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Health-related costs of climate change in Germany

Saskia Reuschel
Britta Stöver

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Authors

Saskia Reuschel

Tel.: +49 (0) 541 40933-283, e-mail: reuschel @ gws-os.com

Dr. Britta Stöver

Tel.: +49 (0) 541 40933-250, e-mail: stoever @ gws-os.com

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Abstract

Climate change has a severe impact on human health and the healthcare system and also causes economic costs. The risk arises in particular from heat and rising temperatures. While the effects of climate change on health and the type of potential costs have already been discussed in numerous publications, there are little information on the exact amount of these costs, especially for Germany. The aim of this paper is to deepen the understanding about the future economic costs of climate-related health damages in Germany. We carried out a scenario analysis using the macro-econometric model INFORGE / PANTA RHEI, considering three climate impacts: hospital admissions due to heat, heat stress for workers, and reduced productivity for allergy sufferers. The results show that the factors affecting labour productivity in particular cause high costs in the form of losses in GDP. Overall, the increased health risks from climate change result in GDP being 1.3% lower in 2050 than in the reference scenario.

Keywords: climate change, health, economic modelling, scenario analysis

JEL classification: Q51, Q54, C53

1 Introduction

Europe is the fastest-warming continent worldwide with temperatures rising twice as fast as the global average since 1980 (C3S 2024). The frequency and severity of extreme events such as widespread flooding, droughts, heat waves are increasing (EEA 2024). These extreme events as well as the continuous rise in temperature affects human health in many different ways, ranging from heat stress and heat-related illnesses to mental health problems, vector-borne diseases and allergies. One consequence of this is, that heat-related mortality has increased by around 30% in the past 20 years (C3S 2024, p. 20). Urbanisation, demographic ageing and climate change will cause this trend to become more pronounced in the future (C3S 2024).

The costs associated with climate change and health are as complex and multi-layered as the different impacts: directly affected are private and public healthcare costs due to injuries, heat-related illnesses, vector-borne diseases, anxiety, depression or post-traumatic stress disorder. Other costs arise from emergency medical services, rescue operations and the reconstruction of healthcare infrastructure after extreme weather events or from productivity losses due to illness, disability or premature mortality (Ebi et al. 2021). Climate change contributes to biodiversity loss, affecting ecosystems and the delicate balance of species. This loss can impact human health directly by disrupting food chains and indirectly by potentially reducing the availability of natural products with medicinal properties. In addition to the purely monetary aspects, there are also social and ecological dimensions that need to be taken into account. Low-income communities, marginalised groups, and regions with limited resources may face more significant health challenges, exacerbating social disparities in health outcomes. Climate change induced migration can strain social systems and create challenges related to access to healthcare, housing, and social services. Additionally, the health impacts of climate change in one region can have cascading effects globally, emphasizing the interconnectedness of health, environment, and economies on a planetary scale.

The collaboration “Lancet Countdown in Europe” provides indicators monitoring the links between health and climate change (van Daalen et al. 2022). The heat-related indicators (indicators 1.1.1 to 1.1.4) show an increase in heat exposure and vulnerability, physical activity related heat stress risk, and in heat-related mortality. The infectious disease indicators (indicators 1.3, non-cholerae Vibrio, West Nile virus, dengue and malaria) point to a rapidly escalating climate suitability for water-borne and vector-borne diseases. The allergen indicator (indicator 1.4) reveals that the clinically relevant pollen seasons for three tree species (birch, alder and olive) start earlier each year in Europe. The indicator mapping the change in labour supply (indicator 4.1.2), already displays a decline in the number of working hours in the past years.

Zuberbier et al. (2014) describe the general economic burden of allergic diseases with no direct link to climate change: Allergies are the most frequent chronic disease in the European Union and negatively affect quality of life, social life, sleep and school/work performance but only 10% of patients are treated optimally. The authors estimate total costs of allergic diseases per worker to range between 1,373 to 2,218 Euro summing up to a total amount of 54.9 billion to 150.8 billion Euro in EU. However it can be assumed that climate change influences the length and severity of allergy-related illnesses by shifting and extending the pollen season, changing the pollen concentration and allergenicity of the pollen and shifting the geographical occurrence (Climate ADAPT 2022). This connection suggests a further increase in the number of allergy sufferers and the associated costs in the future.

