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Annika Seiffert, Sophie Scheidl, Katharina Buse, Elke Hertig, Claudia Andersch, Irena Kaspar-Ott

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ORIGINAL ARTICLE

Bridging the gap between heat action plans and practice: a qualitative study on the implementation of heat protection measures in German hospitals

Annika Seiffert[2] · Sophie Scheidl[1] · Katharina Buse[3] · Elke Hertig[1] · Claudia Andersch[2] · Irena Kaspar-Ott[1]

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Abstract

Aim To examine the implementation and feasibility of heat protection measures in German hospitals and to assess gaps between recommended heat action plans and routine practice.

Subject and methods A qualitative study combined a comparative analysis of four model heat action plans for hospitals and five institution-specific plans with semi-structured expert interviews with hospital representatives responsible for heat protection ($n=7$). Selected literature on the effectiveness of heat protection measures was additionally reviewed to contextualize the qualitative findings. Interview data were analyzed using thematic analysis.

Results Substantial gaps were identified between recommended measures, their inclusion in institutional plans, and their actual implementation. Existing heat action plans covered technical, organizational, and personal measures but placed greater emphasis on patient protection than employee protection. Across hospitals, implementation was incomplete and often limited to low-threshold interventions. Frequently implemented measures included drinking water provision, ventilation, and adaptation of food supply, whereas resource-intensive technical measures were less common. Major barriers were financial constraints, staff shortages, and limited awareness of heat-related risks. Facilitating factors included internal cooperation, exchange between institutions, and occupational safety regulations.

Conclusion The main challenge of hospital heat protection appears to lie less in generating further recommendations than in implementing existing ones. Low-cost organizational measures, such as heat warning communication, hydration strategies, flexible clothing rules, and adapted workflows, may offer feasible starting points for immediate adaptation and should be complemented by long-term investments in climate-resilient infrastructure.

Keywords Heat action plans · Hospitals · Climate adaptation · Heat protection · Implementation

Introduction

Climate change is increasingly recognized as one of the most significant threats to human health, with rising ambient temperatures contributing to a growing burden of heat-related morbidity and mortality worldwide (World Health Organization 2008; Intergovernmental Panel on Climate Change 2021). In Germany, both the average air temperature and the frequency of hot days have increased over recent decades and are projected to rise further under all climate scenarios (Brasseur et al. 2023). These developments are associated with substantial health impacts, including increased mortality, exacerbation of chronic diseases, and rising healthcare demand. In 2023 alone, heat was estimated to cause more than 47,000 premature deaths in Europe, with Germany ranking among the most affected countries (An der Heiden et al. 2019; Gallo et al. 2024).

Beyond its direct health effects, heat also poses significant challenges to working conditions and occupational health. Elevated temperatures are associated with reduced work performance, increased risk of accidents, and higher rates of sick leave (Lancet Countdown 2023; Deutsche

✉ Irena Kaspar-Ott
irena.kaspar-ott@med.uni-augsburg.de

[1] Regional Climate Change and Health, Faculty of Medicine, University of Augsburg, Augsburg, Germany

[2] Institute of Medical Management and Health Sciences, Faculty of Law, Business and Economics, University of Bayreuth, Bayreuth, Germany

[3] Greenzero, Am Thyssenhaus 1–3, Essen, Germany

Gesetzliche Unfallversicherung 2024). In Germany, heat exposure has been linked to a substantial increase in lost labor hours and a growing number of heat-related health complaints among employees (Dehl et al. 2024). Healthcare workers represent a particularly vulnerable group, as they are exposed to physically demanding tasks, often wear protective clothing, and cannot shift to remote work. At the same time, heat events increase hospital admissions and place additional strain on already burdened healthcare systems (Steul et al. 2018; Ebi and Hess 2024).

In response to these challenges, heat action plans (HAPs) have been developed at international and national levels to guide adaptation measures. The World Health Organization has outlined core elements of HAPs, including early warning systems, protection of vulnerable populations, and coordinated response strategies (Matthies et al. 2008). In Germany, national recommendations for HAPs were introduced in 2017 (Straff and Mücke 2017), and a national model HAP specifically targeting hospitals was published by the Federal Ministry of Health in 2024 (Bundesministerium für Gesundheit 2024). These frameworks provide a range of technical, organizational, and behavioral measures intended to mitigate heat-related risks.

However, despite the increasing availability of guidance, the implementation of heat protection measures in hospitals remains limited. Previous studies indicate that many healthcare facilities are still at an early stage of developing and applying structured heat adaptation strategies, and evaluations of hospital-specific HAPs are largely lacking (Blum et al. 2023; Krol et al. 2023). Moreover, existing recommendations tend to focus primarily on patient protection, while comparatively little attention has been paid to the working conditions and health of hospital staff.

Against this background, there is a need to better understand not only which heat protection measures are recommended but also to what extent they are feasible and implemented in practice. In particular, insights into implementation barriers and facilitating factors are essential for translating existing guidance into effective action within healthcare settings.

Therefore, this study aims to assess the feasibility of implementing recommended heat protection measures in hospitals. Combining a comparative analysis of model HAPs, institution-specific plans, and qualitative expert interviews, the study investigates three sequential levels of adaptation: recommended measures, their translation into formal institutional planning, and their practical implementation in routine hospital settings. Furthermore, it recognizes implementation gaps, barriers, and facilitating factors, and identifies measures that appear most feasible for implementation under real-world conditions, particularly with regard to protecting healthcare workers. The findings are intended to support hospital management and policymakers in strengthening climate adaptation and healthcare resilience.

Methods

Study design

This study employed a qualitative research design combining document analysis and expert interviews to assess the feasibility of heat protection measures in hospitals. The approach aimed to integrate insights from existing recommendations with practical experiences from healthcare institutions.

Analysis of HAPs and heat protection measures

A non-systematic literature review was conducted to identify recommended heat protection measures relevant to inpatient healthcare settings. The primary document analysis included four model HAPs specifically developed for hospitals in Germany (Aktionsbündnis Hitzeschutz Berlin 2023; Hansestadt Lübeck 2023b; Landeszentrum Gesundheit Nordrhein-Westfalen 2023a; Bundesministerium für Gesundheit 2024).

In addition, nine German-language guidance documents addressing heat protection in nursing and long-term care settings were included as complementary sources (Aktionsbündnis Hitzeschutz Berlin 2022; Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit 2023; Betreuungs- und Pflegeaufsicht Hessen 2018; Hansestadt Lübeck 2023a; Landessanitätsdirektion Wien 2018; Landeszentrum Gesundheit Nordrhein-Westfalen 2023b; LMU Klinikum Institut und Poliklinik für Arbeits-, Sozial- und Umweltmedizin 2021; Qualitätsausschuss Pflege 2024; Rocker n.d.). Detailed information on all guidance documents included in the analysis is provided in Supplementary Table S1.

The available hospital-specific model HAPs showed substantial overlap in their recommended measures, while heat protection guidance for nursing and long-term care settings has been available for a longer period and provides a broader range of recommendations. The additional guidance documents were considered because hospitals and inpatient nursing facilities share several heat-related challenges relevant to the identification of protective measures, including the care of vulnerable individuals, heat exposure in indoor environments, hydration management, ventilation and cooling, adaptation of care routines, and occupational heat exposure among staff. These documents were used to broaden the identification of potentially relevant heat protection measures and were not treated as hospital-specific standards or used to assess hospital compliance.

