



Heat in German cities: a study on existing and planned measures to protect human health

Laura Hannemann¹ · Debora Janson¹ · Henny Annette Grewe¹ · Beate Blättner¹ · Hans-Guido Mücke²

Received: 21 November 2022 / Accepted: 3 May 2023 / Published online: 24 May 2023
© The Author(s) 2023

Abstract

Aim Extreme heat events caused by climate change continue to increase in frequency, duration, and intensity. People living in cities in particular are exposed to heat as a result of the urban heat island effect. Although negative effects can be mitigated by heat health action plans (HHAPs), it remains unknown how many German cities have implemented such plans or other measures to reduce the health risks from heat. Therefore, this study surveyed the status of planned or published HHAPs and measures in German cities.

Subject and methods Approximately 10% of German cities with the greatest population density were sampled for the study (n = 70 cities). A frequency analysis of city concepts and city webpages was conducted to determine whether cities have already introduced concepts for climate adaptation, climate protection or an HHAP, and which measures are planned in detail.

Results Fifty-one cities have implemented measures to protect health from heat events. Forty-one cities integrated such measures into concepts, and only one city formulated an HHAP. Large cities in particular published measures. Long-term measures proved most common, for example, improved building envelope insulation and urban greening. Other than advice on individual behavior, hardly any acute heat health measures are being taken.

Conclusion Public health authorities can play an active role in communicating the health risks of heat and implementing HHAPs. To this end, the health risks of climate change need to be addressed consistently by all policy fields in Germany. There is also a need for further research in the evaluation of measures and HHAPs.

Keywords Extreme heat · Cities · Heat health action plan · Climate change · Climate adaption · Germany

Introduction

Extreme heat has devastating effects on human health. The summer of 2022 in Europe was marked by heat waves, leading to heat-related deaths and extreme risk to human health (WHO 2022). Yet knowledge of the health risks associated with heat is not new; a prime example is the severe heat event in the summer of 2003 which resulted

in around 70,000 heat-related deaths in Western Europe (Robine et al. 2008). The extreme heat of June 2021, with record temperatures of up to 49.6°C on the Pacific coast of the United States and Canada, caused several hundred deaths and a sharp increase in hospital cases due to heat-related illnesses (Roffel 2021; The Associated Press 2021; WMO 2021). It is clear that such extreme heat events will occur more frequently around the world as a result of human-induced global warming (IPCC 2021, 2022; Philip et al. 2021). Urban populations are particularly strongly affected by heat extremes. Due to the urban heat island (UHI) effect, temperatures in cities centers can be up to 10°C higher compared to the surrounding area (Copernicus Climate Change Service 2020). Approximately half of the world's population lives in municipalities, with a strong trend toward further urbanization (UN 2019). Higher population densities are accompanied by higher building densities and a higher degree of soil sealing, which further intensifies the UHI effect, resulting in an increase in

Beate Blättner is deceased.

✉ Laura Hannemann
laura.hannemann@yahoo.de

¹ Department of Health Sciences, University of Applied Sciences Fulda, Leipziger Straße 123, 36037 Fulda, Germany

² Department of Environmental Hygiene, German Environment Agency (Umweltbundesamt/UBA), Corrensplatz 1, 14195 Berlin, Germany

heat-related risks to the urban population (Steenefeld et al. 2011; Pfeifer et al. 2019; Mücke and Litvinovitch 2020; WHO 2021). At the same time, the increasing frequency, duration, and intensity of extreme heat events also has a significant impact on population health, and there has been a significant increase in premature deaths caused by heat (WHO 2021; IPCC 2022). There is scientific consensus that without strong climate protection and adaptation measures, climate change will inevitably lead to further increases in the heat-related burden of disease (mortality and morbidity) (Pfeifer et al. 2019; WHO 2021). Cities in particular are required to establish appropriate climate projections and implement reliable adaptation plans (IPCC 2021).

Even in Germany, with its warm-moderate climatic zone, a growing number of summers with heat events has led to a significant increase in mortality (an der Heiden et al. 2020; Winklmayr et al. 2022). For example, the summers of 2003, 2006, 2010, and 2015 show a significant number of excess heat-related deaths in Germany, ranging from 4700 to 9700 (an der Heiden et al. 2020). A significant increase in the number of deaths associated with heat was also recorded in the summers of 2018 to 2020 (Winklmayr et al. 2022). Additionally, initial projections indicate unusually high mortality observed in connection with heat waves for the summer of 2022 (Winklmayr and an der Heiden 2022). The effects of heat on morbidity and mortality demonstrate that heat-related health outcomes are a significant issue for public health. In Germany, this was first addressed in the governmental framework “Adaptation Strategy to Climate Change (DAS)” in 2008 (Bundesregierung 2008). Respective progress reports from 2015 and 2020 emphasized that municipalities are key actors in climate change adaptation and action is required in cities to protect human health from heat events (Bundesregierung 2015, 2020). This affects the 77.5% of the German population living in cities (Worldbank 2022).

In response to the increased frequency of heat events in Germany, the document “Recommendations for Action – Heat Action Plans to protect human health” was published by the Federal/State Working Group ‘Adaptation to the impacts of climate change in the health sector (GAK)’ in 2017 (BMU 2017), and was based on “Heat-health action plans”, a guidance document from the Regional Office for Europe of the World Health Organization (WHO) (Matthies et al. 2008). According to this guidance document, a heat-health action plan (HHAP) should compile selected measures to prevent and respond to extreme heat events to avoid heat-related illness and death (Matthies et al. 2008, BMU 2017). These measures should be understood as a framework for the development and establishment of practicable HHAPs tailored to the respective region, and are primarily directed at the federal

states. Implementation should occur predominantly on a municipal level (BMU 2017).

