World Health Organization
REGIONAL OFFICE FOR Europe

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# Heat and health in the WHO European Region:

## updated evidence for effective prevention

**ABSTRACT**

The WHO Regional Office for Europe published guidance on heat–health action planning in 2008, and intends to update this to include the latest evidence. An in-depth review was initiated, based on recent epidemiological and environmental research and lessons learned from implementation in practice. This publication collates and summarizes the most relevant evidence published since 2008, focusing primarily on Member States in the WHO European Region. Findings are organized around the elements the original guidance document identified as "core" to a comprehensive heat–health action plan (HHAP), and these are complemented in each chapter with the results of a WHO survey of heat–health action planning in 2019, where relevant to the topic covered. Despite the existing gaps in knowledge, the evidence presented clearly points to a need to expand the number, coverage and reach of HHAPs in the Region. The updated guidance will be beneficial to support enhanced HHAP implementation.

**KEYWORDS**

CITY PLANNING
CLIMATE CHANGE
EUROPE
EXTREME HEAT
HEAT-HEALTH PLANNING
PUBLIC HEALTH
RISK MANAGEMENT

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# Contents

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# Abbreviations

| | |
|---|---|
| AC | air-conditioning |
| C3S | Copernicus Climate Change Service |
| CI | confidence interval |
| $CO_2$ | carbon dioxide |
| COPD | chronic obstructive pulmonary disease |
| ECMWF | European Centre for Medium-Range Weather Forecasts |
| ER | emergency room |
| EU | European Union |
| EURO-CORDEX | European branch of the World Climate Research Programme's Coordinated Regional Climate Downscaling Experiment |
| GHHIN | Global Heat Health Information Network |
| GP | general practitioner |
| HHAP | heat–health action plan |
| IPCC | Intergovernmental Panel on Climate Change |
| MMT | minimum mortality temperature |
| NGO | nongovernmental organization |
| NHS | National Health Service [United Kingdom] |
| OECD | Organisation for Economic Co-operation and Development |
| $PM_{2.5}$ | particulate matter smaller than about 2.5 μm in diameter |
| $PM_{10}$ | particulate matter smaller than about 10 μm in diameter |
| PPE | personal protective equipment |
| RCP | Representative Concentration Pathway |
| UHI | urban heat island |
| WMO | World Meteorological Organization |

# Executive summary

The climate is warming quickly and dangerously in the WHO European Region, which is experiencing accelerated rates of temperature increase and an unprecedented frequency and intensity of heat-waves. Moreover, these warming trends are projected to continue unabated in the near future and midterm in most climate change scenarios. While some countries in the Region have experienced a slight decrease in heat-related health impacts over time, the majority have seen no change or experienced increases. The evolution of heat risks and impacts on health is underpinned by the changing climate, socioeconomic factors, access to health care, urbanization and ageing, among other factors. This highlights the need for stronger public health responses capable of adapting to ongoing and projected changes.

The WHO Regional Office for Europe's 2008 guidance on heat–health action planning and its associated materials provide a frame of reference for Member States in their efforts to respond to heat-waves and to prevent and minimize their health impacts. More than a decade since the publication of the guidance, the continuous steady rise in both mean temperatures and extreme heat events underscores its importance and the urgency of its implementation throughout the Region. Maintaining operational relevance requires that the recommendations remain supported by the latest scientific evidence. Planned and existing heat–health action plans (HHAPs) should actively integrate the notion of a changing climate and changing population risk factors.

Keeping up with the scientific evidence in this field is a challenge, however. The last decade has seen a prolific number of studies on heat-related health impacts and public health prevention measures in the WHO European Region. In addition to what has been published in peer-reviewed scientific and technical journals and publications, a plethora of government and international organization reports shed light on topics related to implementation, monitoring and evaluation, and stakeholder involvement, among others. Further inputs are routinely collected by the WHO Regional Office for Europe through the Working Group on Health and Climate Change as part of the Environmental Health Task Force. To complement all these sources, in 2019 WHO disseminated and compiled responses to the most comprehensive survey to date on heat–health action planning in the Region.

Together, all this information constitutes a solid basis from which to undertake updating of the 2008 guidance. This publication collates and summarizes the most relevant evidence published since 2008, focusing primarily on the 53 Member States served by the WHO Regional Office for Europe. Findings are organized around the eight elements that the original guidance document identified as "core" to a comprehensive HHAP, and each chapter is complemented with the results of WHO's 2019 survey of heat–health action planning, where relevant to the topic covered. The main contents of each chapter are outlined below.

Chapter 1 sets the scene and outlines the heat and health impacts, both observed and projected, focusing on countries in the WHO European Region. Projections clearly indicate that without adequate efforts for adaptation to climate change, heat-related exposures and the associated health impacts will increase substantially.

Chapter 2 summarizes evidence on the governance of public health responses to heat. The need to define and implement appropriate and agreed-upon public health responses and policies has become increasingly pressing, though the available evidence on what constitutes good practice in the governance of such responses is limited. The key issues to address are becoming increasingly clear, however, including adequate funding and human resources and formal involvement of subnational and non-state actors.

Chapter 3 reports on heat–health warning systems and how HHAPs should be underpinned by them for timely and effective responses. The scientific literature suggests that considerable effort has been invested in improving warning model performance and lead times, targeted dissemination and their understanding among public health stakeholders. Evaluation of warning systems needs to be carried out regularly to ensure constant improvement and understanding.

Chapter 4 summarizes the evidence on how heat-related health information plans communicate heat risks and recommendations. It outlines existing approaches to make heat–health messages effective, and considers how HHAPs can better target warnings, recommendations and information to their various stakeholders and audiences. Countries have generally shifted their HHAP communications towards web-based and mobile technology platforms, and it is important that such transitions are carried out ensuring social justice, without excluding the most vulnerable or those with fewer resources.

Chapter 5 reports on types of intervention and evidence on effectiveness in the reduction of hazardous indoor heat exposure. A wide variety of passive cooling (related to housing and cooling) and active cooling (such as air-conditioning, personal cooling devices) interventions and technologies can be applied. Understanding of the thermal comfort needs of those most vulnerable to heat is still limited, however, and data on the real-time association between outdoor and indoor temperatures in residential settings are lacking. More research is needed on risks of overheating and adaptive solutions in hospitals, residential care homes and other settings.

Chapter 6 outlines the updated evidence on risk factors and vulnerability. That evidence is evolving and becoming more specific in terms of health outcomes, biological mechanisms, causality and the vulnerability of different groups. To date, however, most national HHAPs mention vulnerable groups but do not contain actions addressed to them. More effort should be put into raising awareness and promoting active response measures and training of health and social care professionals. It is important to acknowledge that vulnerable subgroups and their needs change over time and require ongoing monitoring and study.

Chapter 7 reports on the preparedness of the health and social care system for heat. To date, evidence on planning and response measures in place within health care settings and their effectiveness is sparse. A key challenge that remains is the impact of heat-waves in health and social care facilities, despite significant heat-wave events occurring throughout the WHO European Region in recent years. Greater effort needs to be put into sharing best practice planning and response measures in the health sector.

Chapter 8 describes how long-term urban planning can reduce heat risks. Green and blue (water) spaces, urban landscape materials and colours, and urban structure modifications are key areas for the long-term mitigation of health risks from heat and of greenhouse gas emissions. Despite their health protection potential, urban planning interventions remain the least implemented HHAP core element. Tools for intersectoral action are lacking to allow public health agencies to influence urban management decisions in order to protect health from heat.

Chapter 9 explores the use of monitoring and evaluation processes as crucial components of HHAPs. Health surveillance is important to monitor health impacts and evaluate response measures during and after heat-wave events, but it is still a marginal element in HHAPs and needs to be promoted. Evaluation entails multidisciplinary and collaborative action between various stakeholders to address the different aspects and components of the HHAP. Formal and constant monitoring and evaluation of HHAPs are essential to understand their effectiveness and potential areas of improvement.

Chapter 10 provides a summary of the key messages from the report, with specific and overarching conclusions, as well as evidence and research gaps.

The process of information collection, drafting and editing of this report has also revealed that significant gaps in knowledge and evidence continue to hinder heat–health action planning throughout the WHO European Region. While there has been a notable increase of scientific publications on heat and health in the last decade, most studies still covered mainly European Union Member countries, with studies in other areas of the Region few and far between. In addition, more evidence is needed to interpret the observed trends in heat and health in response to HHAPs accurately, and specifically the causal pathways between interventions and measured effects. Best practice evidence and sharing of experiences is vital both locally and at the regional level, yet the published evidence of planning and response measures in the health sector is still limited in the peer-reviewed scientific literature and needs to be promoted. Moreover, the lack of generalized and systematic efforts to monitor and evaluate HHAP processes and outcomes constitutes a challenge to empirically determining the effectiveness of different prevention measures and response and the relative effects of changes in population vulnerability and adaptation, among other factors.

What constitutes good governance of public health prevention of heat also remains an open question, although literature and data from Member States point at significant improvement potential for additional engagement by subnational and non-state stakeholders, which could improve the reach and operationalization of plans. While the last decade of evidence on the links between the built environment, heat exposure and health has provided new insights, important questions remain. A crucial one concerns the thermal comfort needs of vulnerable individuals, as well as the real-life (compared with modelling) effect of housing and built environment interventions in reducing hazardous exposure to heat at the individual level. Lastly, there is a need for more applied research into the regulatory, financial, procedural, knowledge and other barriers that may prevent effective action on heat and health.

Despite the existing gaps in knowledge, the evidence presented in this publication clearly points at the need to expand the number, coverage and reach of HHAPs in the WHO European Region. These policies are urgently needed in European countries facing an increasing risk of high temperatures and heat-waves, to prevent expected increases of climate change-related impacts. Moreover, the initial design, development or revisions to HHAPs, as well as their implementation and core elements, should actively integrate the notion of a changing climate and societies. To support such enhanced HHAP implementation, updating the 2008 WHO heat–health action planning guidance is necessary and fully justified.


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# Introduction: heat–health action planning guidance 10 years on

## Background and purpose

Since its publication, the WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008) and the associated supporting materials (WHO Regional Office for Europe, 2011) have constituted a useful framework for national and subnational governments responsible for planning or implementing heat–health prevention programmes.

In 2018, a decade after the publication of the original guidance, the Regional Office initiated an in-depth review of evidence on recent epidemiological and environmental research and lessons learned from implementation of heat–health action planning in practice. This report presents the review's findings in the form of an overview of relevant recent evidence with clear implications for the prevention of health effects caused by heat-waves. It is primarily intended for practitioners, to support their own processes of revision of national heat–health action plan (HHAP) elements or procedures. It also constitutes a basis from which to organize an update of the 2008 WHO guidance.

The report is based on the findings of a number of literature reviews, focusing on:

- the effectiveness of HHAPs;
- heat in the context of climate change and other global trends;
- heat–health governance;
- risk perception;
- work productivity and heat;
- acclimatization and adaptation to heat;
- urban management interventions.

In addition to systematic reviews to take stock of the wealth of scientific literature, this report also includes "grey literature" in the form of technical reports and studies from government and international organizations, on account of their operational and practical implications for prevention at the national and regional levels. Together, these constitute a much broader foundation from which to look at heat–health action planning than was available when the 2008 WHO guidance was published.