The recently published DAK Health Report also addressed the issue of climate change in the form of heat: Sick leave increases significantly in Germany due to heat, but is still overcompensated by reduced illnesses in autumn/winter (Dehl et al. 2024). However, the authors stressed that performance is impaired, as most employees continue to work despite health problems caused by the heat. The health impairments caused by heat stress primarily manifest themselves in the form of circulatory problems, fatigue, sleep problems, increased sweating and headaches. In the survey, 35% of outdoor workers and 20% of indoor workers stated that they were severely stressed by the heat and 74% of this group also observed a loss of productivity (Dehl et al. 2024). The report focused on the health outcomes and thus made no assessment of related costs.

While the effects of climate change on health and the type of costs that can arise from it have already been discussed in numerous publications (Bobb et al. 2014; Kjellstrom et al. 2016; Ebi et al. 2021; van Daalen et al. 2022; van Daalen et al. 2024), there are hardly any statements on the exact amount of these costs, especially for Germany.

The aim of this paper is to deepen the understanding about the future economic costs of climate-related health damage in Germany. We derive suitable parameters for a scenario analysis from the existing literature. The scenario analysis is carried out using the macro-econometric model INFORGE/PANTA RHEI, which enables the direct and indirect effects of health changes to be analysed through the detailed representation of economic relationships and interdependencies. The scenario analysis focuses firstly on the aspect of heat stress, which will almost certainly increase in intensity and frequency in the future, and secondly on the extension of the pollen season and thus the allergy season.

The results show that the factors affecting labour productivity in particular cause high costs in the form of losses in GDP. Overall, the increased burden on health due to climate change means that GDP in 2050 will be 1.3% lower than in a scenario without ongoing climate change. Between 2024 and 2050, the losses add up to around 530 billion Euros. However, these costs can easily be reduced with suitable adaptation measures. The professional treatment of allergy sufferers, the reduction of heat islands in cities, cooling clothing and sun protection for outdoor professions and a raise of awareness among the population all contribute to reducing the health costs of climate change.

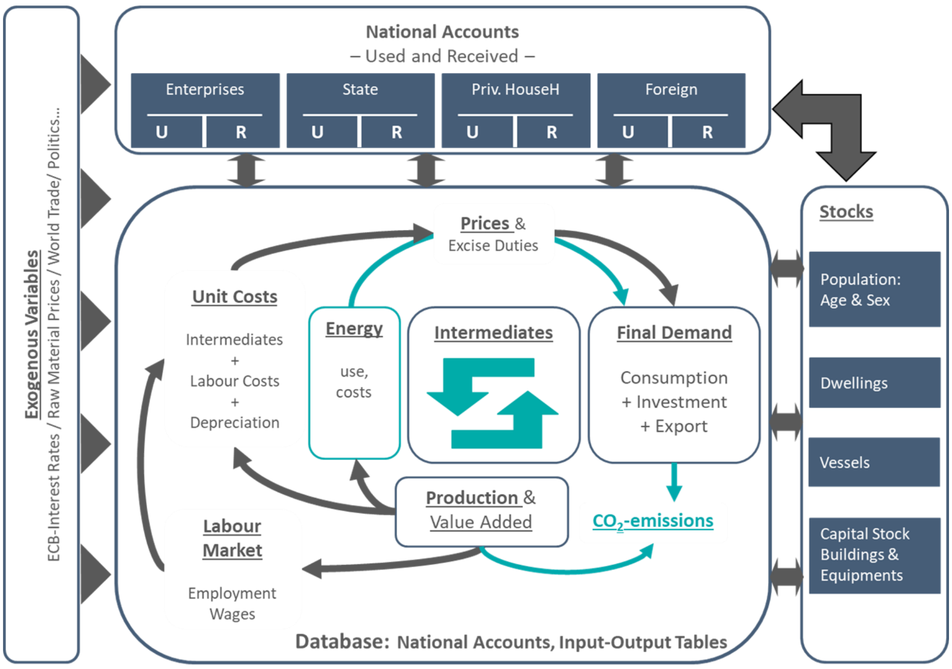
2 Methodology

To make the consequences of climate change on health measurable in terms of costs, we used the technique of scenario analysis. The narrative and the related parameters of the scenario analysis were derived from existing literature. The scenario analysis was carried out in an econometrically sound macroeconomic model environment.