Due to the federal governmental administrative system in Germany, the GAK recommendations (BMU 2017) require a central coordinating body, preferably at the state level, with a decentralized coordinating body at municipal level responsible for the preparation of an HHAP. Municipal tasks are to be carried out by different administrative authorities, e.g., for planning, the environment or health. The GAK recommends the HHAP preparation process is lead by the public health authority (BMU 2017).

The process of encouraging HHAP implementation at state and/or municipal level started directly after the publication of the GAK recommendations in 2017; however, it was a while before the recommendations were observed throughout Germany. To date, the implementation of an HHAP is not legally binding in Germany. Cities and federal states decide independently whether to follow the GAK recommendations or not. As a consequence, a study on the implementation of HHAPs in Germany identified a small number of individual actions that did not indicate clear systematic protection of human health from heat (Blättner et al. 2020). In contrast, specific national action guidelines or regulations for HHAPs entered into force in some other European countries, for example, France, Austria, Spain and the Netherlands, predominantly led by ministries of health (Vanderplanken et al. 2019). In 2017, 35 national and sub-national HHAPs could already be identified across Europe (WHO 2019a).

To ensure the successful implementation of HHAPs in Germany, regional and local authorities must be empowered to develop, implement, and evaluate pilot strategies and actions that are tailored to their local communities, and those which prove successful can go on to be integrated into a national HHAP strategy (Mücke and Litvinovitch 2020). There is no central documentation of existing or planned HHAPs or measures to protect human health from heat. Some cities record their HHAP in documents, while others incorporate an HHAP in other concepts such as climate protection plans, climate adaption concepts or city development strategies. This complicates the collection of standardized documentation and assessments (Kaiser et al. 2021a).

To record the implementation status of primarily project-funded measures and projects for the prevention of heat-related morbidity and mortality in Germany, Blättner et al. (2020) conducted a survey based on systematic internet research conducted from December 2019 to January 2020. Comprehensive coverage was not possible due to the heterogeneous funding structures and levels and their designation on the internet. Most other studies that gather insights on the status of heat or climate adaption in German cities are based on online surveys where stakeholders from municipal administration offices are requested to offer information on

their activities (e.g., Hasse and Willen 2019; Hagelstange et al. 2021; Kaiser et al. 2021b). This approach has a systematic bias as stakeholders which are interested in the issues of climate adaptation are more likely to participate voluntarily in a survey and are able to report on adaptation measures they are involved in. The results of such surveys might indicate that a larger proportion of German cities are working on heat health adaptation than in reality.

Hence, this study analyzes freely accessible data from a previously defined sample of cities in Germany to gain a more precise picture of the proportion of cities planning measures to protect human health during heat events. This study aims to discover which measures are being planned by municipalities and incorporated into wider concepts, such as for climate adaptation, climate protection, HHAP or any others.

Methods

To answer the research questions about the proportion of planned measures in German cities to protect human health from heat in 2021, a frequency analysis was conducted (Früh 2017; Mayring 2010). First, a sample was drawn from all German cities with at least 20,000 inhabitants ($n = 665$) (Destatis 2020). For this purpose, 10% of the cities with the highest population density were selected from the 665 municipalities. Population density was chosen as a relevant criterion because population density represents a high degree of sealing, which is a factor for a higher UHI. These 66 cities are not evenly distributed across the country, but are located in only 12 of the 16 German federal states. To reflect the situation across the country, the cities with the highest population density from each of the missing four German federal states were also included in the sample. This results in a total sample of 70 cities that were examined in more detail. In the next step, the cities' websites were searched using the keywords "heat", "climate adaptation", "climate protection," and "heat action plan". Here, strategies, concepts or papers formulated by the cities are summarized under the term "concept." It was surveyed whether the cities provide access to a document called the HHAP, a concept for climate adaptation or climate protection that is being planned or developed or has already been published. To document the cities' planned activities to protect human health from heat extremes as comprehensively as possible, measures or projects found on cities' websites which target heat in connection with human health but are not mentioned in a concept were also considered. Thus, measures that do not relate to heat and human health were excluded.

The measures were classified and categorized as short to long-term based on the GAK recommendation (BMU 2017), the WHO heat-health guidance (Matthies et al. 2008), the

updated version on health advice (WHO 2019b) and the evidence-based prevention measures of the WHO (2021). At the same time, it was noted which administrative office of a city was responsible for the respective concepts. Thus, quantitative statements on the topic of heat and health can be made based on defined criteria that were collected equally in all 70 cities.

Since adaptation to climate change and heat events in municipalities is dynamic, the systematic search of freely available and accessible data in the internet was conducted in the defined period from May to June 2021. To gain an impression of the developments in the preparation of HHAPs in our sample, a follow-up survey was conducted in March 2022. This follow up survey inquired whether cities plan to have an HHAP, develop an HHAP or have already published an HHAP.

Results

The sample of 70 cities comprises a population of approximately 21 million, which constitutes approximately 26% of the population of Germany. The population density ranged from 970 to 4777 inhabitants per km². The frequency analysis revealed that 91.4% ($n = 64$) of the cities sampled have single measures, concepts for climate adaptation, climate protection or other concepts that addresses the issue climate change. Of these cities, $n = 51$ have a content-related reference to heat in connection with human health. These German cities proved very heterogeneous regarding the type of measures planned, the number of measures per city and their integration into a concept. In the following, the analysis focuses on (a) cities and concepts (b) responsible offices and (c) measures in more detail.

Cities and concepts

The descriptive assessment of the study shows that 51 of the 70 cities analyzed have formulated measures to protect human health from heat events. Forty-one of the cities integrated these measures into concepts, and the remaining 10 cities named single measures, such as a flyer with advice on how to behave during heat events. The 41 cities are shown in Fig. 1, categorized according to the published concept types.

