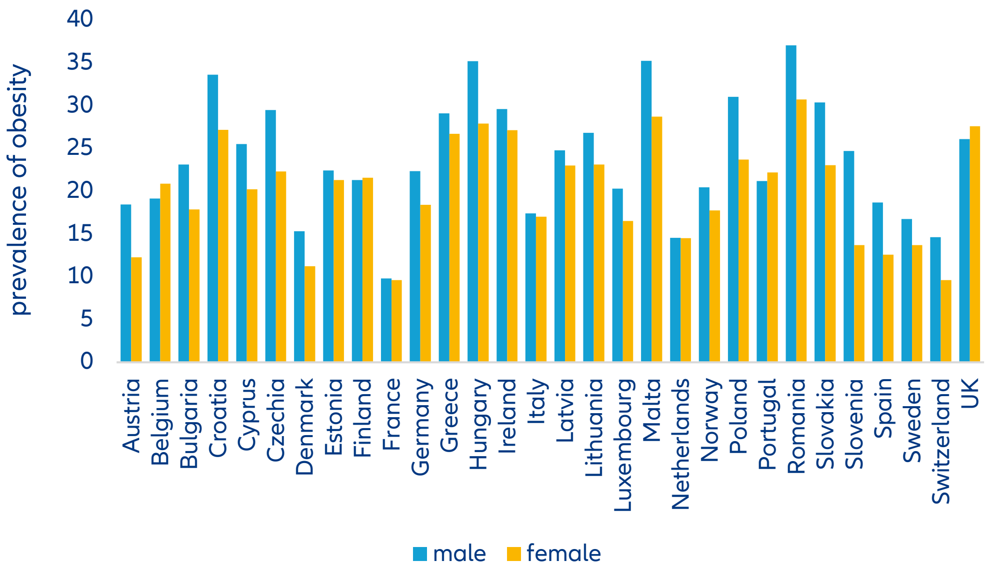
[19] See Bundesärztekammer (2022): Gesundheitswesen auf Hitzewellen nicht vorbereitet

[20] See Statistisches Bundesamt (2023): Durchschnittlich 1500 Krankenhausbehandlungen im Jahr bedingt durch Hitze und Sonnenlicht.

[21] Cardiovascular illness is the primary cause of death during heatwaves.

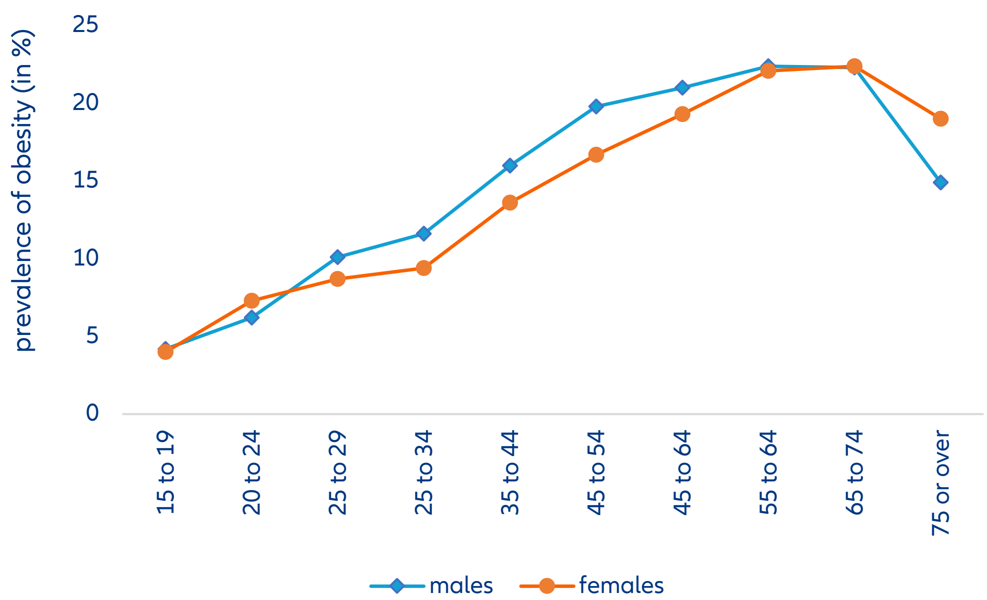
[22] Corresponding to a Body-Mass-Index of 30 and higher. See World Health Organization (2024).

Figure 13: Prevalence of obesity, age group 18 and older (2022)



Source: WHO.