Recommended measures identified across the documents were compiled and grouped according to their content. To structure the analysis, heat protection measures

were categorized according to the established framework of technical, organizational, and personal measures (TOP principle), which is commonly applied in occupational health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin 2022; Aktionsbündnis Hitzeschutz Berlin 2023). Personal measures were further differentiated into measures targeting employees and those targeting patients.

In a subsequent analytical step, five institution-specific HAPs from participating hospitals (hospitals 1, 2, 3, 4, and 6) were analyzed and compared with the measures identified from the model HAPs. Hospitals without a formalized HAP (hospitals 5 and 7) were excluded from this part of the analysis. Selected literature on the effectiveness of individual heat protection measures was reviewed to contextualize the qualitative findings. Studies were selected if they addressed measures identified in the model HAPs and investigated these interventions in healthcare or occupational settings considered relevant to hospital environments. The review was non-systematic; no comprehensive search strategy or formal quality assessment was undertaken, and the literature was not used to derive a formal ranking of measures according to effectiveness. Any prioritization of measures in this study therefore primarily reflects implementation feasibility identified in the qualitative data rather than comparative effectiveness. Figure 1 provides an overview of the documents included in the analysis and the sequential analytical steps from recommended measures to institution-specific planning and implementation in practice.

Semi-structured expert interviews and thematic analysis

To gain practical insights into the implementation of heat protection measures, semi-structured expert interviews were conducted with representatives from seven hospitals in Germany. Hospitals were selected on the basis of their engagement with systematic heat protection, including the implementation of institution-specific HAPs or a comparatively high number of heat protection measures. Participants were identified through professional networks, including contacts from the German Alliance on Climate Change and Health (KLUG), as well as targeted online research. In total, 18 hospitals were contacted. Three declined participation, while eight reported that they had not yet implemented systematic heat protection measures to an extent that would allow them to provide sufficiently detailed information on implementation experiences. Seven hospitals with relevant experience in systematic heat protection were therefore included in the study. The purposive sampling strategy focused on hospitals already engaged in heat adaptation activities because the study aimed to assess the practical feasibility of heat protection measures based on implementation experience. This allowed for an in-depth exploration of implementation experiences and good practices. At the same time, this approach may have resulted in a positive selection bias, as participating institutions likely exhibited above-average awareness, resources, and organizational commitment regarding heat protection. The findings should therefore be interpreted as exploratory and not representative of the broader hospital sector.

An interview guide was developed on the basis of the research objectives and existing literature, following established methodological recommendations for qualitative interviews (Gläser and Laudel 2010; Misoch 2019; Döring 2023). The guide included thematic blocks covering implemented measures, evaluation of measures, organizational aspects, barriers and facilitators, and planned future actions.

Interviews were conducted online via Microsoft Teams, recorded, and automatically transcribed. Each interview lasted approximately 60 to 90 min. To ensure ethical standards, all participants received detailed study information in advance and provided informed consent. Participation was voluntary, and all data were treated confidentially (Gläser and Laudel 2010).

Transcripts were manually reviewed and edited to ensure accuracy. Standard orthography was applied, and nonessential verbal elements were removed to improve readability, while preserving the original meaning of statements (Gläser and Laudel 2010; Mayring 2023). Identifiable information was anonymized, and hospitals were assigned numerical identifiers (hospitals 1–7).

Interview data were analyzed using thematic analysis according to Braun and Clarke (2006, 2022), which allows for an inductive identification of patterns and themes without requiring a predefined theoretical framework. This approach was considered appropriate given the limited existing research on heat protection in hospitals.

The analysis followed established steps: familiarization with the data, initial coding, identification of candidate themes, and iterative refinement of themes (Braun and Clarke 2006). Coding was conducted using MAXQDA software (VERBI GmbH), using a combined deductive–inductive approach. Initial coding was guided by predefined thematic domains related to hospital heat protection, while additional themes were iteratively refined from the data.

Six overarching themes were identified (Table 1), including hospital characteristics, implemented measures, evaluation of measures, implementation barriers, facilitating factors, and planned future actions. Both qualitative comparisons and quantitative assessments of code frequencies were performed to identify patterns across interviews (Gläser and Laudel 2010).

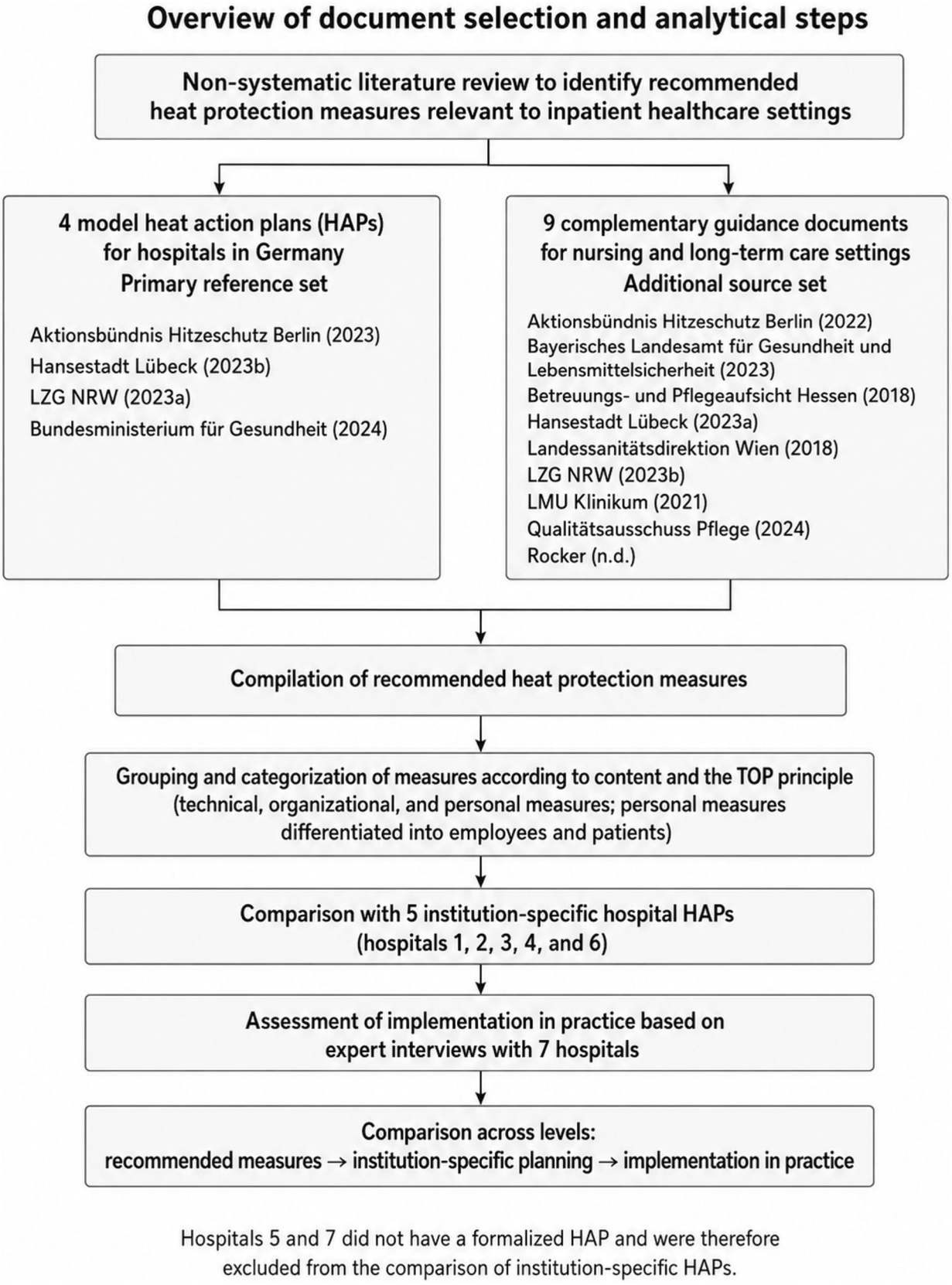


Fig. 1 Overview of document selection and analytical steps from recommended heat protection measures to institution-specific planning and implementation in practice