One city (Offenbach am Main) published an HHAP as a stand-alone document in 2020. Its content was based on the GAK recommendations (BMU 2017). In addition, the city of Bochum prepared a heat concept in 2021 specifically for the target group of homeless people. According to the cities' concepts or websites, seven other cities were planning to draft an HHAP (Herne, Nuremberg, Wuppertal, Bremen, Halle/Saale, Dresden, and Recklinghausen). In 2021 three cities were developing an HHAP (Cologne,

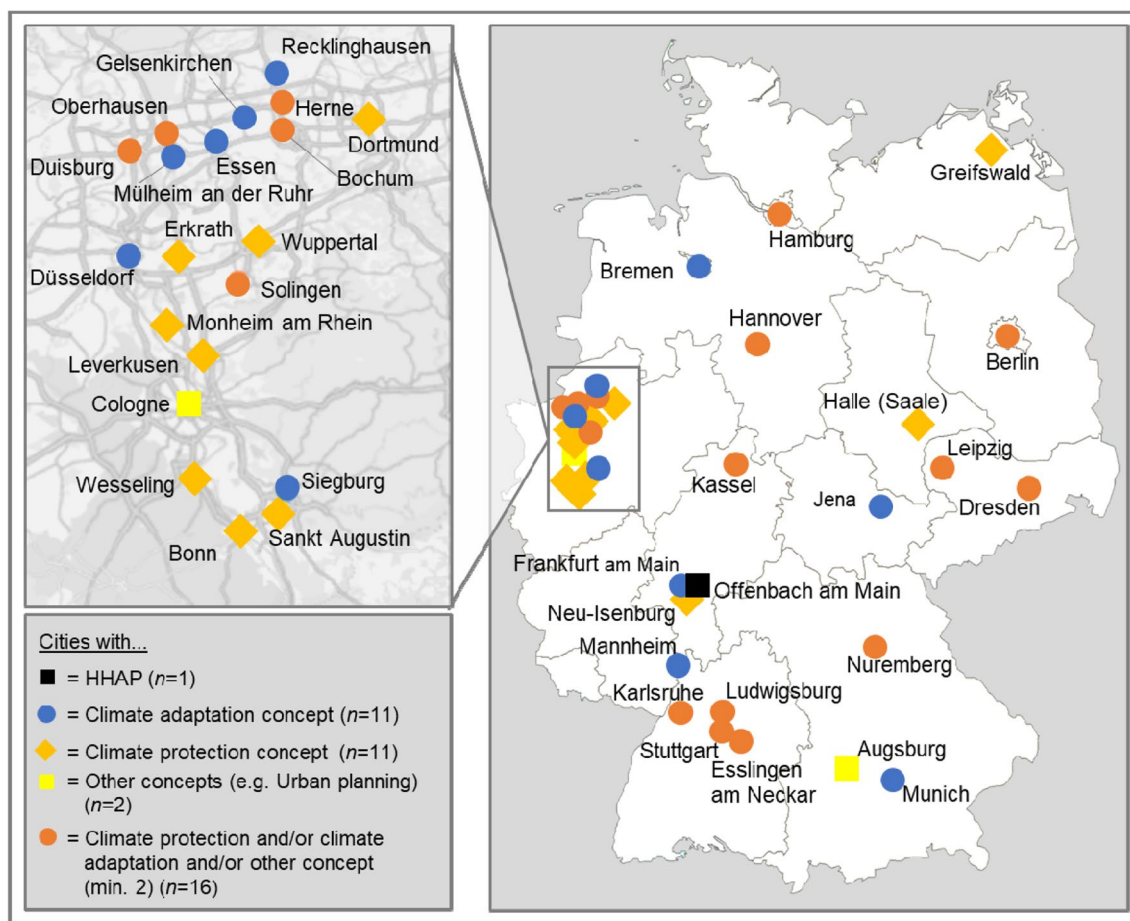


Fig. 1 Map of Germany depicting cities that published a concept with measures to protect human health from heat ($n = 41$ in a sample of 70 cities), categorized according to concept type (own graphic)

Ludwigshafen am Rhein, and Mannheim). The follow-up survey in 2022 showed that the HHAP in Wuppertal is already in development and Mannheim published an HHAP in 2021. The other cities are still planning or developing an HHAP.

In addition, 26 climate adaptation concepts, 18 climate protection concepts, and 12 other concepts (urban planning, land use, urban land use plans) that include measures to protect human health from heat were published. Sixteen of the 41 cities have integrated measures into more than one concept. These concepts were published between 2010 and 2021. In addition, 37 of the 51 cities mentioned individual measures on their websites which were not integrated into concepts. All German cities with more than 500,000 inhabitants ($n = 14$), have heat protection measures in place.

In 19 of 26 climate adaptation concepts and in the HHAP from Offenbach am Main it was specifically stated that an evaluation of the concept and its measures was planned.

Differences in responsibility for administrative offices

In Germany, the decision to prepare concepts focusing on climate change and climate adaptation is taken by each city. The cities also designate the public authorities which are involved in such concepts.

In Offenbach am Main, the Office for Environment, Energy and Climate Protection is responsible for the central coordination of the HHAP, while in Bochum, the Office for Social Affairs is responsible for the heat health concept. As far as this was shown for the HHAPs being planned or under development, the responsibility for the HHAP was most commonly allocated to city authorities with a focus on environment and health. For the 26 climate adaptation concepts, the distribution of responsible offices is as follows. Offices with a focus on environmental issues bear responsibility for climate adaptation concepts in 76.9% ($n = 20$) of cases, offices for urban development

in 15.4% (n = 4) of cases and offices for environment and health in 7.7% (n = 2) of cases.

Measures

Overall, cities in Germany published a variety of measures to protect human health from heat. It should be noted that the formulation of the measures does not specify the institution or administrative body to which the measures are addressed, or who should be responsible for the implementation. In addition, it is often unclear whether a concrete plan exists to put measures into action or whether the cities published lists of measures which could potentially be implemented in the future. In some cases, cities included tips for citizens in their concepts without mentioning any further actions to

promote them. For example, one city prescribed the “use of fans” as a requirement for cooling rooms in city-owned workplaces, while another city advised the population to use fans without providing fans. Both measures are assigned to the category “Fans,” which is listed with two mentions in the frequency analysis, although the outcome of these measures are likely to differ.