Figure 14: The prevalence of obesity by age group (2019)



Source: Eurostat.

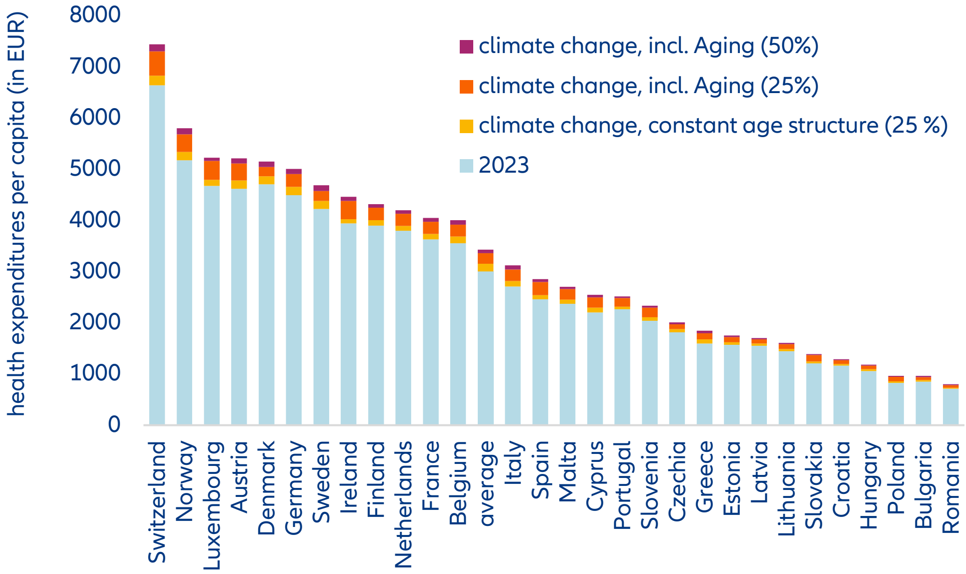
Given the data constraints due to the above-mentioned limits of the International Classification of Diseases, we tried to assess at least part of the impact of climate change on the health system by estimating the potential future number of hospital admissions and related costs caused by heatwaves. In the medium-impact scenario, we assumed that an additional 25% of the population aged 75 or older and that one in three of those suffering from obesity in the respective age groups will need to be hospitalized due to cardiovascular health problems. In our high-impact scenario, 50% of the population aged 75 or older in a country will need to be hospitalized. The costs per capita as well as the average length of treatment were kept constant. The distribution of the costs for inpatient treatment by age group in Switzerland served as approximation for the cost distribution. The source for health expenditure per capita by function as well as the obesity rates by gender and age group was Eurostat.

In order to isolate the aging effect, we assumed again that the age structure remained constant. In the medium-impact scenario, climate change driven hospitalizations alone would increase per capita costs for health by +4.9%, with growth rates ranging between +2% in Ireland and +5% in Greece. However, if we also take into account population aging, our model shows an average expenditure per capita rise of +12% until 2035, with cost per capita increasing between +7.2% in Denmark and +14% in Poland. In the high-impact scenario, the average per capita expenditures in the EU would increase by +14%, with our model showing in some countries like Poland, Greece or Spain growth rates around +16% (see figure 15).

Add an increasing number of accidents due to heat stress, a potential jump in vibrio infections in Northern Europe and of dengue fever in Southern Europe during the summer holiday season and health systems might face a perfect storm. The single direct effects might be manageable, but a potential combination of several factors could easily bring health systems to their capacity limits. In the medium-impact scenario, the increase in hospitalization rates would correspond to 29.7mn additional inpatients, while in the high-impact scenario it would be an additional 43.3mn, most of them elderly.

In order to assess the indirect long-term effects, we assume that the onset of age-related diseases occurs on average five years earlier, assuming that, all other factors constant, the average costs per capita in the age group 56 to 60 would be the same as in the age group 60 to 65. In this case, even if we isolate the aging effect, the health costs per capita in 2035 would be around 3.0% higher than today.