In undertaking the evidence review, three main criteria guided the report's development:

- geographical scope: focusing primarily on the 53 Member States served by the WHO Regional Office for Europe, but including studies from elsewhere if needed;
- novelty: highlighting mainly (but not exclusively) evidence produced since the publication of the 2008 WHO guidance;
- quality: while not based on a formal grading of evidence, focusing on a curated selection of reviews that prioritized peer-reviewed literature – and within it reviews and/or meta-analysis – where available (although some of the most operationally relevant observations in heat–health prevention are frequently published in government or research reports, and these are included where needed).

In addition to a review of the published literature, this report features the results of a survey of heat–health action planning undertaken by the WHO Regional Office for Europe in 2019. This survey was disseminated via members of the Working Group on Health in Climate Change, established under the European Environment and Health Process, and other relevant subnational networks, such as the WHO European Healthy Cities Network and Regions for Health Network. It covered areas related to implementation of HHAPs, organized around the core elements outlined in the 2008 WHO guidance, as well as implementation and operational questions typically not covered in HHAP official description documents. The choice of survey mode was web-based, and the target respondents were government officials or public administrators acting as lead administrators of HHAPs, national or subnational focal points or experts familiar with heat–health action planning in the country. The 35 participating countries were Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Kazakhstan, Lithuania, Malta, Montenegro, the Netherlands, North Macedonia, Norway, Poland, Portugal, the Russian Federation, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkmenistan, Ukraine and the United Kingdom.

While the literature reviews revealed a broad array of new findings, methods and models, they also found large geographical and income-related imbalances in research and evidence. A great increase in research and publications on the impacts of heat on health from the early 2000s, was reported both globally – in particular, in Organisation for Economic Co-operation and Development (OECD) countries – and within Europe (Campbell et al., 2018). Most studies, however, almost exclusively covered European Union (EU) countries, with few considering other areas in the WHO European Region. On the other hand, other types of technical literature – not necessarily published in peer-reviewed journals – and the results of the survey provided insights into both the health impacts of heat and their prevention in non-EU countries.

This report also considers the evidence of the last decade and new insights related to the links between climate change, heat exposure and health. Large compilations and efforts such as the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (Pachauri & Meyer, 2014), the Lancet Commission on Health and Climate Change (Watts et al., 2015) and the Lancet Countdown on health and climate change (Watts et al., 2018) have covered actual and potential links between climate change adaptation and health extensively, including heat–health risks.

Much has happened in the last decade concerning the integration of climate considerations into public health practice and of public health into climate policy-making. In 2017 the WHO Regional Office for Europe and the European Commission also undertook literature reviews and a country survey to analyse developments in health policies to address adaptation to climate change in EU countries and to compile a selection of good practice case studies, including on heat–health management (WHO Regional Office for Europe, 2018).

## Structure

The contents of this report are organized around the eight elements that the WHO Regional Office for Europe's 2008 guidance identified as "core" to a comprehensive HHAP. Because both the evidence base and practices have evolved significantly in the last decade, the scope of each of these elements is generally broader than the original set covered in the 2008 guidance. The descriptions of the elements (covered in Chapters 2–9) have thus been modified to reflect this expanded scope:

- Chapter 2. Agreement on a lead body: governance of public health responses to heat;
- Chapter 3. Accurate and timely alert systems: heat–health warning systems;
- Chapter 4. Heat-related health information plans: communicating heat risk;
- Chapter 5. Reductions in indoor heat exposure: types of intervention and evidence of effectiveness;
- Chapter 6. Care for vulnerable population groups: updated evidence on risk factors and vulnerability;
- Chapter 7. Preparedness: planning for heat–health risks in health and social care settings;
- Chapter 8. Long-term urban planning: reducing heat risks;
- Chapter 9. Real-time information: surveillance, monitoring and evaluation of HHAPs.

In addition to the chapters covering the HHAP core elements, Chapter 1 presents the most relevant recent trends in climate variables, heat exposure and associated risks or impacts. Chapter 10 includes a set of operationally relevant conclusions, as well as a summary of the knowledge gaps and most pressing research needs identified.

The results of WHO's 2019 survey of heat–health action planning have been included where relevant to the topic covered.

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[1] All URLs accessed 27 August 2020.

# Chapter 1. Setting the scene: impacts of heat on health in the WHO European Region

## Summary

In several countries, despite increasing episodes of extreme temperatures, heat-related health impacts seem to be decreasing. This highlights the effectiveness of current prevention measures. Nevertheless, projections for the Region clearly indicate that without adequate efforts for heat–health adaptation to climate change, heat-related exposures and the associated health impacts could increase substantially. Such projections, combined with long-term trends of ageing and urbanization, strongly warrant adoption of a long-term perspective to manage the health effects of temperature in the context of a changing climate.

## Key messages

- Countries in the WHO European Region are experiencing accelerated rates of warming and an unprecedented frequency and intensity of heat-waves.
- These trends are projected to continue unabated in the near future and midterm under current rates of global warming.
- Some countries in the Region have experienced a reduction in heat-related health impacts over time, whereas others have not experienced change or are experiencing increases.
- Within the Region, populations in places with generally higher temperatures tend to be less vulnerable to heat than those with more temperate climates, thanks to adaptive strategies and acclimatization.
- Secular trends (long-term non-periodic variation) in climate change, urbanization and ageing strongly justify adopting longer-term perspectives in public health responses against dangerous heat.

## 1.1 Changes in high temperatures and projections for the Region

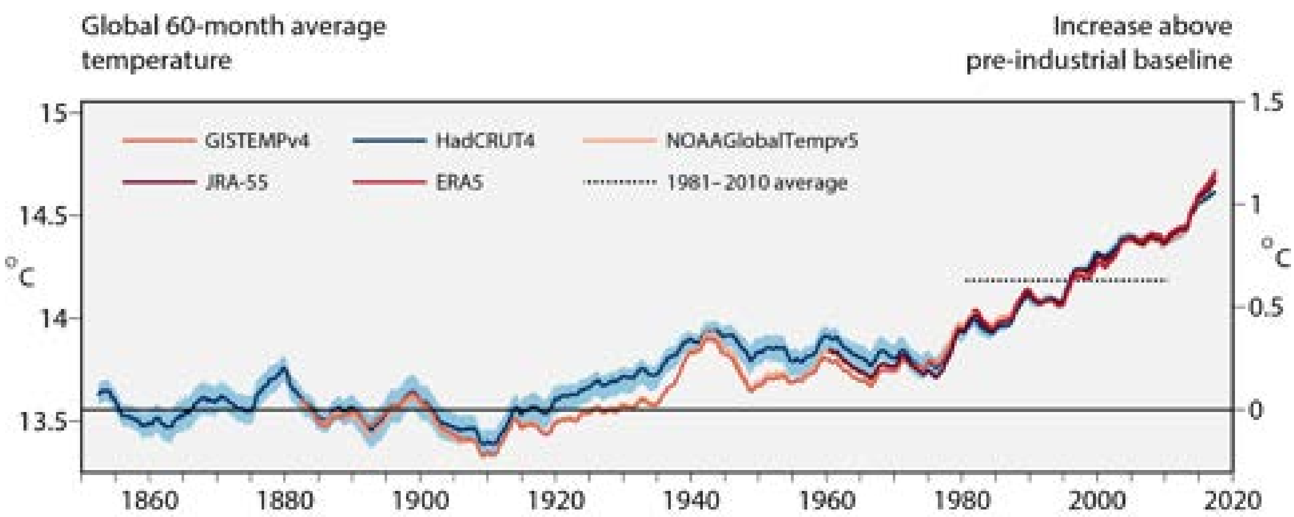
### 1.1.1 Observed trends in temperatures

The WHO European Region is warming, fast and dangerously. The year of inception of this report (2019) was the warmest calendar year on record in the northern part of Region, as well as the second warmest year globally ever recorded. It was not an outlier, however: according to the European Centre for Medium-Range Weather Forecasts (ECMWF), 11 of the 12 warmest years in the Region have all occurred since 2000 (ECMWF, 2020). Both annual and seasonal average temperatures show a clear warming trend over the last four decades. Warming trends in the Region are consistently measured and statistically significant (Gil-Alana & Sauci, 2019); they are routinely evaluated by comparing recent measurements with climate data dating back to pre-industrial times (Fig. 1).

Beyond average temperatures, heat-waves are also growing in frequency, in relative and absolute intensity and in duration, with a significant increasing trend in the Region since 1950 (Donat et al., 2013). The number of hot days has increased by 10 days per decade since 1960 in most of south-eastern Europe and Scandinavia (Russo, Sillmann & Fischer, 2015). A comprehensive study of 59 weather stations in the eastern part of Europe, the Caucasus, the Russian Federation and central Asia, using data from 1951 to 2010, found a clear increasing trend in the frequency of extremely hot summers (with an average temperature equal to or greater than the long-term average plus two standard deviations). While one extremely hot summer occurred during the first 30 years, five occurred during the last 10 years of the study period (Twardosz & Kossowska-Cezak, 2013). An increasing trend in heat-wave frequency and intensity has been observed in Poland, although the increase is statistically significant at only about 60% of analysed stations (Wibig, 2017).

A recent study examining 100 years of data (1917–2016) found significant increasing trends in the frequency, intensity and duration of heat-waves in most of central Asia (which in this study refers to Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan), and especially during the last 50 years in western central Asia (Yu et al., 2020). In Georgia, a statistical analysis demonstrated significant increases in the number, intensity and duration of low- and high-intensity heat-waves (Keggenhoff, Elizbarashvili & King, 2015). Data also indicate that the frequency and duration of heat-waves increased in the western part of Turkey between 1965 and 2006 (Unal, Tan & Mentes, 2013). Other parts of the WHO European Region, including most countries in the Mediterranean basin, have also experienced an increase in the frequency and intensity of heat-waves, as has Israel (Green et al., 2013), where record high temperatures were registered as recently as May 2019 (WMO, 2019).

**Fig. 1. Global air temperature and estimated change since the pre-industrial period**




*Source:* ECMWF (2020).

The lines depict datasets from different institutions: ERA5, ECMWF Copernicus Climate Change Service; GISTEMP v4, National Aeronautics and Space Administration, United States; HadCRUT4, Met Office Hadley Centre, United Kingdom; NOAAGlobalTemp v5, National Oceanic and Atmospheric Administration, United States; JRA-55, Japan Meteorological Agency.

Most worryingly, analyses show that events that would be expected to occur twice a century in the early 2000s – such as the massive 2003 European heat-waves – are now expected to occur twice a decade (Christidis, Jones & Stott, 2015). The number of days with high heat stress levels is increasing in both the northern and southern parts of the WHO European Region. In 2019, for example, large parts of the west and north of Europe experienced strong or very strong heat stress, including areas that on average have not often experienced it in the past (ECMWF, 2020).