The measures were either integrated into concepts for climate adaptation and climate protection, into other concepts such as urban planning, or they were shown as individual measures on the cities’ websites. In total, the cities came up with 378 measures to protect human health from heat (Fig. 2). Not all of the surveyed measures can be clearly assigned to a short, medium or long-term period. Looking at the 11 most frequently mentioned measures in our study,

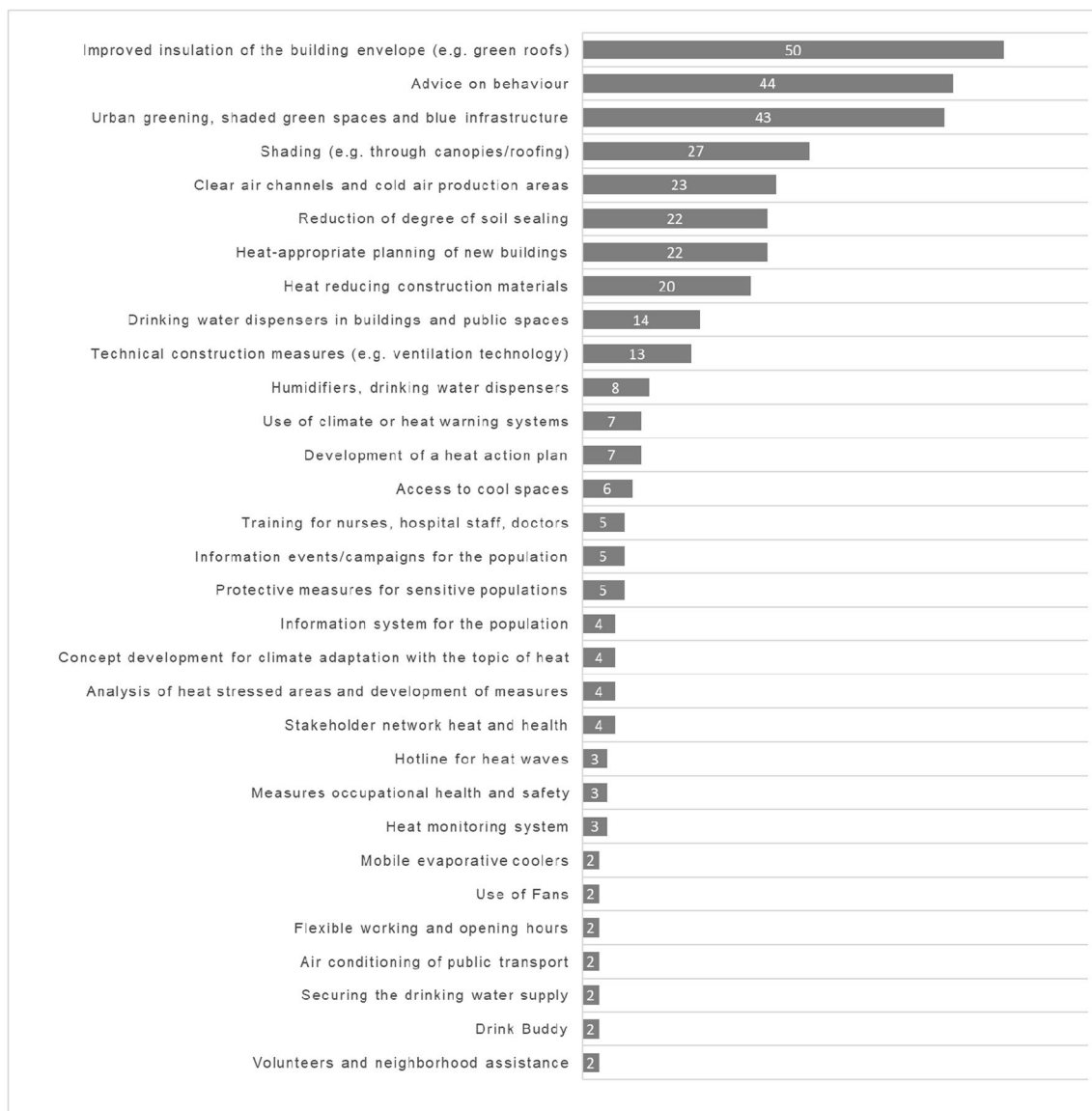


Fig. 2 Distribution of measures to protect human health from heat published at least two times by 51 German cities (own graphic)

it is striking that 10 of them can be classified as medium to long-term. “Advice on behavior” was the only short-term measure to be implemented by the cities.

Overall, medium to long-term measures were planned around four times as frequently as short-term measures. Medium or long-term measures included a collection of building codes, urban planning and land use. The most frequently planned measures were improved insulation and thermal performance of the building envelope (e.g., green roofs) with 50 mentions, followed by urban greening, shaded green spaces and blue infrastructure with 43, shading with 27, creating or keeping clear air channels and cold air production areas with 23, reduction of degree of soil sealing with 22, heat-appropriate planning of new buildings also with 22, heat reducing construction materials with 20, drinking water dispensers in buildings and public spaces with 14, and technical construction measures (ventilation technology, heating and cooling coils, fans and possibly AC systems) with 13 mentions.

In addition, the use of heat health warning systems and the development of an HHAP were both identified seven times. In four of the cities’ cases, an HHAP was also in the planning or drafting stages.

An overview of the measures mentioned at least two times by the 51 cities is given in Fig. 2.

In comparison, short-term measures appear to be less relevant for cities as the establishment of measures such as cooling centers or the use of rooms provided with air

conditioners were planned in one single case. The measures on the use of fans or mobile evaporative coolers were each planned in two cases and access to cool spaces was mentioned in six cases. Thus, the measure “Advice on behavior” was by far the most planned short-term measure ($n = 44$). A list of all measures that were mentioned once by a city can be found in Table 1.