Figure 15: Climate change set to increase health costs, too



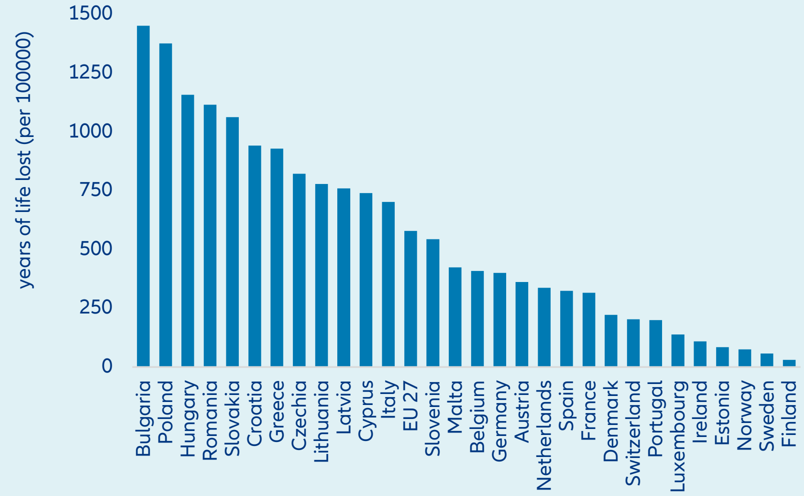
Source: Eurostat, UN Population Division, Allianz Research.

[23] In all scenarios, the costs for making the health sector, which currently accounts for 4.6% of global CO2 emissions, more climate friendly or adapting its infrastructure to climate change, are not taken into account.

Box 2: The other silent killer: Air pollution

Not only heat waves, but also air pollution is another silent killer. In 2021, PM2.5 (fine particulate matter no greater than 2.5 microns in diameter) pollution was attributed to 253679 premature deaths in the EU27. However, there are marked differences between the member states, showing in the rates of premature deaths and years of life lost due to air pollution. In most eastern European member states these two markers are still markedly above the EU27 average. Hungary, Poland, Romania and Slovakia were particularly affected with more than 1000 years of life lost per 100000 inhabitants, compared to 578 in EU average and merely 31 in Finland (Figure 16).

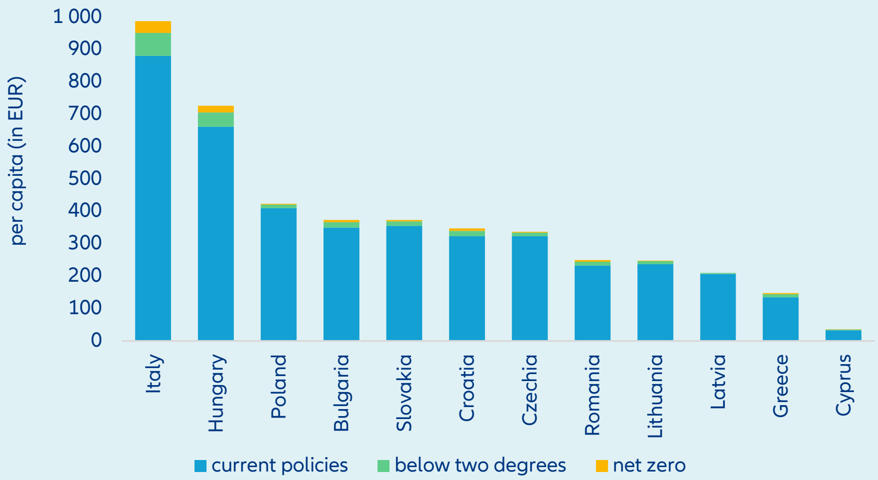
Figure 16: Years of life lost, 2021 (per 100000 people)



Source: Eurostat

Lower greenhouse gas emissions reduce the risk of premature deaths, cardiovascular and respiratory diseases. However, given the costs of reduction measures, the question is what are the economic benefits? In order to answer that question, the World Health Organization developed the Climate change Mitigation, Air Quality and Health (CLIMAQ-H) software tool to quantify the impact of greenhouse gas emission. In the analyzed European member countries, the total economic benefits from averted deaths, hospital admissions and lost workdays would range around EUR 100bn, in 2030. With the economic benefits per capita ranging between EUR36 in Cyprus and around than EUR990 in Italy, if the targets of the net zero emission scenario would be realized (Figure 17).

Figure 17: The economic benefits of reducing greenhouse gas



Source: Eurostat, WHO, NFGS, UN Population Division.

The reduction of mortality rates would have the highest impact, accounting for more than 90% of the economic benefits in the analyzed countries. However, any reduction in morbidity, especially in the numbers of cardiovascular and respiratory hospital admissions would relieve the burden on the health care systems.