Table 1 Definition of identified themes

Theme	Definition
Hospital characteristics	This theme captures introductory information about the hospitals that the interviewees work in. It captures information on the location, age and size of the hospitals as well as their status as a university hospital. Additionally, it includes the stakeholders that are engaged in the core heat protection working group of the respective hospital
Implemented measures	This theme includes data on measures that have been implemented in the interviewed hospitals. These measures are categorized into technical and organizational interventions as well as those specifically aimed at hospital employees or patients
Evaluation	This theme includes evaluations of implemented measures as well as the heat burden within the hospitals. The evaluations are subdivided into the implemented measures and feedback from personnel and patients
Implementation barriers	This theme contains information on factors that hinder the implementation of heat protection measures in hospitals. The barriers are subdivided into external, internal, and financial barriers
Support for the implementation of measures	This theme contains information on factors that support the implementation of heat protection measures in hospitals. The factors are subdivided into those originating from outside or inside the hospital
Next steps	This theme includes heat protection measures that have not yet been implemented in the respective hospitals but are planned for the near future. These measures are categorized into technical and organizational interventions as well as those specifically aimed at reducing the heat burden on employees or patients

The table gives an overview of the six identified themes of the interview material as well as their definitions. The definitions of the themes also give insights into subthemes. Themes were coded according to these definitions of the themes

Results

Heat protection measures recommended in model HAPs

The analysis of model HAPs for hospitals revealed a broad spectrum of recommended heat protection measures across technical, organizational, and personal categories. However, the distribution of these measures was uneven. Across the analyzed model HAPs, 76 distinct measures were identified. Organizational measures accounted for the largest share (32%), followed by care and treatment practice measures for patients (29%), structural and technical measures (23%), and personnel and occupational safety measures (16%). Thus, measures specifically targeting hospital staff represented the smallest category, whereas measures related to patient care and treatment as well as organizational adaptation together accounted for more than half of all identified recommendations. Overall, the findings indicate a stronger emphasis on patient protection and operational continuity than on occupational heat stress among healthcare workers.

Uptake of recommended measures in institution-specific HAPs

To assess how far these recommendations are translated into formal planning, model HAPs were compared with institution-specific HAPs from five hospitals. Overall, only 41% of the measures recommended in model HAPs were included in the institution-specific HAPs across all categories. The degree of uptake varied substantially between measure types. Measures related to care and treatment practice were most frequently adopted, whereas measures addressing personnel and occupational safety were least often included. Differences between hospitals were also pronounced (Table 2). Hospitals 3 and 6 incorporated the largest share of recommended measures (65% and 64%, respectively), while hospitals 1 and 4 showed particularly low uptake (18% and 29%). Notably, hospitals 1 and 4 did not include any measures related to personnel and occupational safety. A substantial gap between recommended and adopted measures was observed, with a continued focus on patient-related interventions.

Implementation of heat protection measures in practice

While institution-specific HAPs reflect planned measures, the analysis of interview data provides insights into their actual implementation.

Figure 2 illustrates the relationship between measures included in institution-specific HAPs and their implementation status across five hospitals. Across all categories, the number of implemented measures is substantially lower than the number of measures included in HAPs.

This gap is particularly pronounced for personnel-related and technical measures, where only a small fraction of planned interventions has been realized. Organizational measures show comparatively higher implementation levels, although a discrepancy between planning and execution remains evident. Measures planned for future implementation represent only a minor share.

Across hospitals, implemented measures varied by category. For personnel, the most frequently reported measures

Table 2 Uptake of measures from model HAPs in HAPs of selected hospitals

Hospital	Personnel & occupational safety	Care & treatment practice	Organizational	Technical/ structural	Average
Hospital 1	0%	33%	29%	11%	18%
Hospital 2	33%	52%	33%	5%	31%
Hospital 3	58%	76%	67%	58%	65%
Hospital 4	0%	43%	46%	26%	29%
Hospital 6	75%	52%	58%	68%	64%
Average	**33%**	**51%**	**47%**	**34%**	
Total measures per category	12	21	24	19	

The table displays the percentages by which the HAPs of the interviewed hospitals 1, 2, 3, 4, and 6 have included the measures of the model HAPs into their institution-specific HAPs

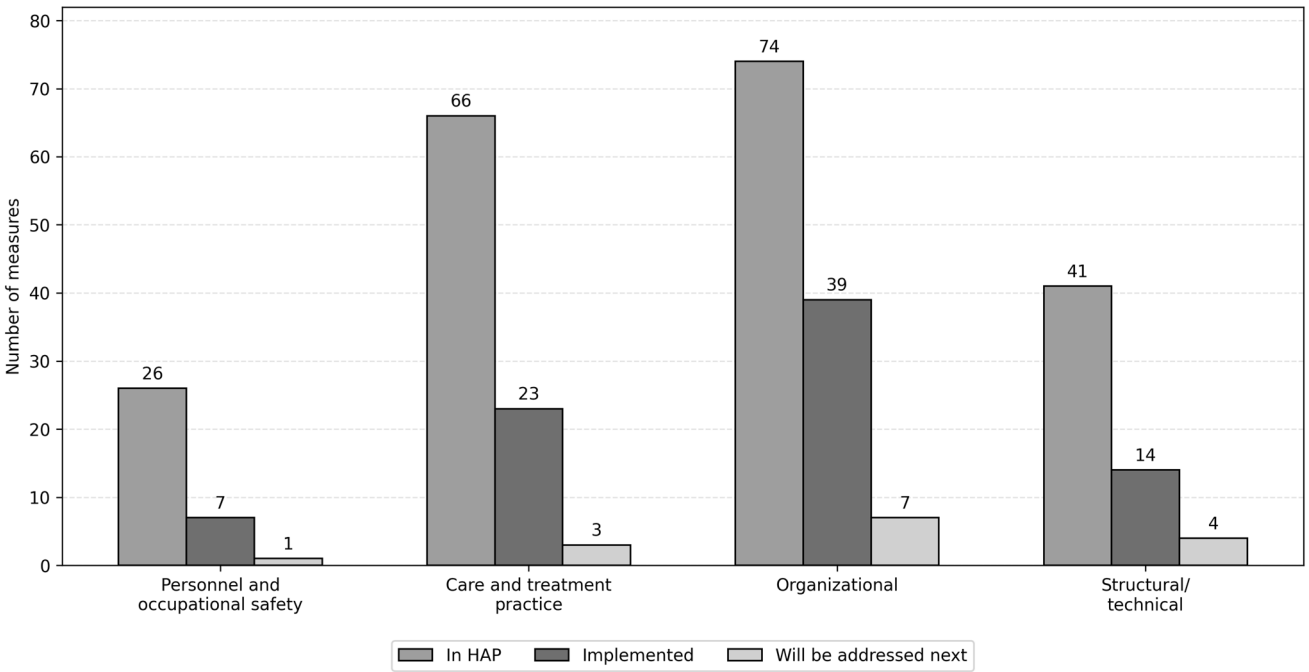


Fig. 2 Comparison of measures included in institution-specific HAPs with their implementation status across hospital 1, 2, 3, 4, and 6. The bars show the number of measures included in the respective HAP (light gray), measures already implemented (dark gray), and measures identified as next implementation steps (gray)

included the provision of drinking water, cooling vests, fans, and cooling pads. Patient-related measures most commonly comprised the provision of drinks, adjustments to food, and the distribution of informational material on self-protection. Technical measures that had already been implemented included air conditioning, exterior shading, and window films, while commonly reported organizational measures included subscription to heat warnings issued by the German Meteorological Service (DWD) and increased ventilation practices.