The World Meteorological Organization (WMO) Statement on the State of the Global Climate in 2019 reported than in June 2019 a heat-wave affecting south-western and central Europe resulted in a number of deaths in Spain and France (WMO, 2020). A more significant heat-wave occurred in late July 2019, affecting much of the central and western part of the Region. In the Netherlands, this event was associated with approximately 3000 deaths – nearly 400 more than the average – while in England, United Kingdom, 572 excess deaths were observed above the baseline for all-cause mortality in people aged over 65 years. In metropolitan France, between the beginning of June and mid-September 2019, over 20 000 emergency room (ER) visits and 5700 home visits by doctors were recorded for heat-related illnesses. Across both the summer heat-waves, a total of 1462 excess deaths were observed in the affected regions.

Another clear and extreme example was the June 2020 heat-wave in Siberia, including a record-breaking 38 °C in Verkhoyansk. Experts of the World Weather Attribution initiative concluded that this extremely hot period was made at least 600 times more likely as a result of human-induced climate change; in other words, it would be almost impossible without climate change (Ciavarella et al., 2020).

The evidence supporting these trends is solid and continues to be strengthened by successive studies. Furthermore, with a relatively dense monitoring network, European temperature measurement data and the evidence base for trend analyses are highly reliable. Meteorological offices throughout the WHO European Region have strong capacities, datasets, remote sensing and modelling capabilities. Important intraregional collaboration networks are also in place, with tangible climate services that are of use for public health (see example in Box 1). Thus, health authorities and practitioners, can use these data with relative confidence for planning and operational purposes.

### 1.1.2 Projections of temperatures

In parallel to this accelerated rise in average temperatures and heat-wave occurrences, global concentrations of carbon dioxide continued to rise in 2019 by around 0.6% globally (ECMWF, 2020a). This rate of increase of anthropogenic emissions of greenhouse gases means that a long-lasting reduction in European temperatures is unlikely within this century. Model predictions reveal an increase in the probability of occurrence of extreme and very extreme heat-waves in the coming years – in particular, by the end of this century. Under the most severe IPCC AR5 scenario, events of the same severity as that in the Russian Federation in the summer of 2010 will become the norm, and are projected to occur as often as every two years for regions such as southern Europe, North America, South America, Africa and Indonesia (Russo et al., 2014). Warming is projected to be more intense in western, northern, central and southern parts of the Region on average than the rest of the planet, according to the European branch of the World Climate Research Programme's Coordinated Regional Climate Downscaling Experiment (EURO-CORDEX). Various models project a realistic warming of EU countries by 2.5–5.5 ºC for the last third of the 21st century, compared to 1971–2000 (Amengual et al., 2014; Jacob et al., 2014).

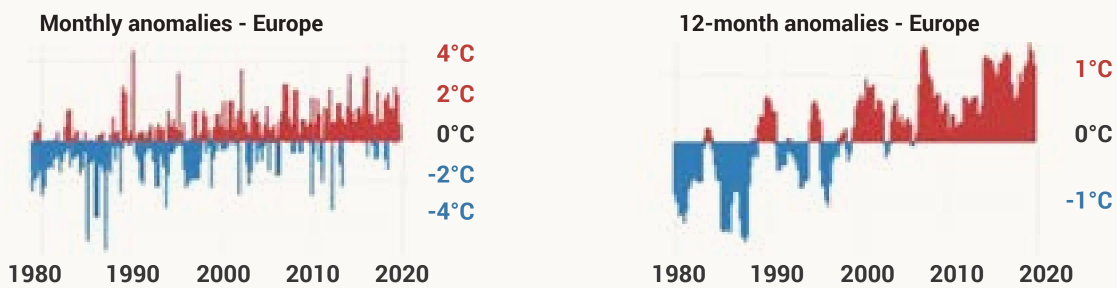
## Box 1. Copernicus Climate Change Service and Climate Data Store

The Copernicus Climate Change Service (C3S) provides access to quality-controlled data about the past, the present and the future of global climate. These include historical observations, global hourly data about all main meteorological parameters extending from 1979 to near-real time (five-day latency), seasonal predictions for the next six months, and global and regional climate projections. Given the impact climate variability and change is having on societies, and the complexity of the processing procedures associated with analysis of climate data, C3S makes high-quality, up-to-date datasets available in an unrestricted manner to all users. The service also provides a free cloud environment in which to process the data and transform it into usable and useful information.

The following example represents a way in which C3S data can be used to inform stakeholders and policy-makers. Fig. 2 shows the trend in change in degrees per year of the surface air temperature for the summer months (June, July and August) during 1979–2019. The values were calculated using a linear trend on the ECMWF re-analysis data for the surface temperature. The figure shows European surface air temperature anomalies relative to the 1981–2010 average, from January 1979 to August 2019. The first graph shows the mean anomalies for every month and the second graph shows the running 12-month averages.

The plot and the code to generate this plot are freely available online on the C3S Climate Data Store platform for anyone to consult or reproduce. The user can also analyse past temperature anomalies for specific months and year through the C3S monthly climate bulletin explorer application.

**Fig. 2. Europe surface air temperature anomalies relative to the 1981–2010 average, January 1979 to August 2019**



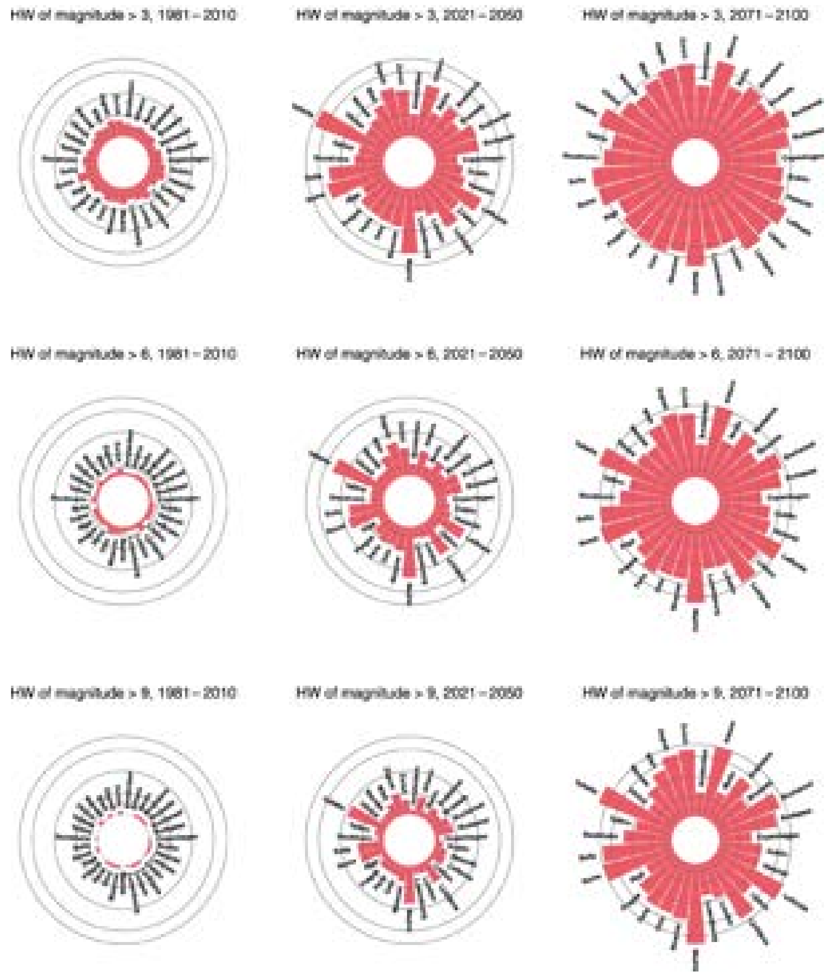

*Source:* ECMWF (2020b).

Greater temperature increases are expected in the north of the Region in winter (potentially decreasing cold-related mortality), and in the south-east and the Balkans in the summer (EEA, 2017). The increase in warming magnitude is expected to be most dramatic in the central southern part of the Region, while the increase in duration of hot conditions is expected to be most pronounced in the Mediterranean (Guerreiro et al., 2018). Nevertheless, extreme heat events may also occur in northern areas that are currently not strongly affected by heat-waves (Nikulin et al., 2011).

In central Asia, assuming a 4 °C increase in global temperatures by the end of the century, around 80% of the land area could be affected by events hotter than three standard deviations beyond the long-term temperature average, and about 50% of the land area could be affected by events hotter than five standard deviations by 2071–2099 (Reyer et al., 2017). In general, solid high extremes temperature projections under climate change are comparatively scarce in the published literature for most areas of the Region beyond EU countries. This scarcity poses a clear challenge for evidence-based heat–health action and health adaptation in these areas.

Both average increases in temperature and projected increases in frequency, intensity and duration of heat-waves are of concern for public health. Globally, under an increasingly probably high warming scenario,[1] every second summer will be as warm or warmer than the hottest summer ever experienced by the population during 1920–2014 (Lehner, Deser & Sanderson, 2018). The increase in probability of extreme heat-waves in large urban areas in the Region is a particular concern, on account of population concentration, urban landscape and demographic factors (explored later in this report). A recent study (Smid et al., 2019) estimated heat-wave[2] probability increases for 31 European capitals (the capitals of the 28 EU countries before 2020, plus Moscow, Russian Federation; Oslo, Norway; and Zurich, Switzerland), and found that all the European metropolitan areas investigated will be more vulnerable to extreme heat in the coming decades (Fig. 3). The number of days with high heat stress

**Fig. 3. Probability of magnitudes of heat-wave occurrence in 31 European capitals in prospective scenarios**




*Source:* Smid et al. (2019).

*HW: heat-wave was defined in this study as a climatic event equal to or longer than three consecutive days, with a maximum temperature above the daily threshold for the reference period, 1981–2010.*

[1] Representative Concentration Pathway (RCP) 8.5; for a description, see Matthews (2018).

[2] Defined through the Heat Wave Magnitude Index daily (Russo et al., 2014).

levels is increasing in both northern and southern parts of the Region. The potential for hazardous exposure to extreme heat has been worsening in recent decades, and will continue to do so across the Region.

## 1.2 How heat affects health and projections for the Region

Heat extremes have serious impacts on public health in Europe. The effects of heat mostly occur on the same day and in the following three days. The observed increase in frequency and intensity of heat-waves – for which there is no globally agreed definition, but for the purposes of this report meaning periods of hot weather lasting for several days – has had significant effects on human health across Europe, particularly among elderly people and in cities due to the urban heat island effect. Age, pre-existing medical conditions and social deprivation are key factors that make people experience more adverse health outcomes related to heat and extreme temperatures. The effects of exposure can be directly related to heat (heat stress and dehydration or heatstroke) or indirectly related – such as a worsening of cardiovascular and respiratory diseases, kidney diseases or electrolyte disorders (WHO Regional Office for Europe, 2018).

### 1.2.1 Observed heat-related mortality impacts and trends

The Global Heat Health Information Network (GHHIN) was initiated in 2016 and launched publicly in 2018 as a joint initiative of the WMO, WHO and United States National Oceanic and Atmospheric Administration to respond to coordination and technical advisory needs identified by the global meteorological and public health communities (GHHIN, 2020). The Network largely serves as a community of practice and a knowledge broker for both individuals and institutions across a broad range of disciplines focused on addressing the human health risks posed by extreme heat.