Figure 3 shows the distribution of measures published by the 51 cities with heat and health related content according to the concept type. The measures are predominantly part of climate adaptation concepts (59%; $n = 223$); 15% ($n = 56$) are included in other concepts (e.g., urban planning), 11% ($n = 40$) in climate protection concepts, and 2% ($n = 8$) in an HHAP. Furthermore, 13% ($n = 51$) of the measures are also planned individually as stand-alone measures without inclusion in a city concept.

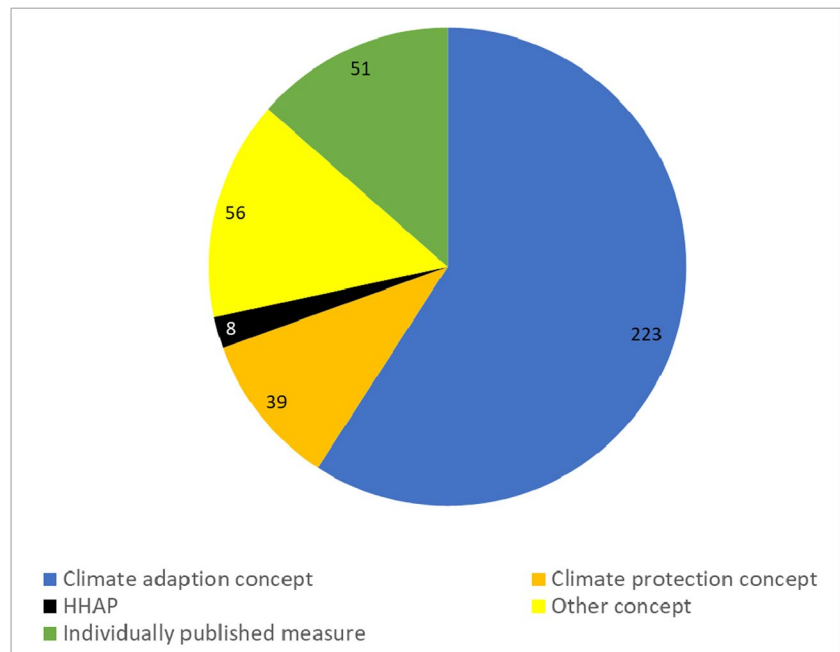
Discussion

In this study, a frequency analysis of city websites and concepts was conducted to find out whether cities in Germany have already formulated concepts or measures which protect human health from heat. The research revealed three main findings about the measures planned. First, that 51 of the 70 analyzed cities in the sample are planning measures and 41 cities have integrated them into various types of concepts, predominantly in climate adaption concepts. Second, that

Table 1 List of measures to protect human health from heat that were mentioned once by 51 cities sorted by concept type (own graphic)

<ul style="list-style-type: none"> -Advice to companies on climate adaptation -Awarding climate adapted buildings -Concept for identifying and addressing heat-vulnerable people -Ensuring the provision of services of general interest (rescue services) -Heat adapted food in canteens and restaurants -Improve the capacity of civil protection to act in the event of heat waves -Information for doctors and nursing homes -Installation of “Cooling Centers” -Monitoring of the HHAP -Preparing the health care system -Promote physical activity to better manage heat stress -Providing pedestrian and bicycle paths to thermally relieved setback areas -Temporary installations of sun protection measures in public spaces -Traffic surfaces with low thermal conductivity and storage capacity
<ul style="list-style-type: none"> -Testing of strategies in road construction, canal and greenery management -Water for administrative employees -Water and sanitation offer for the homeless
<ul style="list-style-type: none"> - Air conditioners
<ul style="list-style-type: none"> ■ Climate adaption concept ■ HHAP ■ Individually published measure

Fig. 3 Distribution of the measures to protect human health from heat mentioned in 51 German cities by concept type (own graphic)



mainly environmental authorities have been made responsible for the measures, and lastly, that of a large number of planned measures, cities have predominantly provided for long-term measures to date. The following discussion will build on these three findings.

First, it can be stated that some cities have already published measures, but only a few cities have provided for a systematic preparation of HHAPs. Since there is no legal obligation to create an HHAP in Germany, among other things, the available resources of a city are crucial in creating a concept that structures the measures. The finding that every German city with more than 500,000 inhabitants ($n = 14$) has published measures to protect human health from heat shows that the city size plays a key role in the development of climate adaption measures. These findings are consistent with those in a study by Otto and colleagues (Otto et al. 2021). The study states that in Germany, city size and the resources associated with it play a major role in creating climate concepts. Large cities have greater capacities to initiate and implement measures locally. In addition, large cities are in a better position than smaller cities to receive funding from external donors, including EU funds (Otto et al. 2021).

The second main finding was the assignment of an office responsible for the concepts and measures. While a Europe-wide comparison showed that mainly health authorities are responsible for the HHAP and measures to protect human health from heat (Vanderplanken et al. 2019), this study shows that in Germany, mostly the offices for environment and urban development are responsible. This is often explained with the historical development of implementing measures to protect human health from

heat. In Europe, many heat action plans originated as a response to the high number of deaths in the 2003 heat-wave summer. In Germany, the “Adaptation Strategy to Climate Change (DAS)” has given rise to many climate change adaptation projects since 2008 and assigns responsibility for addressing climate change to environmental agencies. Also, the Federal Ministry for Environment has taken the lead in publishing the national recommendations for action for the preparation of HHAPs (BMU 2017). The structures developed at the federal level are reflected at the municipal level. In 2020, this issue was taken up at the Conference of Health Ministers and a resolution was passed declaring that municipalities should draw up an HHAP within five years and it should involve stakeholders from the health sector (GMK 2020). No impact of this resolution could be determined in the sample analyzed in this study. The measures and concepts drafted after 2020 do not show that health offices assumed more responsibility than thus published before the resolution. The health department is named as the responsible party, along with other offices, in just three cases of planned HHAPs. It is evident that the health department has a certain responsibility, particularly in the case of acute measures, such as the telephone service during heat events in the German city Kassel. A noteworthy result of the study was the HHAP from Bochum which was published under the direction of the Office for Social Affairs. It is an interesting approach to locate the responsibility or initiative in the Office for Social Affairs and offers the advantage that such authorities have data and knowledge about the city’s population. In addition, social services often have good access

to vulnerable populations. Nevertheless, these examples remain exceptional cases.