More resource-intensive or structurally demanding measures were implemented less frequently and often only in individual hospitals. These included the provision of cooled break rooms, identification and monitoring of particularly vulnerable patients, postponement of surgeries, designation of heat protection representatives, and the installation of drinking water fountains. Hospitals without a written HAP reported the lowest number of implemented measures. Gaps were observed both between recommended and planned measures and between planned and implemented measures.

Implementation barriers

The seven expert interviews identified structural, regulatory, and perception-based barriers that limit the implementation of heat protection measures in hospitals. The most frequently

reported barriers were limited financial resources, staff shortages, and a lack of awareness regarding the necessity of heat adaptation (see Fig. 3).

Financial constraints were particularly relevant for technical and structural measures, such as air conditioning or building modifications, which require substantial investments (Fig. 4a). At the same time, staffing shortages limit the feasibility of organizational measures, including adjustments to work schedules or additional breaks, particularly under conditions of high workload. In addition, a lack of institutional awareness and prioritization of heat-related risks was described as a key barrier, contributing to delays in planning and implementation. Hygienic concerns and regulatory requirements were also reported to restrict the use of certain measures, particularly in clinical environments. Figure 4B illustrates that these concerns were most frequently associated with personal cooling strategies, such as cooling vests, but also affected ventilation-related measures, including the use of fans or air conditioning in patient areas.

Facilitating factors for implementation

Despite the identified barriers, several factors were reported to support the implementation of heat protection measures. These facilitating factors were mentioned with varying frequency across the participating hospitals, with both widely shared and more context-specific drivers (Table 3).

Within hospitals, comprehensive internal cooperation was the most consistently reported factor, as it was mentioned by all participating hospitals ($n = 7$). In addition, the need for occupational safety as a driver for action was highlighted by several hospitals ($n = 3$). Other internal facilitating factors were reported less frequently and included the ability to demonstrate successfully implemented measures to staff ($n = 2$), the use of heat maps to support prioritization ($n = 1$), and forwarding of heat warnings to staff ($n = 1$). Further factors mentioned by individual hospitals included sufficient staffing, the formalization of heat protection concepts, as well as the perception of heat during the summer months.

Factors outside the hospital were also identified as important facilitators. Exchange with other hospitals was among the most frequently mentioned external factors ($n = 5$), highlighting the relevance of inter-institutional learning. In addition, regulatory and structural drivers played a role, such as making heat protection mandatory in hospitals through the German Technical Regulation for Workplaces (ASR) A3.5 "Room Temperature" (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin 2022) ($n = 3$). Other external factors

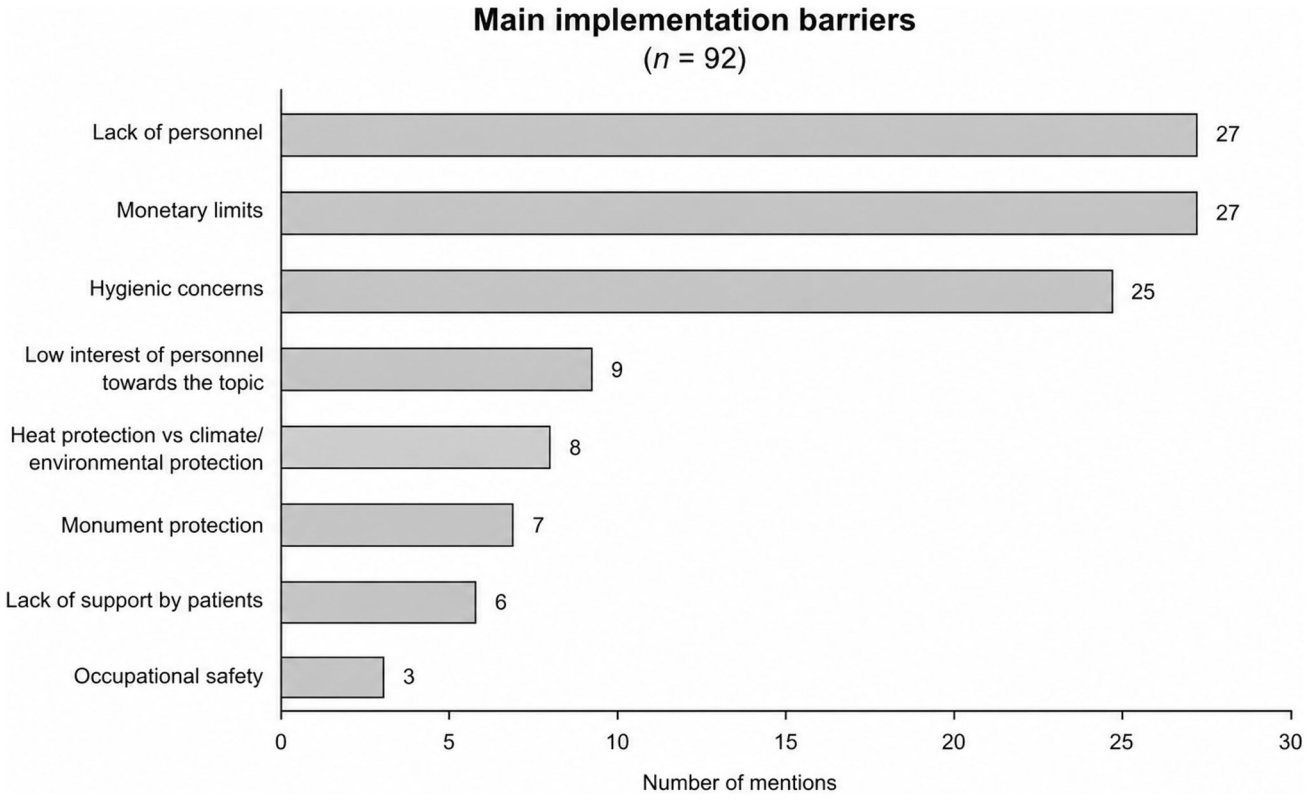


Fig. 3 Main implementation barriers reported in expert interviews. Bars indicate the frequency with which barriers were mentioned across seven interviews (multiple responses possible)