Several studies indicate that heat-related health impacts are generally decreasing over time in many parts – but not all – of the WHO European Region, although this reduction is not homogeneous or generalized. Similar reductions (with similar caveats) have been observed in other parts of the world, including Australia, Japan and the United States of America. Studies of trends in human vulnerability to extreme heat in several countries in the WHO European Region are presented in Table 1, mainly adapted from the review by Sheridan & Allen (2018). The majority of the studies considered mortality health outcomes, probably due to the availability of health data and a lack of information on indirect impacts or health service delivery.

Within the WHO European Region, clear decreases in some measure of vulnerability to heat or health impacts of heat have been observed in France (Fouillet et al., 2008; Pascal et al., 2018), Ireland (Pascal et al., 2013; Paterson & Godsmark, 2020), Italy (Schifano et al., 2012; de'Donato et al., 2018) and Spain (Achebak, Devolder & Ballester, 2018; Díaz et al., 2018). On the other hand, no consistent evidence of a significant decrease has been found for the United Kingdom (Gasparrini et al., 2015), and although no significant excess mortality was observed there in a recent severe heat-wave in 2013 (Green et al., 2016), the overall evidence suggest that heat-related mortality may be increasing (Arbuthnott & Hajat, 2017). In Czechia, a recent analysis points to a comparative increase (Urban, Davidkovova & Kyselý, 2014). Relatively comparable heat-waves in Finland in 2014 and 2018 resulted in 330 and 380 deaths, respectively (THL, 2019). A study carried out in Slovenia found greater heat-related mortality among vulnerable groups in 2015 than in 2013 (Perčič et al., 2018).

**Table 1. Studies of trends in heat-related health vulnerability in countries in the Region**

| Country | Studies and main conclusions |
|---|---|
| Austria | (Vienna) Matzarakis, Muthers & Koch (2011): a decrease in sensitivity to heat stress was observed from 1970 to 2007, particularly for moderate heat stress.<br>(Vienna) Muthers, Matzarakis & Koch (2010a): changes in heat vulnerability were observed from 1970 to 2007.<br>(Vienna) Muthers, Matzarakis & Koch (2010b): sensitivity to heat stress decreased from 1970 to 2007. |
| Czechia | Urban et al. (2017): the summer of 2015 was as pronounced as the summer of 1994 in terms of heat-related mortality.<br>Kyselý & Plavcová (2012): declining trends in mortality impacts were observed from 1986 to 2009.<br>Kyselý and Kríz (2008): the mortality response in 2003 was less than in previous events in the 1990s. |
| Finland | Ruuhela et al. (2017): sensitivity to heat stress decreased from 1972 to 2014.<br>(Helsinki) de'Donato et al. (2015): an increased risk was seen in Helsinki from 1996 to 2010. |
| France | (Central France) Todd & Valleron (2015): the ratio of mortality attributed to high temperatures declined significantly from 1968 to 2009.<br>Pascal, Le Tertre & Saoudi (2012): mortality was lower in the 2006 heat event than the 2003 heat event.<br>Fouillet et al. (2008): decreased excess mortality was observed in the 2006 heat-wave compared to the 1975–2003 baseline heat–mortality relationship. |
| Germany | Gabriel & Endlicher (2011): heat-related mortality was much higher in the 1994 heat event than the 2006 event.<br>Mücke & Litvinovitch (2020): the maximum number of heat-related deaths was 7600 in 2003, followed by 6200 in 2006 and 6100 in 2015. |
| Greece | (Athens) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010. |
| Hungary | (Budapest) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010. |
| Ireland | Pascal et al. (2013): heat-wave-related mortality declined from 1981 to 2006. |
| Italy | (Rome) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010.<br>Morabito et al. (2012): a decrease in the impact of excessive heat effect on mortality in Italy was seen after prevention was implemented (in 2004).<br>Schifano et al. (2012): a significant decrease in heat-related mortality in those aged 65 years and older was observed in 2006–2010 following implementation of a national prevention plan. |
| Kazakhstan | Grjibovski et al. (2013): higher temperatures were associated with higher mortality from cerebrovascular diseases during the warm seasons (April–September) of 2000–2001 and 2006–2010. |
| Latvia | Pfeifer et al. (2020): short-term associations were seen between heat-waves and both all-cause and cardiovascular mortality in Riga. |
| Netherlands | Ekamper et al. (2009): reduced effects of heat from 1930 in the Netherlands can be attributed to changes in nutrition, clothing and education.<br>Folkerts et al. (2020): the susceptibility of humans to heat decreased over time in the Netherlands. |
| North Macedonia | Martinez et al. (2016): during 2007–2011, 4.5% of deaths during the warm seasons were attributable to mean temperatures exceeding the estimated threshold. |

**Table 1 contd**

| Country | Studies and main conclusions |
| --- | --- |
| Republic of Moldova | Corobov et al. (2013): the relationships identified between ambient temperatures and human mortality may not be stationary in time, being only relevant to the time period studied (2000–2008). |
| Spain | Linares et al. (2015): a significant decrease in heat-related mortality was observed in some locations, while others did not show any change.<br>(Barcelona, Valencia) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010.<br>Gasparrini et al. (2015): mortality risk associated with high temperatures was lower in 2006 than 1993.<br>(Central Spain) Mirón et al. (2015): heat-related respiratory mortality did not decrease as circulatory cases declined from 1975–2008.<br>(Galicia) De Castro et al. (2011): mortality associated with the 1990 heat-wave was higher than during the 2003 event, despite the latter being more extreme. |
| Sweden | Åström et al. (2016): the effect of temperature on mortality decreased over time in 1800–1950.<br>(Stockholm) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010.<br>(Stockholm) Åström et al. (2013a): the relative risk of heat-related mortality remained stable from 1980–2009.<br>(Stockholm) Åström et al. (2013b): while heat events have increased in the last two decades, their impact on mortality overall declined during 1901–2009. |
| Switzerland | Ragettli et al. (2017): a reduction in the effect of high temperatures on mortality was found after 2003, although it is not statistically significant. |
| United Kingdom | (England) Green et al. (2016): despite the sustained 2013 heat-wave, mortality was lower than expected.<br>(London) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010.<br>(England and Wales) Christidis, Donaldson & Stott (2010): a small, positive trend in heat-related mortality was observed after 1976; this was due to more events, despite a weaker response.<br>(London) Carson et al. (2006): despite an ageing population, there was a significant reduction in temperature-related deaths over the 20th century. |

*Source:* adapted from Sheridan & Allen (2018).

In the absence of countrywide trends, city-specific studies can provide a useful reference. A multicity study of nine European cities showed a reduction in mortality due to heat in Mediterranean cities but not in cities in the north of the WHO European Region. The authors attribute this difference to implementation of prevention plans, a higher level of adaptation of the local population and greater awareness of the population about exposure to heat (de'Donato et al., 2015).

Some indication of decreases in heat-related health impacts or vulnerability have been observed in Vienna, Austria (Muthers, Matzarakis & Koch, 2010a; 2010b) and Athens, Greece (de'Donato et al., 2015; Scortichini et al., 2018). While de'Donato et al. (2015) found decreases over time of heat-related mortality in Budapest, Hungary, and Stockholm, Sweden, Scortichini et al. (2018) found no significant trend of heat-related mortality in either, with the exception of the peak heat-related mortality of 2007 in Budapest. Similarly, while de'Donato et al. (2015) found an increase in heat-related mortality in Helsinki, Finland, Scortichini et al. (2018) found no trend – except a peak in 2010.

A recent study found no trends within the (significantly increased) overall excess mortality between 2013 and 2017 in Istanbul, Turkey (Can et al., 2019). Similarly, no significant trend of heat-related mortality has been observed in recent decades in Lisbon, Portugal (Alcoforado et al., 2015).

Evidence suggests that heat-related mortality may have decreased in Frankfurt am Main, Germany, since 2003 (Heudorf & Schade, 2014; Steul, Schade & Heudorf, 2018).

Even within the observed decreases in health impacts, internal variability can be observed. In some cases, decreases were observed for both cardiovascular and respiratory mortality (Bobb et al., 2014; Ng et al., 2016); in others only for cardiovascular mortality (Muthers, Matzarakis & Koch, 2010b; Mirón et al., 2015). Morbidity trends are even less consistent, with some studies finding decreases in heat-related cardiovascular morbidity (Fechter-Leggett, Vaidyanathan & Choudhary, 2016) and others finding increases in hospitalizations and ambulance calls for heat-related illnesses (Nitschke et al., 2011). Most studies have not found systematic gender differences in the reduction in heat-related mortality (Sheridan & Allen, 2018), and there is little evidence of differences in reductions across age groups (Coates et al., 2014; de'Donato et al., 2015). Generally, evaluations of heat-related mortality in the Region are more frequent and less uncertain, whereas morbidity assessments tend to focus on a very limited set of outcomes, which makes studies difficult to compare.

Similarly, the geographical distribution of heat-related mortality follows complex patterns. In general, the scientific literature on heat and health consistently finds that the relationship between heat and mortality differs by latitude (as a proxy for prevailing climate), so that southern locales show smaller effects of heat but substantial effects of cold, while northern ones show the reverse. Moreover, the temperature beyond which heat-related mortality can be observed (known as the minimum mortality temperature (MMT)) tends to be higher in warmer places (Kinney, 2018). Within the WHO European Region, several studies have also confirmed that meridional locations tend to have higher temperature thresholds for both heat-related mortality and morbidity (Follos et al., 2020). In other words, all else being equal, places with high temperatures are less vulnerable to heat than those with more temperate climates.

France documented the health impacts of high-magnitude events for two heat-waves in 2019: 1462 excess deaths (+9.2%) were observed during the periods when the alert thresholds were exceeded for the regions. While the over-75 years age group was the most affected, the 15–44 and 65–74 years age groups were also affected. The excess mortality in the latter group was approximately 50% higher than the average of the affected regions (Santé Publique France, 2019).

A modelling study estimating MMTs for 599 European cities larger than 100 000 inhabitants (Krummenauer et al., 2019) revealed that southern cities had much higher MMTs than northern cities (from 27.8 °C to 16 °C). Other studies, however, suggest that such a gradient does not fully capture the variability in the relationship between heat and health impacts in the Region. A study of the relationship between heat stress indicators and mortality in 17 European countries (Di Napoli, Pappenberger & Cloke, 2018) found different clusters of countries but significant variability within those clusters in terms of the specific relationship between heat stress and mortality. Noting that caveat, at a macro/regional level, it can generally be assumed that populations exhibit health responses mainly at temperatures that are extreme within their local context. Thus, in colder climates health impacts may be expected at temperatures that would be considered moderate in southern areas.

### 1.2.3 Projections in heat-related health impacts

Before considering projections of heat impacts, it is worth noting that a proportion of the observed heat extremes is confidently attributed to climate change (ECMWF, 2020a). Moreover, some of the heat-related burden of illness in the WHO European Region is also already attributable to climate change (Vicedo-Cabrera et al., 2019). The warming the Region has already experienced is countering prevention efforts, strengthening the argument for climate action from a public health perspective. Moreover, wherever a reduction of heat impacts on health is observed, the warming climate is moving countries further from the goal of minimizing the heat-related burden of illness throughout the Region.