Going green is the better air conditioner

Given the impact of heat on human health, adaptation measures need to be implemented, fast. Air conditioning can help to reduce heat stress and the risk of heat-related cases of illness markedly. Given that currently only 16% of the European households have air conditioning, the potential is huge. But apart from the fact that not every household can afford it, it is also a double-edged sword. As long as the energy system is not emission-free, air conditioning contributes to climate-change emissions; air conditioning related CO2 emissions in Europe are already equivalent to the total CO2 emissions of Bulgaria.[24] Furthermore, in urban areas, air conditioning also aggravates the heat-island effect.

Against this background, alternative measures like the greening of cities, are better suited and should be prioritized. Urban planning plays a key role here: green spaces, reflective materials and structural modifications can contribute to reducing heat in cities. Increasing green and blue spaces in Europe's densely populated areas could reduce the impact of heatwaves by reducing local temperatures, and by improving air quality. Another positive effect of more green areas and better access to nature is the improvement in wellbeing and mental health. In fact, there has been already some progress in this respect: population-weighted greenness has already increased in most European countries, especially in southern Europe, though western Europe is still lagging behind.[25]

One of the pioneers in this respect is Singapore's "Cooling Singapore" project, a multi-discipline research project to develop solutions that indicate how urban planning and greening could help to mitigate the impact of climate change (see Box 3).

[24] See van Daalen, Kim R et al. (2024): The 2024 Europe report p. 13.

[25] See van Daalen, Kim R. et al. (2022): The 2022 Europe report of the Lancet Countdown [...], p. e943.

Box 3: Cooling Singapore

According to the latest climate projections, in Singapore, the average annual occurrence of warm days with daily maximum temperatures exceeding 34°C is expected to increase from around 76 days to 178 days by mid-century, and to 188 until the end of the century in the low-emission scenario. However, in the high-emission scenario, this number would climb to 288 days by mid-century and reach 340 days at the end of the century. The annual number of very hot days in which the temperature is even higher than 35°C is expected to increase from 21.4 days to 73 and until end-century to 85 days in the best case. In the high-emission scenario this number is projected to increase to an average 129 and 305 days per annum, respectively.[26] Furthermore, the number of warm nights in which the minimum temperature is 26.3°C or higher is also projected to increase markedly: from 76 nights per year today to more than 330 nights in all three scenarios[27]. That is, in the future, almost every night will be a warm night, which could have negative impacts on sleep quality and mental health in the long term.

Air conditioning is one way to cope with the increasing heat and humidity. However, relying on air conditioning alone aggravates the urban heat-island effect, which averages around 4°C but can peak at 7°C in Singapore[28] and drives up energy consumption further. In order to find ways to dampen the temperature increase, the multi-disciplinary research project "Cooling Singapore" was initiated. The idea was to develop a digital urban twin to better understand the impact of planned measures and the impact of heat effects on buildings, transport and industry.

An important element in climate-change adaptation is the greening of urban areas, including greening roofs, vertical greening, planting trees or greening parking lots. These measures can help reduce the ambient temperature as well as energy consumption and at the same time improve the quality of life.

The greening of roofs, for example, can reduce the surface temperature of a roof by 15-45°C compared to keeping a conventional roof. Energy consumption could be reduced by 10% and depending on the number of buildings with green roofs in an urban area, the air temperature at pedestrian level could be reduced by 0.5-1.7°C.[29] Vertical greening, i.e. growing vegetative elements on the external façade of a building, can reduce the external surface temperature of the building, which helps to keep the temperature in the building cooler or at least more stable. Green facades and so-called living walls also reduce the surrounding temperature.

Planting trees and replacing the concrete used for the pavements or parking lots at least partially by grass could also help to reduce temperatures and the heat-island effect in urban areas. Estimates suggest that tree-shadowed streets could lower air temperature between 0.9°C and 2.6°C. However, when planning where to plant trees, the wind flow should be considered to avoid building windshields and thus hindering cooling. Even local and microscale urban greening can help to reduce heat exposure and improve well-being. This can be achieved by transforming some urban areas into midsize parks or by planting trees along a street. In fact, according to the simulations, if all buildings in Singapore were greened as planned, the average temperature would be 2°C degrees lower.

[26] Meteorological Service Singapore. Centre for Climate Research Singapore (2024): Climate change projections to 2100, p. 54.

[27] Meteorological Service Singapore. Centre for Climate Research Singapore (2024): Climate change projections to 2100, p. 52.

[28] See ETH Zürich (2021): Strategies for Cooling Sinapore, p. 5.

[29] See ETH Zürich (2021): Strategies for Cooling Sinapore, p. 20ff.

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