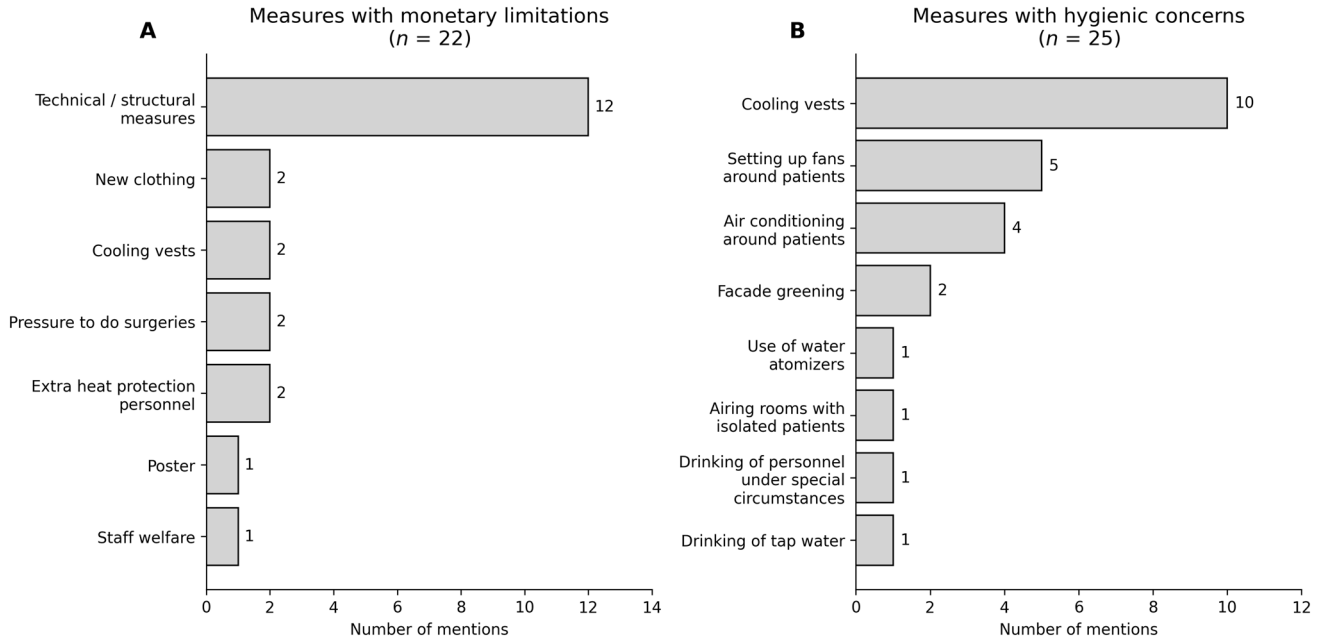


Fig. 4 Reported implementation barriers in expert interviews. (**a**) Measures limited by financial constraints. (**b**) Measures associated with hygienic concerns. Bars indicate frequency of mentions across seven interviews

Table 3 Recommendations for heat protection by the interviewees

Named by	Supportive factor
Factors inside the hospital	
All hospitals	Comprehensive cooperation inside the hospital
Hospitals 3, 4, & 5	Need for occupational safety
Hospitals 4 & 7	Being able to show employees successfully implemented measures
Hospital 3	Binding personnel to the hospital to increase motivation for work and additional tasks
Hospital 4	Forwarding information about heat warnings
Hospital 3	Heatmap to be able to explain prioritization of measures
Hospital 3	Improve the welfare of personnel
Hospital 5	Objective, neutral approach to the topic of heat protection
Hospital 4	Perception of heat burden during summer increases the willingness to adapt
Hospital 1	Provision of enough personnel
Hospital 4	Writing down a heat concept
Factors outside the hospital	
Hospitals 2, 3, 4, 6, & 7	Exchange with other hospitals regarding heat protection measures
Hospitals 2, 4, & 6	Heat protection being mandatory in hospitals
Hospitals 2 & 3	Change in media coverage on the topic of heat
Hospital 7	Better accessible funding options
Hospital 3	Change in federal health policy
Hospital 2	Increased awareness of heat as a problem in the society
Hospital 2	Use of model HAPs as templates for development of institution-specific HAP

The table shows the hospitals that stated the respective organizational recommendations for the establishment of heat protection. The list is ordered with descending frequency of hospitals that recommended the supportive factor and in alphabetical order

included changes in media coverage ($n = 2$), increased societal awareness of heat-related risks ($n = 1$), and the use of model HAPs as templates for institution-specific plans ($n = 1$).

Feasibility of heat protection measures

The feasibility of heat protection measures varied substantially depending on their type and resource requirements. Organizational measures requiring limited financial and administrative resources were most often identified by interviewees as particularly feasible. These included the use and communication of heat warnings, relaxation of clothing regulations, and the provision of drinking water. Many of these measures were already implemented or could be introduced with relatively low effort. Organizational measures also showed a comparatively high uptake into institution-specific HAPs (47%) compared with technical and structural measures (34%) (Table 2). Technical and structural measures were generally described as less feasible in the short term because of high investment costs, infrastructural constraints, and long planning and implementation timelines. Some of these measures were nevertheless perceived by interviewees as potentially effective in reducing heat exposure. The uptake of patient-related measures into institution-specific HAPs ranged from 33% to 76%, while the uptake of personnel-related measures ranged from 0% to 75%. This variation may reflect differences in local organizational conditions, particularly staffing levels and internal prioritization. Overall, the findings suggest that feasibility is closely linked to resource requirements, with low-cost, flexible organizational measures being prioritized over resource-intensive technical interventions. Feasibility and effectiveness were therefore treated as distinct dimensions: the feasibility assessment reflects practical implementation conditions reported by the participating hospitals, whereas no formal ranking of measures according to effectiveness was undertaken.

Discussion

A multi-level implementation gap and limitations of formal HAPs

This study reveals substantial multi-level implementation gaps in hospital heat protection, spanning from recommended measures in model HAPs to their inclusion in institutional plans and their actual implementation in practice. While model HAPs provide a comprehensive set of recommended measures (Matthies et al. 2008; Straff and Mücke 2017; Bundesministerium für Gesundheit 2024), only part of these are adopted into institution-specific HAPs, and even fewer are implemented in routine practice. This is consistent with previous findings suggesting that healthcare systems are still at an early stage of adapting to climate-related risks (Blum et al. 2023; Krol et al. 2023; Kammerer 2026). This is particularly relevant since evidence from other settings suggests that heat action plans can contribute to measurable reductions in heat-related mortality when effectively operationalized (Benmarhnia et al. 2016).

The results further show that formal planning alone does not guarantee implementation. Although institution-specific HAPs can help structure and prioritize adaptation, barriers also arise during operationalization, when measures must be integrated into existing workflows, responsibilities, and resource constraints, consistent with implementation science frameworks emphasizing the importance of context and organizational capacity (Nilsen 2015). Hospitals without a formalized HAP reported fewer implemented measures, indicating that plans may facilitate action while they remain insufficient on their own. Given the purposive selection of hospitals already engaged in heat protection, the observed level of implementation may represent a comparatively advanced segment of the German hospital sector. The implementation gaps identified in this study may therefore be at least as pronounced, and potentially greater, in hospitals with less experience or organizational commitment to heat adaptation.

Overall, the observed gaps appear to reflect structural and organizational constraints rather than a lack of knowledge or guidance. Similar challenges have been described in the broader climate and health literature, where the translation of evidence into practice is often hindered by institutional inertia and fragmented responsibilities (Matthies et al. 2008; Ebi and Hess 2024).