In addition to climate change, several variables and long-term trends affect the relationship between temperatures and health in the Region – the main factors being population ageing and urbanization. Population ageing strongly affects the relationship between heat and population health. Given the epidemiological profile of high temperatures as a health threat (in which elderly and chronically ill people are at higher risk), ageing and population structures are a key dynamic factor to account for in HHAPs. The WHO European Region is ageing: the median age of the population in EU countries increased by 4.2 years between 2002 and 2017, and the proportion of people aged 65 years and over increased by 2.4% in the last decade (Eurostat, 2018). While the non-EU eastern European and central Asian Member States have younger populations overall, these are also ageing faster due to migration and rapid fertility declines (Bussolo, Koettl & Sinnott, 2015).

Urbanization increases heat exposures and their impacts, as this report explores in Chapters 5 and 8. Reduced vegetation, heat-conserving urban materials, urban geometry and abundant heat sources all contribute to the urban heat island effect (UHI, 2014). Other factors, like household insulation, access to air-conditioning and individual vulnerability may also increase heat-related risks for some urban populations (Wolf, McGregor & Analitis, 2009; Wolf & McGregor 2013). Moreover, higher population density, all else being equal, increases the population at risk in urban areas. Albeit at a slowing pace, the overwhelmingly urban WHO European Region is still becoming more urbanized (UNDESA, 2014). This has practical consequences for heat–health prevention, as the urban landscape aggravation of heat-related health impacts further highlights the importance of a broad perspective in heat–health action planning. Limiting the urban heat island effect through city adaptation plans can not only protect local populations but also significantly enhance international mitigation efforts – for instance, through a reduction of energy use for cooling (Estrada, Botzen & Tol, 2017).

The scientific consensus is that without strong levels of adaptation, climate change is bound to increase the heat-related burden of disease (mortality and morbidity). A large number of scientific studies published in the last decade give projections of heat-related health impacts in the WHO European Region, in EU countries, and at the national, subnational and local levels. Within the Region, those increases would be sharpest in central and southern Europe (Gasparrini et al., 2017). Estimates under an optimistic scenario (RCP 4.5) assess additional annual heat-related premature mortality of over 85 000 deaths in the 27 countries in the EU from 2020, plus Switzerland and Norway, in 2046–2055 compared with 1991–2000 (Orru et al., 2019). In an assessment including 38 countries in the WHO European Region, Kendrovski et al. (2017) projected an overall excess of 46 690 and 117 333 premature deaths per year under the RCP 4.5 and RCP 8.5 scenarios respectively for the period 2071–2099, in addition to the 16 303 additional deaths estimated under the historical scenario. Mediterranean countries and those in the eastern part of the Region would be the most affected by heat, but a non-negligible impact would still be registered in northern continental countries.

In addition to regional estimates, many projections of heat-related health impacts have been made under various climate scenarios at the national and subnational levels (Ciscar et al., 2014; Hajat et al., 2014; Petkova, Gasparrini & Kinney, 2014; Roldán et al., 2014; Wu et al., 2014; Forzieri et al., 2017). Several of these projections of the possible impact of heat on future mortality consider a fixed, unchanging threshold temperature based on retrospective observations. Under this hypothesis, and as a consequence of the increase in temperatures associated with climate change (Smith et al., 2014; IPCC, 2018), important increases in mortality attributable to heat have been suggested. This assumption, however, needs to be analysed carefully in terms of its operational implications. Wherever they have been analysed across a long enough time frame, temperature thresholds of heat-related mortality have shown change over time. Population ageing (widely observed throughout the WHO European Region) would have an influence on such a threshold, lowering it by increasing the pool of vulnerable individuals (mainly people over 65 years of age) (Montero et al., 2012; Carmona et al., 2016).

The impact of heat on health in European cities is expected to worsen under likely climate change scenarios (Kendrovski et al., 2017). In fact, climate change-driven increases in daily maximum temperatures may already have increased the number of heat-related deaths substantially (Christidis, Stott & Brown, 2011). How far the resulting health impacts might be minimized due to acclimatization is unclear (Baccini et al., 2011; Honda et al., 2013; Martinez et al., 2018). Also unclear is whether milder winter temperatures in a climate that is more variable overall might lead to a decrease in cold-related deaths. Studies suggest that cold-related mortality has either remained constant or increased (Gasparrini et al., 2015; Díaz et al., 2015; Linares et al., 2016). The IPCC (Smith et al., 2014) concludes that by the middle of the 21st century heat-related deaths will outweigh health gains due to fewer cold periods in temperate areas like the WHO European Region, and later studies have confirmed those findings (Díaz, López-Bueno et al., 2019).

On the other hand, although valid as a counterfactual scenario for policy advocacy, a complete absence of adaptive processes is unlikely. Variable levels of autonomous and planned adaptation are to be expected, even in the absence of large and concerted efforts. From the "institutional" side, these would include further empowerment of the population to adopt protective behaviours against heat (Bobb et al., 2014); implementation of prevention plans (Schifano et al., 2012; Van Loenhout & Guha-Sapir, 2016); improvements in health services (Ha & Kim, 2013); and improvements in socioeconomic circumstances and housing (Carmichael et al., 2020; Samuelson et al., 2020). In addition, a certain degree of "autonomous" adaptation may be expected from individuals and families, not least in the form of improved shading, insulation and/or an increase in the number of air-conditioning units (Díaz et al., 2018; Watts et al., 2018). In addition to active adaptation, there is a certain degree of physiological acclimatization to heat, although this is assumed to be quite limited until reaching "peak heat stress" (Sherwood & Huber, 2010). As a result of these factors, the threshold temperature used to define a heat-wave will vary over time in most locations (Díaz, Sáez et al., 2019).

Despite these caveats, current and forthcoming trends and projections of climate change, ageing and urbanization strongly warrant and advocate adopting a long-term perspective in managing the health effects of temperature in the context of a changing climate. Yet against this background, most HHAPs operated by national and subnational authorities follow a largely reactive, static approach. The existing evidence highlights that long-term measures show the lowest levels of implementation within HHAPs, as do surveillance and plan evaluation (Bittner et al., 2014). As the responses to a survey of heat–health action planning undertaken by the WHO Regional Office for Europe in 2019 show (the results are highlighted throughout the chapters of this report), most current HHAPs in the Region do not explicitly address the question of whether and how their core elements should evolve in a changing climate, shifting demographics and increasingly urban populations. HHAPs can benefit from the rapidly expanding knowledge and practice of overall climate change adaptation, and become prime examples of effective health adaptation. This report is designed to help HHAP administrators and practitioners in their efforts to create an anticipatory and adaptive approach to the prevention of heat impacts on health.

## 1.3 Conclusions

A decade has passed since the publication of the WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008). Since then, the evidence has become increasingly clear on the accelerating trends in frequency and in relative and absolute intensity of heat-waves throughout the Region. In some countries, despite increasing episodes of extreme temperatures, heat-related health impacts seem to be decreasing. In others, however, the evidence is mixed; in some, heat vulnerability seems to be increasing. All cases highlight the need to strengthen prevention efforts further. Projections for the Region under a changing climate indicate that heat-related exposures and impacts could increase substantially through the combined effects of climate change, urbanization and ageing. Moreover, an enormous new corpus of scientific evidence has been published, covering almost every aspect of the public health responses to heat. All these factors suggest the need for and pertinence of a re-evaluation of the guidance to ensure its continued operational relevance.

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# Chapter 2. Agreement on a lead body: governance of public health responses to heat


## Summary

The question of how best to organize and govern public health responses to heat events gained particular relevance in the WHO European Region in the aftermath of the 2003 summer heat-waves. The need to define and implement appropriate and agreed-upon public health responses to heat has since become increasingly pressing, with the latest occurrence of extreme and deadly heat-waves in the summer of 2019. Yet little evidence is available on what constitutes good practice in the governance of such responses.

A recent survey undertaken by the WHO Regional Office for Europe shows an increasing role for national and federal authorities in developing and issuing guidance for subnational actors, although the roles and responsibilities of such actors are only infrequently specified. Moreover, HHAPs are usually not formally linked to crucial related policies, such as disaster risk reduction or national environmental planning. Multilevel governance of heat–health action could capitalize on the comparative strengths of local and non-state actors, thereby contributing to better integration of HHAPs with closely related policy areas.


## Key messages

- The published scientific literature and operational evidence do not provide sufficient information to identify the most effective governance design for HHAPs.
- Despite the generally high rate of benefits per costs invested, HHAPs in Europe are not adequately resourced in terms of funding or human resources.
- Most HHAPs specify roles and responsibilities at the national level, but lose specificity at the subnational, local and non-state actor level.
- HHAPs are well integrated with national climate change policies, but less so with national health, disaster/emergency response and environmental policies.
- Further involvement of local government and non-state actors can increase the reach and effectiveness of HHAPs; such involvement could be promoted through well tested strategies from other policy areas.
- The integration of HHAPs with other early warning systems, health adaptation and climate-resilient health systems strengthening could result in synergies and efficiency gains.

# 2.1 Good governance of public health responses to heat

### 2.1.1 Governance in the WHO Regional Office for Europe's 2008 guidance

The question of how to best organize and govern public health responses to heat gained particular relevance in the WHO European Region in the aftermath of the 2003 summer heat-waves. Their high death toll (Robine et al. (2007) estimated it at 70 000 excess deaths) showed the general inadequacy of preparedness and plans, even in the few countries where formal heat preparedness and response plans existed. Soon thereafter, national and subnational health authorities throughout the Region started planning and implementing prevention activities to protect populations from the adverse effects of high temperatures. The scope of these activities varied widely, both geographically and in terms of target populations and health outcomes.

Based on these initial experiences, the WHO Regional Office for Europe identified the core elements that such prevention activities should ideally encompass, and proposed to incorporate them into comprehensive HHAPs (Matthies et al., 2008). This framework was subsequently adopted as a blueprint for prevention by various countries and subnational authorities. Implicit within the 2008 WHO guidance on core elements and flows of information is a governance framework, understood as a way to organize actors and resources to make decisions and take action.

Wherever governance is addressed explicitly in the 2008 WHO guidance (for instance, when describing the roles and responsibilities of the "lead body") it is done generically and not prescriptively. The key governance elements in the guidance can be categorized along these lines:

- using existing systems and arrangements for emergency preparedness and response;
- working intersectorally, with coordination arrangements such as working groups;
- defining roles and responsibilities formally and in advance;
- identifying a lead agency – normally a health authority;
- applying multilevel governance involving national, regional and local authorities;
- ensuring bidirectional information flows as close to real time as possible;
- securing stakeholder engagement as crucial to well functioning protection;
- ensuring every actor has enough information and resources to take action;
- designing action to cover the short, medium and long term;
- re-evaluating HHAP governance based on monitoring and evaluation principles.

In practice, these principles are translated by countries into answers to key questions with operational relevance. For instance: What roles and responsibilities are typically best addressed by national authorities or by subnational ones? What are the most operationally efficient institutional arrangements for heat–health action planning? Does every actor have the necessary information and resources to play their roles, and how can this be established?