The third finding in this study offers another hypothesis regarding the assignment of responsibility to offices for environment and urban planning observed to date. Most published measures are long-term measures that address building insulation, urban greening, shading, and facade greening, among other issues. It can therefore be hypothesized that making offices for environment and urban planning responsible for adapting to heat extremes in many cases will lead to an emphasis on structural measures for buildings and urban planning. In addition, concepts for climate protection and climate adaptation have existed longer in Germany than the idea of implementing an HHAP, especially through the “DAS.” Therefore, some of the measures were implemented for other reasons.

However, this study reaches its limits when it comes to the implementation of the measures. Although many measures have been published by cities, it cannot be assumed that all measures have actually been implemented and the way of implementing measures differs between cities. For example, the implementation status of the most frequently mentioned measure, “Improved insulation and thermal performance of the building envelope (e.g., green roofs),” indicated that this measure has not yet been implemented in all cities. The main problem with implementation is that cities cannot directly influence the roofs and facades of private owners. A closer look at the published measures shows that in most cases local governments have established funding programs for greening roofs and/or facades of residential and commercial buildings. This type of funding was chosen in many municipalities to gain initial experience before going on to develop a concept. In many cases, the measure was intensively promoted again at a later stage with the publication of a concept. Other cities are introducing greening of buildings and energy standards for municipal buildings. Through this, they aim to set the standard for private-sector companies and private owners.

The second most mentioned measure, “Advice on behavior,” is mostly implemented in the form of an information flyer that citizens can view or download from a website. However, the results show that few other short-term measures are being implemented to protect human health from heat events in acute situations. Measures such as the information flyer, which can be implemented easily and quickly and show the outside world that something is being done for the population, can be considered low hanging fruits. With such measures, there is a risk that no measures beyond these will be planned and implemented, and thus measures of key importance will be overlooked (Blättner et al. 2021).

To summarize measures for the protection of human health in a structured way in an HHAP, this should include three types of strategies. These are communication with the

public and support systems, management of acute events for vulnerable populations, and long-term effective measures to protect against extreme heat (Ragettli and Rösli 2021b). Initial evaluations show that HHAPs with measures following these three strategies (risk communication, management of acute heat events, and long-term measures) led to a smaller increase in the number of daily deaths during the 2019 heatwave in Switzerland (Ragettli and Rösli 2021a). The HHAPs that exist in Germany have not yet been evaluated and thus it remains unknown which measures have an impact. However, it is clear from the results that there is a particular lack of acute measures targeted at vulnerable groups. It is the role of public health to actively participate in the development and implementation of acute measures. The results also show that the healthcare system is involved in only a few measures, for example “Training for nurses, doctors and hospital staff.” Nevertheless, the stakeholders in the healthcare sector have recognized the danger of heat waves for human health. For example, at the German Medical Congress 2021, HHAP developments in Germany were described as insufficient and healthcare facilities were called upon to take immediate measures to protect patients and staff (Bundesärztekammer 2021).

However, comprehensive country-wide coverage of measures and activities in German cities exceeds the scope of this study, in which freely accessible concepts and measures in a pre-defined sample of 70 cities were considered. Furthermore, measures with no direct connection to human health were excluded from the sample. Some urban planning or construction measures can nonetheless have positive effects on human health, and this can also apply to other measures that were initiated for completely different reasons. This data shows an excerpt of measures at a certain point in time.

Conclusion

Heat waves in Germany over the past 30 years, and most recently in the summer of 2022, show how important it is to prepare HHAPs and, in particular, to have measures in place to protect human health during acute heat extremes. However, this study shows that in a sample of 70 cities, extremely few German cities have implemented an HHAP. In any case, since heat and health are cross-cutting issues, it is crucial that the responsible authority promotes and coordinates cross-sectoral collaboration between offices, including health, urban planning, civil protection, and construction. As identified, in Germany, considerable shortcomings are evident in cross-sectoral collaboration to implement measures to protect human health from urban heat. The creation and implementation of adaptation measures on climate change, including HHAP, require

a cross-sectoral network of stakeholders, including health, urban planning, civil protection, and construction.

This is where public health authorities in Germany can take responsibility and play an active role in emphasizing the health consequences of heat and calling attention to the vulnerability of the population. They also should promote dialogues between sectors and thereby identify possible solutions for prevention and formulate acute adaptation measures, as well as provide information on effectivity and efficiency of such heat health measures for implementing and allocating resources, as required by decision-makers. The results of the study presented is part of a first national investigation and an initial evaluation of the recommendations for heat health actions published for HHAPs in Germany. Further research is needed to follow-up and evaluate the development, implementation, outcome, and impact of heat health measures in Germany over the next few years. Further, national and state authorities should provide guidance and legislative instructions to support the implementation of HHAPs in municipalities. Therefore, the national adaptation strategy on climate change in Germany and its focus on health prevention is part of the “Health in All Policies” approach, as joint action must be taken by the various policy sectors. As the study showed, today actions on heat health prevention and protection run on low priority at the state level in Germany. However, due to the pressure induced by frequent heat events in recent years, Germany should learn from appropriate examples in Europe to implement HHAPs on a legal basis.