Implementation barriers and adaptive capacity

A central finding of this study is the dominant role of structural and resource-related barriers in shaping hospital heat adaptation. Financial constraints were consistently identified as a key obstacle, particularly for technical and infrastructural measures such as air conditioning or building modifications, which require substantial investments and long planning horizons (Krol et al. 2023). At the same time, staffing shortages and high workload limited the implementation of even low-threshold organizational measures, including schedule adjustments or additional breaks. Given the already high occupational burden in healthcare settings, additional adaptation requirements may exceed the operational flexibility of many hospitals (Dehl et al. 2024).

These findings point to a broader trade-off between effectiveness and feasibility. Evidence from building-related heat adaptation research indicates that structural modifications can reduce indoor temperatures (Das et al. 2025), while hospital-specific evidence suggests potential

benefits of cooling and heating, ventilation, and air-conditioning (HVAC) systems for reducing heat stress and improving patient outcomes (Lenzer et al. 2020). However, such measures are often difficult to realize in the short term because of financial, infrastructural, and regulatory constraints. In contrast, organizational measures such as adapted work–rest schedules, hydration strategies, and room ventilation practices are generally less resource-intensive and may therefore be easier to implement in the short term. Evidence from occupational settings indicates that hydration and adapted work–rest strategies can reduce physiological heat strain (Ioannou et al. 2021; Maté et al. 2016). However, their effectiveness depends on the specific intervention and context, and evidence cannot be directly transferred to hospital settings. Accordingly, the prioritization of these measures in this study reflects implementation feasibility rather than an assessment of their comparative effectiveness.

In addition, insufficient awareness and prioritization of heat-related risks within hospital management emerged as an important barrier. Despite growing evidence on heat-related morbidity and mortality (Lancet Countdown 2023; Gallo et al. 2024), heat protection is often not yet embedded in strategic planning processes.

Overall, current adaptation patterns appear to be driven primarily by feasibility considerations rather than by potential effectiveness alone. Hospitals may therefore benefit from combining low-cost organizational measures as immediate responses with long-term infrastructural investments that address underlying structural vulnerabilities (Ibbetson et al. 2025).

Perceived versus actual barriers: the role of hygiene concerns

An additional aspect highlighted in this study is the role of hygiene requirements as a perceived barrier to the implementation of certain heat protection measures, particularly personal cooling strategies such as cooling vests. Interviewees expressed concerns that such measures may conflict with existing hygiene standards in clinical settings. However, available evidence suggests that personal cooling strategies may help reduce thermal strain among healthcare workers wearing protective equipment (Bonell et al. 2021). This discrepancy suggests that barriers to implementation may not solely arise from objective constraints but also from uncertainty or lack of guidance regarding the compatibility of heat protection measures with established hygiene protocols. Clearer guidance, evidence-based recommendations, and closer integration of infection control and occupational health perspectives in the development of HAPs may help address this issue.

Underrepresentation of occupational heat protection

Another important finding is the consistent underrepresentation of measures targeting healthcare workers in both model HAPs and their practical implementation. While more than half of the recommended measures focus on patient protection, comparatively few address occupational heat exposure. This imbalance is particularly noteworthy given the multiple heat-related risks faced by healthcare workers, including physically demanding tasks, the use of personal protective equipment, and increased patient loads during heat events (Messeri et al. 2021; Dehl et al. 2024). Heat exposure has been associated with fatigue, impaired concentration, and reduced work performance, particularly when protective clothing is required (Messeri et al. 2021). Recent evidence further suggests that the needs and well-being of healthcare professionals are at risk of being overlooked within current heat adaptation efforts, as research and mitigation strategies in healthcare settings remain limited and largely focused on individual-level measures rather than organizational or structural interventions (Freire et al. 2025). Neglecting occupational heat protection may therefore have wider consequences for staff well-being, care delivery, and healthcare system resilience (Morrissey et al. 2021). The observed prioritization of patient-centered measures may reflect a structural bias within healthcare systems, where staff well-being is not yet fully integrated into climate adaptation strategies. Addressing this imbalance will be essential to protect healthcare workers and sustain care quality during extreme heat events.

Governance and implementation strategies of heat adaptation

The identification of internal cooperation and exchange between hospitals as key facilitating factors underscores the importance of governance and knowledge-sharing mechanisms for successful heat adaptation. Internal coordination structures, such as interdisciplinary working groups, may support the integration of heat protection into existing workflows, while inter-institutional exchange can accelerate the dissemination of practical solutions and best practices. In addition, regulatory frameworks, including occupational health and safety regulations (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin 2022), were perceived as important drivers of implementation. This is consistent with recent findings from German healthcare facilities, where 43% of respondents expressed a need for stronger political support and 29% for binding legal requirements for heat protection implementation (Kammerer 2026). It suggests that voluntary recommendations alone may be insufficient to ensure widespread adoption of heat protection measures.

At the same time, the findings indicate that adaptation strategies must account for substantial differences between hospitals in terms of resources, infrastructure, and organizational capacity. Rather than aiming for the immediate implementation of comprehensive HAPs, hospitals may benefit from prioritizing measures that are feasible within their specific context. Low-resource organizational measures can serve as practical entry points, helping institutions build experience, awareness, and internal support. These short-term measures should, however, be embedded within longer-term strategies that include structural and technical interventions to address more fundamental vulnerabilities. This perspective aligns with incremental approaches to climate adaptation, which emphasize stepwise implementation and continuous learning rather than one-size-fits-all solutions.

However, the need for context-specific adaptation should not be interpreted as an argument against stronger regulation. In Germany, the implementation of HAPs is largely assigned to the municipal level and is not supported by nationwide mandatory requirements (Krol et al. 2023; Bundesministerium für Gesundheit 2024). Effective adaptation may therefore require a combination of flexible, context-sensitive implementation at the institutional level and stronger regulatory frameworks at higher governance levels.

From a policy perspective, this includes dedicated funding for infrastructural adaptation, stronger integration of heat protection into regulatory frameworks, and greater awareness among decision-makers. Similar needs have also been highlighted by Blum et al. (2023). In addition, future HAPs should explicitly address occupational heat exposure as a key component of health system resilience. Strengthening the adaptive capacity of hospitals will be increasingly important in light of projected future heat burdens (Brasseur et al. 2023).

Limitations

Several limitations should be considered when interpreting the findings. The qualitative design and relatively small sample size limit the generalizability of the results. In addition, participating hospitals were already engaged in heat protection activities, which may lead to an overestimation of implementation compared to less active institutions. Furthermore, conclusions regarding the relative effectiveness of heat protection measures are based on selected literature rather than a systematic review. Consequently, this study cannot determine which measures are most effective, nor does it provide a formal ranking of interventions based on effectiveness. Instead, the recommendations presented primarily reflect implementation feasibility identified in the qualitative data, interpreted alongside available evidence from the literature. Future research should aim to provide a more comprehensive evaluation of the effectiveness and cost-effectiveness of different interventions.