While answers to such questions are highly context-dependent, the accumulation of experience in the Region and beyond can provide some insights. The peer-reviewed literature contains valuable information for public health planners seeking to design or review their efforts to reduce the health impacts of heat. The operational experience of various HHAPs throughout the Region can provide valuable inputs for peer learning and the eventual development of agreed-upon good practices. This chapter provides a succinct overview of the most operationally relevant evidence from literature and from a survey of heat–health action planning undertaken by the WHO Regional Office for Europe in 2019.

### 2.1.2 Governance in the scientific and technical literature

Most HHAPs and health-relevant adaptation strategies in the WHO European Region are designed for the national level (Boeckmann & Zeeb, 2014; WHO Regional Office for Europe, 2018a). They are typically managed at the national level and implemented by national and regional agencies, following distributions of competences across health systems. A number of studies have analysed the organization of HHAPs (Matthies & Menne, 2009; Lowe, Ebi & Forsberg, 2011; Bittner et al., 2014; Austin et al., 2016), finding some basic patterns.

- Whether the HHAP is managed at the national or local/regional level largely mirrors the overall decentralization of competences in the country.
- The development of an adaptation plan or HHAP is typically led by either the ministry of health or the ministry of the environment, whereas subnational response coordination is most often led by departments of health.
- Warnings are based on information provided by weather services, while actions can be triggered by individual agencies or via coordinated action.
- National and/or subnational health services are usually informed about heat events and often disseminate this information and take action.

Collaboration between sectors is one common good practice outlined in the existing literature (Austin et al., 2016; Bittner et al., 2014). Taking into account the scarcity of evidence on good governance practices for HHAPs, experiences from outside the Region can provide useful information. Akompab et al. (2013) analysed stakeholder involvement processes for HHAP development and implementation in Adelaide, Australia. They found that interagency discussions, meetings and workshops, as well as invitations to key stakeholders to offer feedback on the HHAP draft, ensured a transparent approach. Leadership support was perceived as essential. The public was mainly informed rather than actively involved in the process; the stakeholders were all government agencies. The interagency cooperation in Adelaide might have benefited from its state's involvement in the Health in All Policies approach, which facilitates intersectoral responses to health challenges (Kickbusch, Williams & Lawless, 2014). In a study from India (Knowlton et al., 2014), the entire development of the HHAP and its implementation were conducted as part of an international–local consortium. Community organizations were involved with workshops and public consultations.

In Japan (Martinez, Imai & Masumo, 2011) and selected examples from the United States (White-Newsome et al., 2014), volunteering played an important role in ensuring the safety of vulnerable groups. The extent to which volunteers received support from the authorities in designing their approaches and their roles in the development of HHAP were, however, unspecified in these studies. In European peer-reviewed studies, examples of stakeholder involvement are also unspecific. While different government organizations were always involved to some degree, the public or communities were perceived as recipients of advice and warnings and as vulnerable groups, rather than as active stakeholders (Lowe, Ebi & Forsberg, 2011; Hansen et al., 2014). Interagency cooperation, however, was stressed as an important component of an HHAP (Austin et al., 2016).

Overall, the evidence base is limited in the peer-reviewed scientific literature, as few articles explicitly examine the organization of HHAPs and no conclusions can be drawn from these studies about whether a specific approach is better. More operational research into the governance of HHAPs would be useful to illustrate the advantages and disadvantages of different organizational arrangements and governance modes. Some areas of improvement are, however, suggested in the published literature, including:

- provision of adequate financial and human resources (Boeckmann, 2016; Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016);
- multilevel governance arrangements favouring local involvement in implementation (Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016), including better stakeholder engagement and more effective outreach to vulnerable groups (Sampson et al., 2013; Hansen et al., 2014);
- better integration of HHAPs with other relevant regulations and heat–health governance elements (Mees, Driessen & Runhaar, 2015; Wistow, Curtis & Bone, 2016).

## 2.2 Survey responses: status of HHAP governance

The governance of HHAPs can be examined further by comparing national and regional approaches and published examples of current practice. One such comparison was undertaken in a survey conducted by the WHO Regional Office for Europe in 2019, which looked into governance and institutional arrangements for HHAPs. This survey of HHAP administrators, national and local focal points and experts is the most comprehensive effort to date by WHO to assess the status of public health preparedness for high temperatures in the Region.

The survey featured several sets of questions to mine information on HHAPs established at each national, subnational or local level. The definition used for the existence of an HHAP was that (i) the document title stated that it specifically addressed heat-wave response; and (ii) it was approved as a formal document. Of a total of 35 countries participating in the survey:

- 16 indicated the existence of a national HHAP (Austria, Belgium, Croatia, France, Germany, Hungary, Italy, Malta, the Netherlands, North Macedonia, Portugal, Slovenia, Spain, Sweden, Switzerland and the United Kingdom);
- 10 indicated, explicitly, that they did not have a national HHAP in place (Denmark, Cyprus, Estonia, Finland, Israel, Montenegro, Norway, Poland, Serbia and Turkmenistan);
- 6 indicated the existence of subnational HHAPs (Belarus, Belgium, Czechia, Italy, Spain and Switzerland);
- 10 indicated the existence of local HHAPs (Albania, Belgium, Bulgaria, Germany, Greece, Kazakhstan, Lithuania, the Netherlands, the Russian Federation and Ukraine).

This report presents an analysis of the 16 responses from countries with national HHAPs in terms of implementation of the elements recommended by the framework of the 2008 WHO guidance (Matthies et al., 2008).

While management practices at one location or setting may not be applicable elsewhere due to the range of different health systems and their organization across the Region, the findings of the survey provide valuable insights. Longer-term evaluations of a number of governance approaches are needed to show whether the examples in place are indeed best practices.

### 2.2.1 Economic and human resources

Several HHAPs in the Region are not adequately resourced. Among the 16 countries that reported the existence of a national HHAP, only 37% of the survey respondents thought that their HHAPs were supported by the necessary financial and human resources, whereas 56% said those resources were insufficient. Areas where respondents felt that most resources were needed included training for staff in hospitals, nursing homes and care centres for homeless people; helping vulnerable people at home; adapting schools to heat; locating the most isolated people; and conducting research on epidemiology and prevention.

Most national HHAPs (almost 90%) were funded through internal allocation of resources from the lead agency's own budget; only 10% received earmarked funding from parent organizations or external budgets (such as those for climate change adaptation) for operation of the HHAP. The idea that more resources were needed to reduce risk in domestic and care settings was a recurrent one, as was (in cases where resources were deemed insufficient) that idea the lack of resources could even threaten the continuity of the HHAPs themselves.

Yet investing in public health is demonstrably good business. Interventions that address the environmental and social determinants of health, build resilience and promote healthy behaviours are shown to be particularly cost-effective (WHO Regional Office for Europe, 2015). HHAPs are a good example of this, yielding high economic benefits compared to their costs. In a recent assessment, cost–benefit ratios for existing heat-wave warning systems in Europe were estimated at 11 times the amount invested for London, United Kingdom, 308 times for Prague, Czechia, and 913 times for Madrid, Spain; those ratios increased extensively in the near future under all climate scenarios (Hunt et al., 2017). Indeed, human health costs from climate change – and specifically those from increased heat – constitute a large proportion of the calculated economic impacts from climate change in Europe (Ciscar et al., 2014).

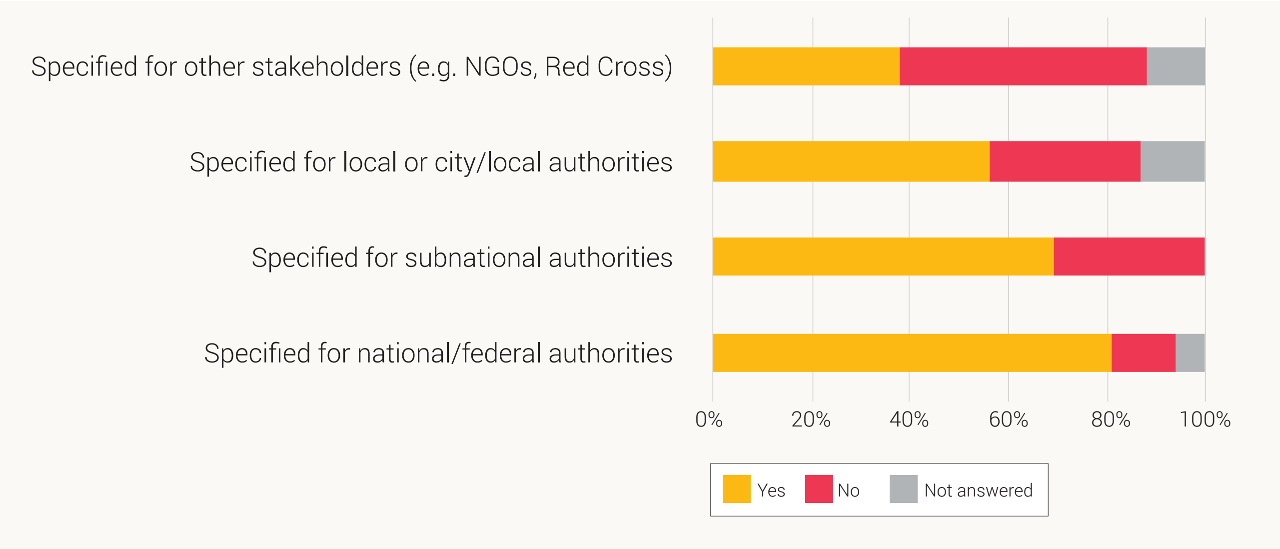
### 2.2.2 Actors, roles and responsibilities

Asked about the status of implementation of the core elements of their national HHAPs, almost 100% of the survey respondents assessed their designation of a "lead agency" as fully or partly implemented. Those who assessed implementation as partial were mostly countries that have devolved HHAP implementation to subnational authorities (provinces, Länders, cities, municipalities or cantons in Austria, Belgium, Germany, Malta, Slovenia, Sweden and Switzerland), and thus do not have designated lead response agencies at the national or federal level. Most also listed multiple subnational activities or systems for heat–health prevention at the subnational level, with which they coordinated.

Most HHAPs specify roles and responsibilities for national and federal authorities (exceptions are made for fully decentralized systems). Meteorological agencies are generally in charge of issuing heat warnings and informing the agency leading the health response (usually a national public health agency or ministry of health; sometimes a subnational health agency). Almost 70% of national HHAPs also specify roles and responsibilities for subnational authorities, but the level of such specification decreases as implementation gets closer to the target populations, with 56% for local or city authorities and 38% for other stakeholders (including nongovernmental organizations (NGOs) such as the Red Cross/Red Crescent) – see Fig. 4.

The low degree of specification of roles and responsibilities of non-state actors does not mean that they do not participate in planning and response. Among the 16 countries that reported the existence of a national HHAP, half involve NGOs such as the Red Cross/Red Crescent in their response, whereas the involvement of businesses or the private sector is infrequent (in about 20% of the plans). Other types of institution involved in communicating the advice include associations of pharmacists, the media, academia and public transport authorities. Beyond the coordination that may happen ad hoc or regularly with NGOs and volunteer-based organizations during the response phase, a more formalized engagement of non-state actors has been observed to boost the reach of public health responses to heat (Martinez, Imai & Masumo, 2011). This engagement may take diverse forms, ranging from participation of local NGOs or volunteer-based organizations for outreach to vulnerable groups, to the allowance or facilitation of use of facilities as cooling centres (such as shopping malls).