Acknowledgement The authors do not have a conflict of interest to declare, and are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Contributions L. Hannemann, D. Janson, and B. Blättner conceptualized the study and designed the methodology. L. Hannemann collected, analyzed and visualized the data in consultation with B. Blättner, H.A. Grewe, and D. Janson. L. Hannemann wrote the manuscript. H.G. Mücke, H.A. Grewe, and D. Janson reviewed and commented on previous versions of the manuscript.

Funding Open Access funding enabled and organized by Projekt DEAL. This work is part of the project “HAP-DE” (Analysis of Heat Action Plans and Health Adaptation Measures to Heat Extremes in Germany) and is funded by the BMUV (The Federal Ministry for the Environment and Consumer Protection) and commissioned by the UBA (German Environment Agency).

Availability of data and material Not applicable

Code availability Not applicable

Declarations

Ethics approval Not applicable

Consent to participate Not applicable

Consent for publication We give consent to the publication of the study.

Conflicts of interest The authors have no conflicts of interest to declare.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- An der Heiden M, Muthers S, Niemann H, Buchholz U, Grabenhenrich L, Matzarakis A (2020) Heat-related mortality: an analysis of the impact of heatwaves in Germany between 1992 and 2017. *Dtsch Arztebl Int* 117:603–609. <https://doi.org/10.3238/arztebl.2020.0603>
- Blättner B, Janson D, Roth A, Grewe HA, Mücke HG (2020) Gesundheitsschutz bei Hitzeextremen in Deutschland: Was wird in Ländern und Kommunen bisher unternommen? *Bundesgesundheitsblatt* 63:1013–1019c
- Blättner B, Grewe HA, Janson D, Rosin V, Jordan HA (2021) Arbeitshilfe zur Entwicklung und Implementierung eines Hitzeaktionsplans für Städte und Kommunen. https://www.hs-fulda.de/fileadmin/user_upload/FB_Pflege_und_Gesundheit/Forschung_Entwicklung/Arbeitshilfe_Hitzeaktionsplaene_in_Kommunen_2021.pdf. Accessed 07 June 2022
- BMU (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit) (2017) Handlungsempfehlungen für die Erstellung von Hitzeaktionsplänen zum Schutz der menschlichen Gesundheit. Version 1. BMU Referat IG II 7, Bonn. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/HHAP_handlungsempfehlungen_bf.pdf. Accessed 15 Mar 2022
- Bundesärztekammer (2021) 125. Deutscher Ärztetag Beschlussprotokoll –Berlin 01.– 02. November 2021. https://www.bundesaerztekammer.de/fileadmin/user_upload/BAEK/Aerztetag/125.DAET/pdf/Beschlussprotokoll_125DAET2021_Stand_24112021.pdf. Accessed 22 Aug 2022
- Bundesregierung (2008) Deutsche Anpassungsstrategie an den Klimawandel. BMU. https://www.bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/das_gesamt_bf.pdf. Accessed 15 Mar 2022
- Bundesregierung (2015) Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel. BMU. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimawandel_das_fortschrittsbericht_bf.pdf. Accessed 15 Mar 2022
- Bundesregierung (2020) Zweiter Fortschrittsbericht zur Deutschen Anpassungsstrategie an den Klimawandel. BMU. https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimawandel_das_2_fortschrittsbericht_bf.pdf. Accessed 15 Mar 2022
- Copernicus Climate Change Service (2020) Urban heat island intensity for European cities from 2008 to 2017, derived from reanalysis. <https://cds.climate.copernicus.eu/cdsapp#!/software/>