Conclusion

This study demonstrates that the main challenge of hospital heat protection lies not in generating further recommendations, but in implementing existing ones. While gaps persist between guidance, planning, and practice, the findings suggest that low-cost organizational measures, such as heat warning communication, hydration strategies, flexible clothing rules, and adapted workflows, offer feasible starting points for immediate adaptation. However, their feasibility should not be interpreted as evidence of greater effectiveness in reducing heat exposure. Structural and technical interventions, such as building modifications or cooling systems, may provide substantial reductions in heat exposure but often require considerably greater financial resources, planning, and implementation time. At the same time, systematic evidence on the effectiveness of individual heat protection measures in hospitals remains limited, making it difficult to assess whether the resources required for implementation are proportionate to their actual benefits. Future implementation strategies should therefore be accompanied by robust evaluation frameworks. In addition, heat protection measures should be informed by context-specific climate and risk analyses to adequately assess local hazards and enable targeted adaptation planning. Embedding heat protection into routine hospital management will be essential to protect patients, support healthcare workers, and strengthen healthcare system resilience under climate change.

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Data availability The interview data generated and analyzed during this study are not publicly available due to confidentiality and data protection considerations.

Declarations

Ethics approval The study was conducted in accordance with generally accepted ethical principles for research involving human participants,

including the principles of the Declaration of Helsinki. No formal ethics committee approval was obtained. The study involved expert interviews with hospital professionals in their professional roles and did not involve patients, clinical interventions, or the collection of patient data. All participants received detailed study information and provided informed consent. Participation was voluntary, and all data were treated confidentially and anonymized prior to analysis.

Consent to participate All participants received detailed study information in advance and provided informed consent prior to participation. Participation was voluntary.

Competing interests The authors declare that they have no competing interests.

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References

Aktionsbündnis Hitzeschutz Berlin (2022) Musterhitzeschutzplan für stationäre Pflegeeinrichtungen, Tages- und Kurzzeitpflegeeinrichtungen und Pflege-Wohngemeinschaften. Berlin. https://hitzeschutz-berlin.de/wp-content/uploads/2022/06/Musterhitzeschutzplan-Pflege-stationaer.pdf. Accessed 19 Mar 2025

Aktionsbündnis Hitzeschutz Berlin (2023) Musterhitzeschutzplan für Krankenhäuser. Berlin. https://hitzeschutz-berlin.de/wp-content/uploads/2023/01/Musterhitzeschutzplan-Krankenhaus-2023.pdf. Accessed 19 Mar 2025

An der Heiden M, Muthers S, Niemann H, Buchholz U, Grabenhenrich L, Matzarakis A (2019) Schätzung hitzebedingter Todesfälle in Deutschland zwischen 2001 und 2015. Bundesgesundheitsbl Gesundheitsforsch Gesundheitsschutz 62:571–579. https://doi.org/10.1007/s00103-019-02932-y

Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (2023) Pflege und Hitze: Informationen für Pflegekräfte. Erlangen. https://www.bestellen.bayern.de/application/pictureSrv?SID=103827169&ACTIONxSESSxSHOWPIC(BILDxKEY:%27lgl_ges_00102%27,BILDxCLASS:%27Artikel%27,BILDxTYPE:%27PDF%27)=Z. Accessed 23 Mar 2025

Benmarhnia T, Bailey Z, Kaiser D, Auger N, King N, Kaufman JS (2016) A difference-in-differences approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec). Environ Health Perspect 124:1694–1699. https://doi.org/10.1289/EHP203

Betreuungs- und Pflegeaufsicht Hessen (2018) Außergewöhnliche Hitzeperioden: Vorbereitung und Vorgehen in stationären Einrichtungen der Alten- und Behindertenhilfe. Gießen. https://rp-giessen.hessen.de/sites/rp-giessen.hessen.de/files/2022-04/broschuere_handlungsempfehlungen_hitzeperioden_bf.pdf. Accessed 19 Mar 2025

Blum K, Janson D, Löffert S (2023) DKI-Blitzumfrage: Hitzeschutz im Krankenhaus. Umfrage Oktober 2023. Düsseldorf. https://www.dki.de/fileadmin/user_upload/2023_11_07_DKI-Blitzumfrage_-_Hitzeschutz_im_Krankenhaus_final.pdf. Accessed 18 Mar 2025

Bonell A, Nadjm B, Samateh T, Badjie J, Perry-Thomas R, Forrest K, Prentice AM, Maxwell NS (2021) Impact of personal cooling on performance, comfort and heat strain of healthcare workers in PPE, a study from West Africa. Front Public Health 9:712481. https://doi.org/10.3389/fpubh.2021.712481

Brasseur G, Jacob D, Schuck-Zöller S (eds) (2023) Klimawandel in Deutschland: Entwicklung, Folgen, Risiken und Perspektiven, 2nd edn. Springer Spektrum

Braun V, Clarke V (2006) Using thematic analysis in psychology. Qual Res Psychol 3:77–101. https://doi.org/10.1191/1478088706qp063oa

Braun V, Clarke V (2022) Thematic analysis: a practical guide. SAGE

Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (2022) Technische Regeln für Arbeitsstätten: ASR A3.5 Raumtemperatur. Berlin. https://www.baua.de/DE/Angebote/Regelwerk/ASR/ASR-A3-5. Accessed 18 Mar 2025

Bundesministerium für Gesundheit (2024) Bundesempfehlung Musterhitzeschutzplan für Krankenhäuser. Berlin. https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/H/Hitzeschutzplan/Musterhitzeschutzplan_Krankenhaeuser_BF.pdf. Accessed 19 Mar 2025

Das JK, Kumari B, Rahman AR, Azhar M, Khan S, Masood U, Karan D, Yasin R, Burman C, Augustin JL, Bonell A, Bhutta ZA (2025) Evaluation of community-based heat adaptation interventions: a systematic review. BMJ Public Health 3:e002332. https://doi.org/10.1136/bmjph-2024-002332

Dehl T, Hildebrandt S, Zich K, Nolting H-D (2024) Gesundheitsreport 2024: Analyse der Arbeitsunfähigkeiten. Gesundheitsrisiko Hitze. Arbeitswelt im Klimawandel. Beiträge zur Gesundheitsökonomie und Versorgungsforschung, vol 48. medhochzwei Verlag

Deutsche Gesetzliche Unfallversicherung (2024) Auswirkungen des Klimawandels auf die Sicherheit und Gesundheit von Beschäftigten bei der Arbeit – Umfrage 2024. Berlin. https://dguv.de/medien/inhalt/mediencenter/pm/pressearchiv/2024/quartal_3/umfrage_2024___auswirkungen_des_klimawandels_auf_die_sicherheit_und_gesundheit.pdf. Accessed 18 Mar 2025

Döring N (2023) Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften. Springer

Ebi KL, Hess JJ (2024) Introduction to JAMA climate change and health series. JAMA 331:436–437. https://doi.org/10.1001/jama.2023.25878

Freire K, Green E, Kernaghan L, Castelletto K, Schubert JA (2025) Impact of heat and mitigation strategies on healthcare professionals: a scoping review. Public Health Nurs 42:1408–1420. https://doi.org/10.1111/phn.70012

Gallo E, Quijal-Zamorano M, Méndez Turrubiates RF, Tonne C, Basagaña X, Achebak H, Ballester J (2024) Heat-related mortality in Europe during 2023 and the role of adaptation in protecting health. Nat Med 30:3101–3105. https://doi.org/10.1038/s41591-024-03186-1

Gläser J, Laudel G (2010) Experteninterviews und qualitative Inhaltsanalyse: Als Instrumente rekonstruierender Untersuchungen, 4th edn. VS Verlag für Sozialwissenschaften