**Fig. 4. Specification of roles and responsibilities in national HHAPs**




The specification of roles and responsibilities refers in this report to legally binding duties and tasks of institutions and actors within an HHAP. In some cases, national plans provide detailed guidance or examples of possible roles and responsibilities that other levels of administration could play. Although these are not legally binding, the guidance itself can contribute to enabling action in a relatively standardized way. Even in cases where roles and responsibilities are not formally allocated, the plan frequently contains clear recommendations or guidance for regional authorities, municipalities or both (as in the German HHAP (BMU, 2017)).

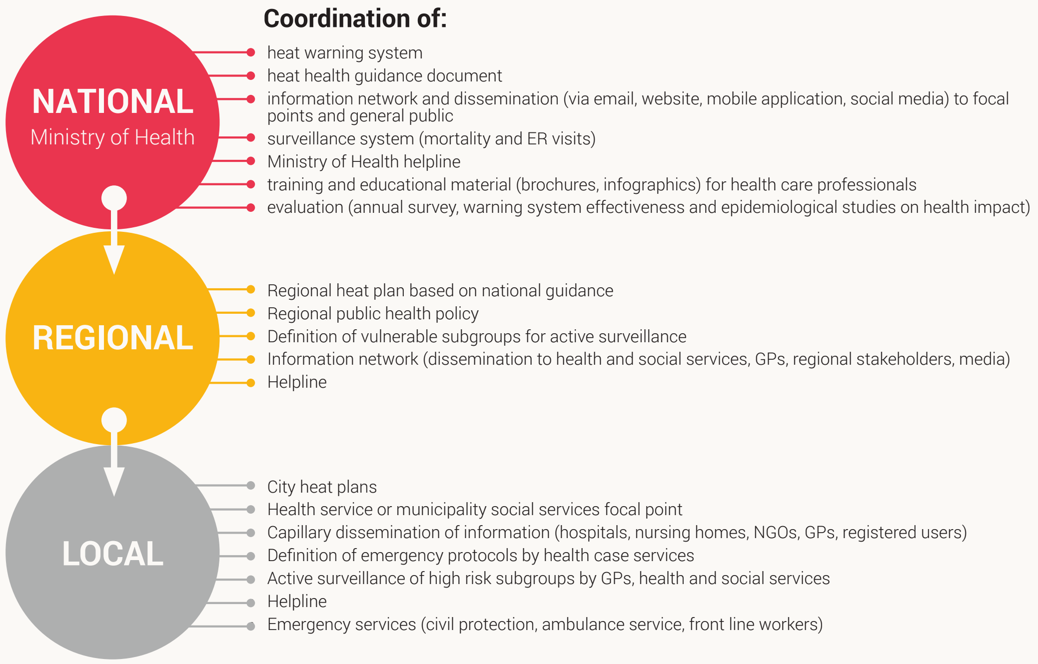
Beyond these institutions, the backbone of HHAP implementation relies on direct stakeholders and actors on the ground, for whom specific advice and instructions are provided. The responses to the survey specified the following categories as providers of advice: health care practitioners (including doctors, nurses and pharmacists – in over 80% of the HHAPs), nursing homes (in 75%), health care administrators (such as hospital managers – in about 70%), social workers (in 44%) and schools (in under 20%). Box 2 describes the multilevel coordination within the national HHAP of Italy.

## Box 2. Coordination of national, regional and local heat–health action in Italy

The Italian HHAP focuses on urban areas and is structured around the core components of the 2008 WHO guidance. The Ministry of Health (2019) provides a national guidance document, which is the basis for definition of heat prevention plans at the local level. This is updated regularly to include new aspects and evidence, and to reflect lessons from implementation so far. Some core elements are coordinated at the national level, such as the heat warning system and dissemination of warning information via email, the Ministry of Health website and social media accounts (Twitter, Facebook) and the mobile application "Caldo e Salute [Heat and Health]" (Ministry of Health, 2018); the near real-time surveillance system (mortality and ER visits) for monitoring health impacts during heat-waves and changes over time; provision of training and educational materials for health care professionals; evaluation of the HHAP; and the national helpline. Finally, every year a survey is carried out to collect information on prevention measures put in place regionally and in each city to promote sharing of experiences between local authorities and to help dissemination of information, as well as to evaluate the components of the HHAPs.

According to the guidance, prevention measures have to be modulated according to warning levels and targeted to vulnerable population subgroups. Italian health services are managed at the regional level, so heat prevention actions and specific response measures are defined locally by each region, municipality and local health authority, based on the Ministry of Health's national guidance document (Fig. 5). Specifically, regional and local plans identify vulnerable subgroups to whom active surveillance should be addressed by health or social services; define emergency response protocols; and manage local helplines and the dissemination of warnings and heat advice. A key element of local prevention plans is the active surveillance of high-risk subjects by general practitioners (GPs), health services and social services during heat-waves. Hospitals and nursing homes define their own emergency protocols, including measures such as postponing non-urgent surgery and discharging patients during high-risk periods (ensuring continuity of care from the hospital unit to home); staff rotation restrictions; mobilization of at-risk patients to air-conditioned rooms/wards; and increasing bed availability during the summer.

**Fig. 5. Heat–health prevention at the national, regional and local levels**



# 2.3 Links of HHAPs with broader policies

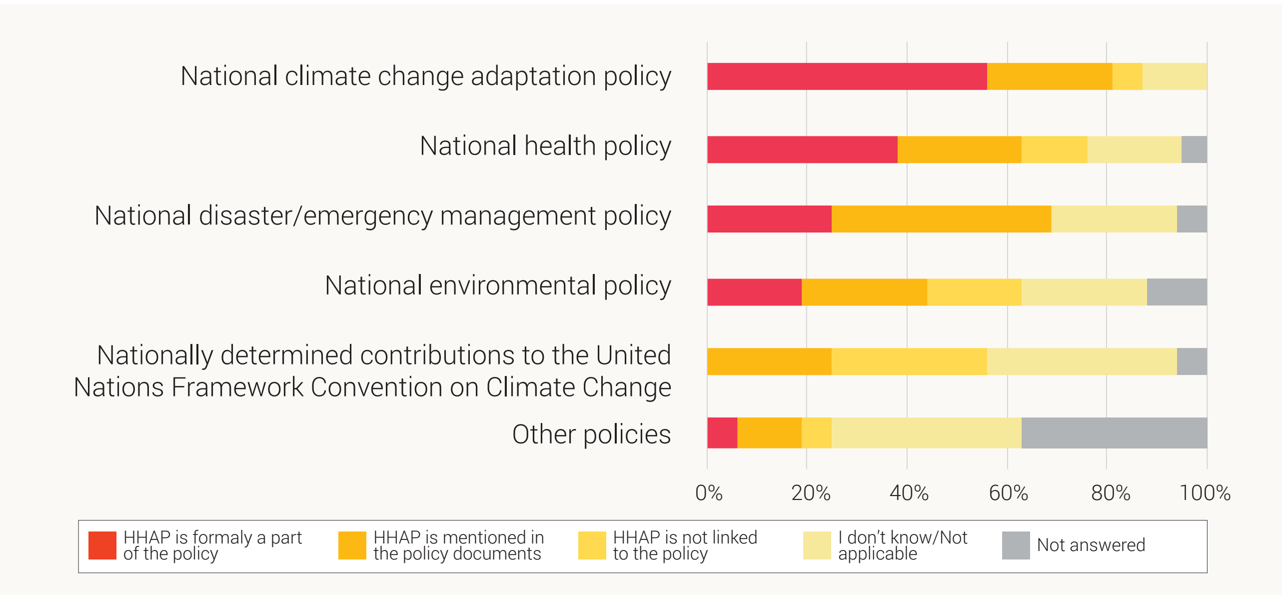
## 2.3.1 Links to other national/federal policies

In terms of links with other policies, WHO's 2019 survey of heat–health action planning shows that national HHAPs are most often related to national climate change policies (81%) – either as a formal element (56%) or mentioned in these (25%). They are less frequently related to national health policies (63%), and are often not a formal element of these (38% are a formal element; 25% are mentioned in them). HHAPs are rarely a formal element in national disaster/emergency management policies (25%), although they are frequently mentioned (44%), despite the fact that heat is the deadliest weather extreme in the Region. HHAPs are infrequently a formal element of national environmental policies (19%), or mentioned in them (25%), and they are not formally part of countries' nationally determined contribution priorities, although they are occasionally mentioned in them (25%) (Fig. 6).

That HHAPs would often be part of national/federal climate change policies seems reasonable. Geared towards the minimization of health impacts of current and future climate variability, HHAPs constitute a prime example of health adaptation. Moreover, once the relationship between temperature and population morbidity and mortality has been ascertained locally, the effect of future climate change on those outcomes in the absence of adaptation can be modelled with certainty. This provides a clear monitoring and evaluation framework in a policy area (climate change adaptation) fraught with uncertainties and dynamic discourses over metrics.

The low levels of formal inclusion of HHAPs in national/federal health policies are also not surprising, although this lack of ownership by health systems is not restricted to HHAPs. Rather, this is a common occurrence in most environmental health early warning systems and/or prevention plans – in part related to low institutional attention to and spending on health prevention (which stands at around 3% of total health expenditure in OECD economies) (Gmeinder, Morgan & Mueller, 2017). This adds to the well known barriers to intersectoral action for health, for both the health and environmental sectors (Ndumbe-Eyoh & Moffatt, 2013; Rantala, Bortz & Armada, 2014).

**Fig. 6. Links of national HHAPs to other national/federal policies**



### 2.3.2 Links to local governments and non-state actors

Although consensus is lacking on whether decentralization by itself contributes to better health system performance, there is increasing evidence that involvement of local governments in public health interventions is important for their effectiveness (Tomm-Bonde et al., 2013). Local authorities are well positioned to make HHAPs and other public health interventions more effective through a number of factors (Department of Health, 2011):

- direct accountability of results to local communities;
- ability to tailor services to local needs;
- ability to act on social determinants of health and health inequalities.

These strengths are particularly useful for prevention strategies requiring stakeholder engagement and effective outreach to target groups. The involvement of local governments in HHAPs, as well as more generally in health adaptation, however, may be hindered by a lack of awareness of and political commitment to the need to address climate change drivers and impacts, inadequate governance structures, a scarcity of data or a lack of specialist knowledge (EU, 2013).

From a pragmatic perspective, many actions at the local scale are directed or constrained by higher levels. Since most policies (national or otherwise) tend ultimately to be implemented locally, the local authority has a crucial role as implementer or facilitator. In countries such as Italy, the Netherlands and various Scandinavian countries, local governments hold general competence to undertake any actions in the perceived interest of their citizens, within the limits of the law. In contrast, local governments in several other countries only have the right to fulfil their statutory aims (Keskitalo, 2010).