2.1 Model

The economic model INFORGE/PANTA RHEI, that is used in this context to quantify the effect of climate change on health, is a macro-econometric input-output model. The model philosophy does not follow equilibrium theory, but uses approaches from evolutionary economics, i.e. explain developments from the past via estimating equations and parameters and extrapolate them into the future (Lehr and Lutz 2020). Therefore, the model methodology allows for myopic behaviour among market actors as well as imperfect markets such as incomplete competition, partially rigid prices and market dependencies, and determines mark-up prices (Becker et al. 2022).

Figure 1: The model structure of INFORGE



Source: own figure.

The model INFORGE/PANTA RHEI is a country model for Germany being fully integrated into the System of National Accounts including input-output interdependencies (see Figure 1 and Becker et al. 2022). Thus, interactions, indirect effects and other cause-effect relationships are mapped at a high sectoral level of detail. It is designed to analyse complex socioeconomic and economic structures including their dependencies and assess economic, energy, climate and environmental policies up to the year 2050. Thus, the model provides empirically based long-term development and offers the possibility of scenario based analysis.

2.2 Scenario assumptions

We used scenario analysis to assess the costs of climate change related to health. We compared two different developments, one representing changes in health due to climate change (climate change scenario) and one in which climate change does not continue (reference scenario). The difference between the reference and the climate change scenario accounts for the loss in GDP and represents the costs of climate change.

For the climate change scenario we focused on three aspects of the impacts of climate change on health: increased hospital admissions due to heat, reduced performance in hay fever allergy sufferers and reduced work performance due to discomfort and health impairment due to heat. We chose these three areas, as there were sufficient quantifiable information available for setting parameters.

Fehler! Verweisquelle konnte nicht gefunden werden. gives an overview of the scenario a ssumptions. For increased hospital admissions due to heat we argue that heat exposure causes health problems, particularly to older people (Hsiang et al. 2017), which lead to higher healthcare expenditure due to increased hospital admissions (Barrage 2023; Hübler et al. 2008; Hübler 2014; Karlsson and Ziebarth 2018; Limaye et al. 2019; Schmuker 2021). In order to capture the additional costs of heat days in the healthcare system, the healthcare expenditure per capita was increased. We assume an increase of around 17 euros per capita (0.09 % per capita) up to 2050, which corresponds to a total of around 400 million euros in 2050.This results in additional expenditure in the healthcare system, which the government compensates for by making savings on other state services.

For the reduction in the performance of hay fever allergy sufferers, we assumed that the proportion of allergy sufferers among employees corresponds to that of the population. In 2019, 6% of the population suffered from a hay fever allergy, 19% more than in 2010 (Holstiege et al. 2021). We have projected this development linearly until 2050, resulting in an increase of 54% allergy sufferers. Following Zuberbier et al. (2014), we have assumed that the ability to work during the allergy period - which we assume takes up three quarters of the year - decreases by 20%. With these assumptions, the average annual working time per employee was reduced by 1.4% by 2050.

The third effect of climate change on health results from the heat stress experienced by employees. The results of the DAK Health Report show that 35% of outdoor workers and 20% of indoor workers experience a high level of stress due to heat and 74% of this group stated that their productivity was noticeably impaired as a result (Dehl et al. 2024). This group corresponds to 17% of employees in Germany. Based on Zander et al. (2015), we assume a productivity loss of 35% on hot days. According to RCP 4.5, there will be approx. 8.3 hot days per year in 2050. A working day in Germany has an average of 5.2 working hours due to the mix of full-time and part-time workers. Overall, this results in a loss in annual working hours of 0.7% by 2050.

The climate change scenario was designed in such a way that the impact of climate change on health could be assessed. This means that reactions to mitigate climate change or to adapt to its impacts were not integrated into the scenarios.

Table 1: Scenario assumptions

Climate signal	Effect	Assumption (2024-2050)
Heat	Increased hospital admissions for elderly people	Increase in health expenditure per capita: +17 Euro (+0.09 %)
Temperature	Extension and intensification of the flowering period with longer and more intense allergic reactions	Loss in average annual working hours per capita: -1.4%
Heat	Heat stress for workers	Loss in average annual working hours per capita: -0.7%