Hansestadt Lübeck (2023a) Musterhitzeschutzplan für stationäre Pflegeeinrichtungen, Tages- und Kurzzeitpflegeeinrichtungen und Pflege-Wohngemeinschaften. Lübeck. https://www.luebeck.de/files/stadtentwicklung/Klimaschutz/hitzeportal/Musterhitzeschutzplan%20station%C3%A4re%20Einrichtungen.pdf. Accessed 20 Mar 2025

Hansestadt Lübeck (2023b) Musterhitzeschutzplan Krankenhaus – Stadt Lübeck. Lübeck. https://www.luebeck.de/files/stadtentwi

cklung/Klimaschutz/hitzeportal/Musterhitzeschutzplan%20Krankenhaus.pdf. Accessed 19 Mar 2025
Ibbetson A, Cairns J, Oikonomou E, Petrou G, Mavrogianni A, Howard A, Gupta R, Davies M, Milojevic A (2025) Cost-benefit analysis of interventions to protect care home residents in England against heat risks. Environ Res Health 3:045014. https://doi.org/10.1088/2752-5309/ae25c8
Intergovernmental Panel on Climate Change et al (2021) Summary for policymakers. In: Masson-Delmotte V (ed) Climate change 2021: the physical science basis. Cambridge University Press, pp 3–32
Ioannou LG, Mantzios K, Tsoutsoubi L, Nintou E, Vliora M, Gkiata P, Dallas CN, Gkikas G, Agaliotis G, Sfakianakis K, Kapnia AK, Testa DJ, Amorim T, Dinas PC, Mayor TS, Gao C, Nybo L, Flouris AD (2021) Occupational heat stress: multi-country observations and interventions. Int J Environ Res Public Health 18:6303. https://doi.org/10.3390/ijerph18126303
Kammerer K (2026) Welche Hitzeschutzmaßnahmen werden in der stationären Pflege umgesetzt? Z Gerontol Geriatr. https://doi.org/10.1007/s00391-025-02537-y
Krol U, Nakoinz A, Jagla-Franke M (2023) Hitzeschutz in (deutschen) Krankenhäusern und Pflegeheimen. Wernigerode. https://www.hs-harz.de/dokumente/extern/Forschung/NWK2023/TagungsbandNWK2023.pdf. Accessed 18 Mar 2025
Lancet Countdown (2023) Germany: Lancet Countdown on Health and Climate Change Data Sheet 2023. https://lancetcountdown.org/wp-content/uploads/2024/06/Germany_v1.pdf. Accessed 18 Mar 2025
Landessanitätsdirektion Wien (2018) Leitfaden Hitzemaßnahmenplan: Für medizinische und pflegerische Einrichtungen zur Erstellung eigener Hitzemaßnahmenpläne. Wien. https://www.wien.gv.at/gesundheit/sandirektion/leitfaden-hitzemassnahmen.html. Accessed 18 Mar 2025
Landeszentrum Gesundheit Nordrhein-Westfalen (2023a) Einrichtungsbezogener Hitzeschutz in NRW: Arbeitshilfen für Krankenhäuser. Bochum. https://www.lzg.nrw.de/_media/pdf/hitze/Hitzeschutz_NRW-Arbeitshilfen_Krankenhaeuser_Gesamt.pdf. Accessed 18 Mar 2025
Landeszentrum Gesundheit Nordrhein-Westfalen (2023b) Einrichtungsbezogener Hitzeschutz in NRW: Arbeitshilfen für stationäre Pflege- und Wohneinrichtungen. Bochum. https://www.lzg.nrw.de/_media/pdf/hitze/Hitzeschutz_NRW-Arbeitshilfen_Pflege-_und_Wohneinrichtungen_Gesamt.pdf. Accessed 18 Mar 2025
Lenzer B, Rupprecht M, Hoffmann C, Hoffmann P, Liebers U (2020) Health effects of heating, ventilation and air conditioning on hospital patients: a scoping review. BMC Public Health 20:1287. https://doi.org/10.1186/s12889-020-09358-1
LMU Klinikum Institut und Poliklinik für Arbeits-, Sozial- und Umweltmedizin (2021) Hitzemaßnahmenplan für stationäre Einrichtungen der Altenpflege: Empfehlungen aus der Praxis für die Praxis. München. https://cdn.lmu-klinikum.de/da989c211355113f/9e5343110616/LMU_Klinikum-Hitzemassnahmenplan_ONLINE.pdf. Accessed 23 Mar 2025
Maté J, Siegel R, Oosthuizen J, Laursen PB, Watson G (2016) Effect of liquid versus ice slurry ingestion on core temperature during simulated mining conditions. Open J Prev Med 6:21–30. https://doi.org/10.4236/ojpm.2016.61002
Matthies F, Bickler G, Marín CN, Hales S (2008) Heat-health action plans: Guidance. WHO Regional Office for Europe, Copenhagen. https://iris.who.int/bitstream/handle/10665/107888/9789289071918-eng.pdf. Accessed 18 Mar 2025
Mayring P (2023) Einführung in die qualitative Sozialforschung: Eine Anleitung zu qualitativem Denken, 7th edn. Beltz
Messeri A, Bonafede M, Pietrafesa E, Pinto I, de'Donato F, Crisci A, Lee JKW, Marinaccio A, Levi M, Morabito M, on behalf of the Worklimate Collaborative Group (2021) A web survey to evaluate the thermal stress associated with personal protective equipment among healthcare workers during the COVID-19 pandemic in Italy. Int J Environ Res Public Health 18:3861.https://doi.org/10.3390/ijerph18083861
Misoch S (2019) Qualitative interviews, 2nd edn. De Gruyter
Morrissey MC, Brewer GJ, Williams WJ, Quinn T, Casa DJ (2021) Impact of occupational heat stress on worker productivity and economic cost. Am J Ind Med 64:981–988. https://doi.org/10.1002/ajim.23297
Nilsen P (2015) Making sense of implementation theories, models and frameworks. Implement Sci 10:53. https://doi.org/10.1186/s13012-015-0242-0
Qualitätsausschuss Pflege (2024) Bundeseinheitliche Empfehlung des Qualitätsausschusses Pflege zum Einsatz von Hitzeschutzplänen in Pflegeeinrichtungen und -diensten. Berlin. https://www.gs-qsa-pflege.de/wp-content/uploads/2024/05/Bundeseinheitliche-Empfehlung-zum-Einsatz-von-Hitzeschutzplaenen-gem.-%C2%A7113b-Abs.-4-Satz-3-SGB-XI.pdf. Accessed 18 Mar 2025
Rocker P (n.d.) Handlungsempfehlungen für Pflegeeinrichtungen zum Umgang mit Hitzewellen. Münster. https://www.uni-potsdam.de/fileadmin/projects/extrass/Pflege_Hitze.pdf. Accessed 25 Aug 2024
Steul KS, Latasch L, Jung H-G, Heudorf U (2018) Morbidität durch Hitze – eine Analyse der Krankenhauseinweisungen per Rettungseinsatz während einer Hitzewelle 2015 in Frankfurt/Main. Gesundheitswesen 80:353–359. https://doi.org/10.1055/a-0586-8255
Straff W, Mücke H-G (2017) Recommendations for action: heat action plans to protect human health. Bonn. https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/hap_handlungsempfehlungen_en_bf.pdf. Accessed 18 Mar 2025
World Health Organization (2008) Climate change and health: Report by the Secretariat. Geneva. https://iris.who.int/bitstream/handle/10665/346168/9789240036727-eng.pdf. Accessed 18 Mar 2025

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