- [app-health-urban-heat-islands-current-climate?tab=overview](#). Accessed 22 June 2021
- Destatis (2020) Daten aus dem Gemeindeverzeichnis. Städte in Deutschland nach Fläche, Bevölkerung und Bevölkerungsdichte.
- Früh W (2017) Inhaltsanalyse: Theorie und Praxis, 9th edn. UTB GmbH, Stuttgart
- GMK (Gesundheitsministerkonferenz) (2020) Beschlüsse der GMK 30.09.2020 - 01.10.2020. TOP: 5.1 Der Klimawandel - eine Herausforderung für das deutsche Gesundheitswesen. <https://www.gmkonline.de/Beschluesse.html?id=1018&jahr=2020>. Accessed 22 Aug 2022
- Hagelstange J, Rösler C, Runge, K (2021) Klimaschutz, erneuerbare Energien und Klimaanpassung in Kommunen. Maßnahmen, Erfolge, Hemmnisse und Entwicklungen – Ergebnisse der Umfrage 2020. Difu Papers Februar 2021
- Hasse J, Willen L (2019) Umfrage Wirkung der Deutschen Anpassungsstrategie (DAS) für die Kommunen – Teilbericht. Umweltbundesamt, Climate Change 01/2019
- IPCC (2021) Summary for Policymakers. In: Masson-Delmotte V, P Zhai, A Pirani, SL Connors, C Péan, S Berger, N Caud, Y Chen, L Goldfarb, MI Gomis, M Huang, K Leitzell, E Lonnoy, JBR Matthews, TK Maycock, T Waterfield, O Yelekçi, R Yu and B Zhou (eds.) Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press
- IPCC (2022) Summary for Policymakers [H-O Pörtner, DC Roberts, ES Poloczanska, K Mintenbeck, M Tignor, A Alegría, M Craig, S Langsdorf, S Löschke, V Möller, A Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H-O Pörtner, DC Roberts, M Tignor, ES Poloczanska, K Mintenbeck, A Alegría, M Craig, S Langsdorf, S Löschke, V Möller, A Okem, B Rama (eds.) Cambridge University Press. In Press
- Kaiser T, Kind C, Dudda L (2021a) Bund/Länder-Handlungsempfehlungen zur Erarbeitung von Hitzeaktionsplänen: Bekanntheit und Rezeption in Bundesländern und Kommunen [Recommendations for the preparation of heat-health action plans in Germany: awareness and reception in federal states, districts and municipalities]. UMID 1/2021:17–26. https://www.umweltbundesamt.de/sites/default/files/medien/4031/publikationen/210628-umid_heft_01_2021_interaktiv_neu.pdf. Accessed 26 Mar 2023
- Kaiser T, Kind C, Dudda L, Sander K (2021b) Klimawandel, Hitze und Gesundheit: Stand der gesundheitlichen Hitzevorsorge in Deutschland und Unterstützungsbedarf der Bundesländer und Kommunen [Climate change, heat and health: Status of heat prevention in Germany and need for support of federal states and municipalities]. UMID 1/2021:27–38. https://www.umweltbundesamt.de/sites/default/files/medien/4031/publikationen/210628-umid_heft_01_2021_interaktiv_neu.pdf. Accessed 26 Mar 2023
- Matthies F, Bickler G, Marin NC, Hales S (2008) Heat-Health Action Plans. Guidance. WHO Regional Office for Europe, Copenhagen
- Mayring P (2010) Qualitative Inhaltsanalyse: Grundlagen und Techniken, 11th edn. Beltz, Weinheim
- Mücke HG, Litvinovitch JM (2020) Heat extremes, public health impacts, and adaptation policy in Germany. *Int J Environ Res Public Health* 17(21):7862. <https://doi.org/10.3390/ijerph17217862>
- Otto A, Kern K, Haupt W et al (2021) Ranking local climate policy: assessing the mitigation and adaptation activities of 104 German cities. *Climatic Change* 167:5. <https://doi.org/10.1007/s10584-021-03142-9>
- Pfeifer S, Rechid D, Reuter M, Viktor E, Jacob D (2019) 1.5°, 2°, and 3° global warming: visualizing European regions affected by multiple changes. *Region Environ Change* 19(6):1777–1786
- Philip SY, Kew SF, van Oldenborgh GJ et al (2021) Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021. World Weather Attribution. <https://www.worldweatherattribution.org/wp-content/uploads/NW-US-extreme-heat-2021-scientific-report-WWA.pdf>. Accessed 26 Mar 2023
- Ragetti MS, Rösli M (2021a) Die Bedeutung von Präventionsmaßnahmen. Hitzebedingte Sterblichkeit im Sommer 2019. *Prim Hosp Care Allg Inn Med* 21(03):90–95. <https://doi.org/10.4414/phc-d.2021.10296>
- Ragetti MS, Rösli M (2021b) Hitze-Maßnahmen-Toolbox 2021. Ein Massnahmenkatalog für den Schutz der menschlichen Gesundheit vor Hitze. Bundesamt für Gesundheit (BAG) Schweiz. <https://www.bag.admin.ch/bag/de/home/gesund-leben/umwelt-und-gesundheit/hitze.html>. Accessed 26 Mar 2023
- Robine JM, Cheung SLK, Le Roy S, Van Oyen H, Griffiths C, Michel JP, Herrmann FR (2008) Death toll exceeded 70,000 in Europe during the summer of 2003. *Comptes Rendus Biologies* 331(2):171–178
- Roffel B (2021) B.C.'s heat wave likely contributed to 719 sudden deaths in a week, coroner says — triple the usual number. CBC News. <https://www.cbc.ca/news/canada/british-columbia/heat-wave-719-deaths-1.6088793>. Accessed 12 July 2021
- Steenefeld GJ, Koopmans S, Heusinkveld BG, van Hove LWA, Holtslag AAM (2011) Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. *J Geophys Res* 116(D20):1–14
- The Associated Press (2021) Death toll from Northwest heat wave expected to keep rising. NBC News. <https://www.nbcnews.com/news/us-news/death-toll-northwest-heat-wave-expected-keep-rising-n1273016>. Accessed 12 July 2021
- UN (United Nations), Department of Economic and Social Affairs, Population Division (2019) World Urbanization Prospects 2018: Highlights (ST/ESA/SER.A/421)
- Vanderplanken K, van Loenhout J, Guha-Sapir D, van den Hazel P, Marx M, Shams A, Louis VR (2019) Heat plan compilation. Deliverable 2.1. Evaplan Scorch Publications. https://www.evaplan.org/wp-content/uploads/2019/04/D2.1_Heat-plan-compilation.pdf. Accessed 07 July 2021
- WHO (2019a) Updating the evidence related to heat-health action planning, Meeting report 21–22 November 2018. WHO Regional Office for Europe, Copenhagen
- WHO (2019b) Public health advice on preventing health effects of heat. New and updated information for different audiences. WHO Regional Office for Europe, Copenhagen
- WHO (2021) Heat and health in the WHO European Region: updated evidence for effective prevention. WHO Regional Office for Europe, Copenhagen
- WHO (2022) Heatwave in Europe: local resilience saves lives – global collaboration will save humanity. Statement by WHO Regional Director for Europe, Dr Hans Henri P. Kluge. <https://www.who.int/europe/news/item/22-07-2022-heatwave-in-europe%2D%2Dlocal-resilience-saves-lives%2D%2Dglobal-collaboration-will-save-humanity>. Accessed 26 Mar 2023
- Winklmayr C, ander Heiden M (2022) Hitzebedingte Mortalität in Deutschland 2022. *Epid Bull* 42:3–9. <https://doi.org/10.25646/10695>
- Winklmayr C, Muthers S, Niemann H, Mücke HG, an der Heiden M (2022) Heat-related mortality in Germany from 1992 to 2021. *Dtsch Arztebl Int* 119:451–457. <https://doi.org/10.3238/arztebl.m2022.0202>
- WMO (2021) June ends with exceptional heat. World Meteorological Organization (WMO) <https://public.wmo.int/en/media/news/june-ends-exceptional-heat>. Accessed 15 Mar 2022
- Worldbank (2022) World Development Indicators. Germany, Urban Population (% of total population). <https://databank.worldbank.org/reports.aspx?source=world-development-indicators>. Accessed 12 Apr 2022

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.