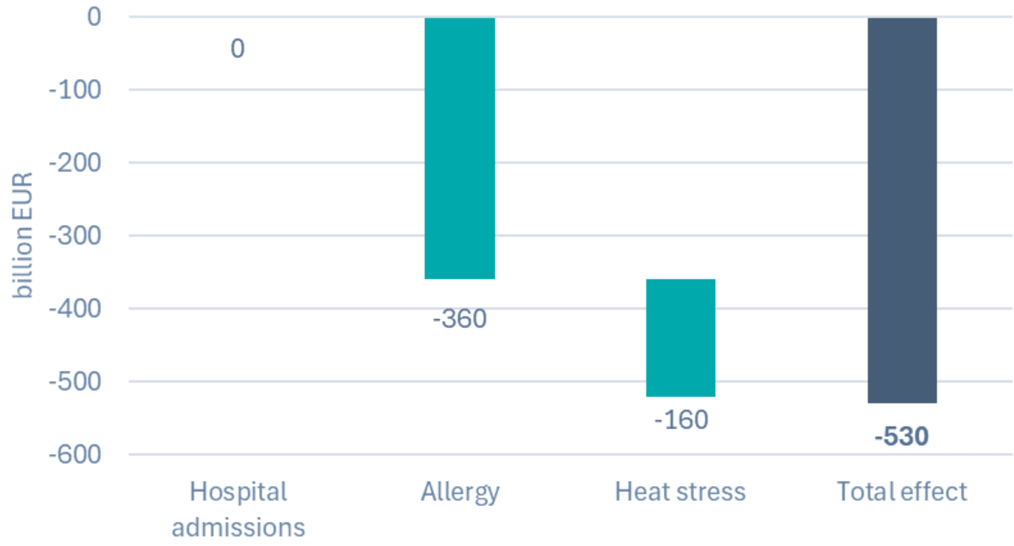
Source: own compilation.

3 Results

To assess the economic costs of climate-related health damages in Germany, we carried out a scenario analysis using the macro-econometric model INFORGE / PANTA RHEI. Figure 2 shows the real GDP losses for each climate impact considered and of the climate change scenario in total. The health effects caused by climate change could lead to a loss in real GDP of more than 500 billion euros by 2050. In 2050 GDP will be 1.3% lower than in a scenario without ongoing climate change.

A breakdown according to the individual scenario components also depicted in Figure 2 shows that allergies in particular contributed to these losses: the loss of performance of employees suffering from untreated allergies accounted for more than 70% of the total loss in GDP corresponding to a total sum of 360 billion euros. In general, the loss of productivity of employees had a clearly negative effect in the scenario assessment, while the increase in hospital costs was barely perceptible. The high contribution of productivity losses to total costs indicates a high sensitivity of the settings with regard to labour productivity. The settings of the parameters should therefore be critically reviewed and the results should be interpreted as an initial assessment. The scenario results are discussed in depth below, focussing in particular on the points of performance losses due to allergies and heat stress.

Figure 2: Contribution of the climate impact to the accumulated GDP loss (billion Euros, rounded to 10, 2024-2050)



Source: own figure.

4 Discussion and Conclusion

At first glance, the costs of climate change appear very high. In addition to the aforementioned constraint that no climate mitigation and adaptation measures were taken into account in this scenario analysis, there are further points that need to be discussed.

The assumptions about the future development of allergy sufferers, the share of climate change in this and the associated loss of working hours are particularly relevant and critical for the scenario results. The growth rate of future allergy sufferers was derived from the previously known growth in treated allergy sufferers. The previous historical growth could be distorted if more and more allergy sufferers are being treated without the total number increasing. Unfortunately, the time series does not provide any information on this. However, the results of the literature study by Gutowska-Ślesik et al. (2023) indicate that the number of allergy sufferers has increased significantly worldwide. It could therefore be concluded that most of the observed increase is due to an increase in prevalence. The proportion in the increase of allergy sufferers that can be directly attributed to climate change is also very uncertain. In addition to climate change, factors such as air pollution, lifestyle (diets) and a sterile, urban environment can also be triggers for an increase in allergies (Edwards-Salmon et al. 2022). Due to a lack of detailed information on the contribution of climate change, the linear extrapolated increase in allergy sufferers was attributed entirely to climate change. The effect of this assumption on the scenario results need to be reviewed in a sensitivity analyses and the parameters should then be adjusted if necessary. The loss of labour productivity of allergy sufferers of 20 to 35% based on Zuberbier et al. (2014) can also be critically questioned. Their findings were used as an initial starting point, as specific information on the loss of labour productivity was provided. The assumptions could be compared with more recent study results such as those of Hillerich et al. (2024) at a later date.

The crucial parameter settings for the scenario component “heat stress for workers” were the number of future hot days and the heat-related loss of labour productivity. The number of future hot days were deducted from past development and IPCC scenarios. Hence, we assume the setting to be very plausible and sound. More critical is the assumption regarding the heat-related loss of labour productivity. The amount of 35% was based on Zander et al. (2015). Just as in the case of the loss of labour productivity in allergy sufferers, the robustness of the result should also be checked here using sensitivity analysis. Consideration should also be given to different productivity losses depending on the type of work (indoors or outdoors, remote work), regional settings (rural or urban work place), working environment (poorly insulated hall, air-conditioned rooms or good, cooling building fabric). It is to be expected that labour productivity decreases significantly less in a cooler environment than when directly exposed to heat. The fact that the proportion of affected employees is very likely to increase in the future due to demographic ageing was also not taken into account in the scenario setting: According to Dehl et al. (2024), older workers aged 50 and over suffer more from the heat than younger workers. As their share of the workforce will increase significantly in Germany in the future, heat stress at work will increase, further reducing labour productivity.

The numeric parameter settings for the hospital costs for the scenario component “hospital admissions” were largely deducted from Karlsson and Ziebarth (2018). The study has some limitations, as only hospitalisations are included, not outpatient visits to the doctor or self-treatment. Furthermore, the observation period 1999-2008 includes only a few years with extreme heat in Germany. Consequently, this could mean that the parameters derived here were underestimated. Furthermore, heat-related damage to foetuses, which could cause long-term follow-up health-care costs in particular, were not taken into account (van den Berg et al., 2006; Wilde et al., 2017).

Despite these weaknesses, the results provide an initial estimate of the health-related costs that climate change could cause in Germany. The initial results on the extent of the costs already point to the need for action. In addition to investments in climate change mitigation, which are essential to prevent a further rise in temperature and a significant increase in heatwaves and other extreme weather events, adaptation measures can also help to significantly reduce the amount of costs. However, few adaptation measures have been implemented to date. C3S (2024) explain the slow, consistent implementation of adaptation measures with low social pressure, trust in existing healthcare systems and a lack of awareness of the links between health and climate change.

With regard to heat there exists guidance for heat health action plans provided by the EU as part of ClimateADAPT (https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/heat-health-action-plans). For Germany, the Federal Ministry of Health provides a template heat protection plan for hospitals (Musterhitzeschutzplan für Krankenhäuser) and concentrates its initiatives on measures with short-term heat protection effects, such as communication and awareness-raising. The implementation of the heat protection plans and more awareness for adapted behavior in hot weather would imply that the hospital costs would not rise as much as assumed in the scenario. At work level, there are already many ways to make it easier for employees to work in the heat: Air conditioning, darkening options, flexitime and protection with cooling waistcoats are just a few examples of measures that have already been implemented. The Federal Ministry of Labour and Social Affairs is also currently adapting workers protection standards and developing a framework for climate-friendly work. An application-oriented design and the actual implementation of climate-friendly work would mitigate the negative effects of the climate change scenario by preventing labour productivity from falling more or less sharply. Awareness also plays a major role in the field of allergies. Until now, most allergies have only been treated by self-medication and not by doctors (Zuberbier et al. 2014). However, professional treatment would prevent the negative effects in the form of absenteeism and reduced productivity (Zuberbier et al. 2014). If the treatment of allergies were to become more popular, the costs incurred in the scenario could be significantly reduced. However, higher medical treatment costs would have to be offset. It should also be noted that there can be trade-offs between different adaptation measures: While planting trees and creating parks helps to regulate the heat in cities, it can also increase the exposure to allergies (Aerts et al. 2021). Thus, care should be taken when selecting trees and plants. For the implementation of adaptation measures, this means always keeping an eye on side effects.

Summing up, we conclude that climate change has the potential to have a significant impact on healthcare costs in Germany. The results provide an initial estimate of health costs, but there is still a need for further research. On the one hand, the climate impacts considered here need to be analysed further, for example using sensitivity analysis. Furthermore, other direct and indirect climate change-related impacts on health, such as those resulting from vector-borne diseases or heavy rainfall and flooding, need to be analysed in order to obtain a more comprehensive picture. Moreover, adaptation measures should also be quantified and included in the scenario calculations.

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