The competences of local governments in Europe over either health or climate change adaptation (the two policy areas most closely related to HHAPs) are wide ranging, from almost complete to virtually non-existent. Climate change adaptation has so far largely been regulated through planning systems, thus giving pre-eminence to the level with the planning power (Newman & Thornley, 2002). Local authorities with ample planning powers therefore have ample competence over local adaptation, although they may lack many other enabling factors (such as funding or specialist personnel) (Lorenz et al., 2017). Similarly, while local authorities in some European countries may hold almost all competences in health systems – from health care provision to financing – others may only hold them over basic public health activities, following the inherent complexities of health systems governance (Pyone, Smith & van den Broek, 2017). Most local governments with enough capacity have some degree of competence over public health activities, however. It is on this minimum common denominator that the debate over health adaptation should take place.

In the case of HHAPs, local governments hold both agency and often competence to address elements in most core elements of prevention. On account of resources and economies of scale, a municipality may not be well suited to be a lead agency in an HHAP, or to lead efforts in epidemiological surveillance and evaluation. Otherwise, its participation would add value in all elements: being an active part of the health information plan, providing and coordinating resources for reductions in heat exposure, ensuring care for vulnerable groups, coordinating with the local health and social care systems, and integrating heat and climate into long-term urban planning efforts.

In their answers to WHO's 2019 survey of heat–health action planning, among the 16 countries that reported the existence of a national HHAP, over 80% of respondents listed examples of ongoing heat–health activities at the subnational level, describing a vast ecosystem of heterogeneous subnational activities towards the prevention of health effects from heat in WHO European Region.

Obtaining an accurate list and taxonomy of such activities was beyond the scope of the survey, but the responses suggested that guidance issued by national authorities is an important enabler of subnational action on heat and health. On the other hand, the subnational authorities implementing their own plans were often in principal regions or cities (in other words, those more populated and wealthier); several capital cities had their own versions of an HHAP (including Athens and Moscow).

Various evaluations confirm that local stakeholders welcome and put to use guidance and resources from higher levels of governance (Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016; PHE, 2020; Pascal, Laaidi & Beaudeau, 2019). Targeted efforts that could strengthen the implementation of heat-wave plans at a local government level include clearer directions from national and regional administrations; consistency in approaches; cross-sectoral and cross-agency collaboration; and the fostering of support from state government (Tomm-Bonde et al., 2013). If local implementation of heat-wave plans is strengthened, this will also improve the adaptive capacity of communities, meaning that they will be better able to respond to heat-waves and therefore reduce their health risks (Mimura et al., 2014). In addition, the benefits of strengthening community resilience to respond to the health impacts of heat-waves can improve responses to other extreme events (Berry & Richardson, 2016).

The involvement of local governments can be facilitated through provision of information and support to the local employees involved, and via integration of HHAP efforts into existing structures. Through such involvement, HHAPs could tap into the potential of local volunteering structures, community capacity and in-depth knowledge of local needs. Inviting these stakeholders to the table early on in the design of an HHAP and before implementation could highlight gaps or barriers to effective communication or outreach strategies. It is important to note that a number of these stakeholders have been successfully engaged in some settings – for instance, in Japan (Martinez, Imai & Masumo, 2011; Boeckmann and Rohn, 2014; Boeckmann, 2016) – proving the value of these efforts.

The schematic flow of information or resources in an HHAP originally proposed by the 2008 WHO guidance suggested a relatively passive role of local governments, as recipients or channels of information only (Matthies et al., 2008). By contrast, the comparative strengths of local governments could make them multiplicators, boosting the effectiveness of efforts. Municipalities could play an important role in mapping and organizing local stakeholders; this could make a great difference in the effectiveness and reach of heat-wave risk management strategies. The stakeholders include not only government bodies (such as health departments and police) but also health care providers, retirement home managers, landlords, business administrators, NGOs and others. As noted by Lass et al. (2011), these heterogeneous networks cannot be organized in a top-down manner; instead, cooperative forms of coordinated action are required. Building on that coordination, during the heat-wave response phase, involvement of municipalities could increase the effectiveness of short-term measures to reduce heat exposure, including advice on behaviour, access to cool spaces and allocation of mobile cooling technology.

In the medium and long term, local governments would be in a privileged position to enable or support:

- necessary retrofitting of building envelopes and insulation;
- efficient active cooling;
- shading and passive cooling technologies;
- supporting green and blue infrastructure projects;
- ultimately, adaptation of building regulations, urban planning and land use.

Non-state actors can also contribute to better governance of HHAPs by broadening the scope and reach of the system. Furthermore, environmental justice, climate justice and public health all aspire to principles of inclusion and community action (Wilson et al., 2010; Breen & O'Connor, 2014; McDonald et al., 2015; Mendez, 2015); these necessitate further involvement of relevant stakeholders. A number of studies suggest that vulnerable populations do not feel spoken to during heat warnings (Abrahamson et al., 2009; Wolf et al., 2010; Alberini, Gans & Alhassan, 2011), or that culturally appropriate suggestions for adaptation are needed (Banwell et al., 2012; Hansen et al., 2014). Stakeholders who might be further involved also include other vulnerable people, such as homeless populations and those with unstable housing situations, migrants (particularly those currently travelling or in unstable housing) and people with limited mobility who are not routinely included in HHAPs.

An extensive body of literature exists on strategies for increasing participation from communities through participatory research approaches and "urban lab" real world experiments in urban climate change mitigation and adaptation activities (Bulkeley & Castán Broto, 2013; Castán Broto & Bulkeley, 2013). These could be used to support stakeholder involvement in HHAP activities more efficiently.

## 2.4 Strengthening synergies of HHAPs with other policy areas

WHO's 2019 survey of heat–health action planning revealed a certain degree of integration of HHAPs in broader policy, with stronger links to climate change adaptation and weaker links to other areas, including health, emergency management and the environment. There is, however, a clear need for stronger links between HHAPs and other existing plans and policies.

The most obvious way forward towards such integration is insisting on the pathway to intersectoral action for health. Interdisciplinary approaches are essential for identifying and implementing appropriate management strategies and collaborations across different fields. In a recent comprehensive summary, the WHO Regional Office for Europe (2018b) identified various elements to consider when promoting intersectoral action for health. Crucially, it requires triggers: both high-level political support from the ministers and ministries responsible and the introduction of data and evidence, particularly on cost–effectiveness and the economic benefits of the intended interventions. Successful cases typically take the form of longer-term initiatives with permanent coordinating structures rather than short-term projects. Facilitating factors include a clear mandate to reach out beyond the health sector, sufficient resources, supporting data and evidence, sufficient capacity, and civil society and media engagement. By contrast, a lack of political will or commitment, lack of resources, lack of coordination mechanisms and entrenched siloed thinking are direct challenges to intersectoral action for health. The following sections set out some specific examples of links of particular importance for good heat–health governance.

### 2.4.1 Integration with other early warning systems

There is a clear case for integration of HHAPs with other early warning systems for health – particularly those with a climatic component. The Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations, 2015) highlights the need to increase availability of and access to multihazard early warning systems. Restricting the scope of analysis to early warning systems for climate-sensitive exposures (such as heat, air pollution, aeroallergens and vectors, to name but a few) shows that these plans are usually activated individually. Although they demonstrate good results from the point of view of minimizing health impacts, as in the case of high temperature plans, they commonly fail to address the synergies across various climate-related or climate-aggravated exposures. Since a number of those exposures tend to occur concurrently, failure to integrate them into prevention efforts could affect the effectiveness and reach of such action. Thus, an integrative approach is needed for the multiple effects that climate change has on population health (Linares et al., 2020).

### 2.4.2 HHAPs as adaptation to climate change

In line with the climate resilience of health systems, HHAPs are a prime example of health-protecting adaptation to climate change. Governance mechanisms for integrating climate action into health policy and planning seem well established – at least in the EU countries in the WHO European Region, most of which are considering implementing adaptation actions to address climate change-related health impacts. In a 2017 survey (WHO Regional Office for Europe, 2018a)[1], all 20 respondent countries had a multisectoral body in place to deal with climate change and the health sector; 65% had a designated climate change and health focal point within the health ministry with their activities specified in a programme of action, and 13 countries had developed national policies (strategies or plans) on health and climate change (Austria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Germany, Lithuania, Luxembourg, Malta, Spain and Sweden). Climate-related early warning systems, and among them HHAPs, constituted a large proportion of those policy efforts. This highlights an opportunity for HHAP administrators to communicate their importance clearly within their countries' and Europe's climate change adaptation efforts.

Heat–health governance can also be strengthened through further integration with other policy areas related to climate change adaptation. Occupational health is an important one; this is touched on in Chapter 6 of this report, and spans instruments from research to industry-specific standards and enforcement of regulatory compliance. Also important are the links between policy, governance and investment in infrastructure, housing and energy, and their modification effect on heat and health; these are addressed in Chapters 5 and 8.

## 2.5 Conclusions

Preparing and responding to heat extremes is an area of urgent priority for health policy and practice, given the current and projected increases in heat events – in both frequency and intensity. While it is a positive step that good governance elements and principles are outlined in international and national guidance, their translation into practice is highly context-dependent, with no generally agreed-upon best practice. WHO's 2019 survey of heat–health action planning revealed important patterns regarding HHAP governance at the national/federal level:

- most HHAPs lack adequate economic and human resources for implementation;
- most HHAPs specify roles and responsibilities at the national level, but are less specific when addressing the subnational and local levels, including non-state actors;
- HHAPs are relatively well integrated with national climate change policies, but less so with national health, disaster/emergency or environmental policies.

Strategies for further involvement of local governments and non-state actors in HHAPs can be

[1] This survey is different from the one whose results are featured in this chapter, and was undertaken earlier; it was conducted in collaboration with the European Commission, specifically to investigate health within climate change adaptation strategies in the EU.

borrowed from other disciplines, which might result in better reach and effectiveness. The integration of HHAPs with other climate-sensitive early warning systems, health adaptation and climate-resilient health systems strengthening, as well as other areas of governance, could result in synergies and efficiency gains.

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[2] All URLs accessed 31 August–1 September 2020.

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# Chapter 3. Accurate and timely alert systems: heat–health warning systems

## Summary

Heat–health alert or warning systems are a key component of HHAPs, as they inform local populations and stakeholders about the health risks associated with heat. They thereby raise awareness and ensure timely activation of prevention measures and emergency protocols. Several European countries have a fully operational heat–health warning system in place as part of their HHAPs, and have been able to extend the lead times of their forecasts.

The majority of heat–health warning systems are developed and managed by national meteorological services and information is passed to the HHAP lead body to take action. Effort has also been invested in improving warning dissemination and understanding among stakeholders to improve timely response. A formal evaluation of the warning system should be carried out on a regular basis to improve uptake and efficiency of warning systems and of the HHAP as a whole. The evaluation should include both process and outcome indicators: forecast performance and warning thresholds, dissemination, awareness among stakeholders and modulation of actions based on warning levels.

## Key messages

- Heat–health warning systems are a key component of HHAPs.
- Heat–health warnings need to be based on the temperature–health association (defining the temperature threshold for issuing warnings in a way that accounts for changing vulnerability patterns in health outcomes).
- Response measures and actions need to be varied according to the warning level.
- Understanding of warnings by different stakeholders and vulnerable groups is crucial, and dissemination of warning bulletins needs to be targeted.
- Evaluation of warning systems needs to be carried out regularly.

# 3.1 Introduction: the nature of heat–health warning systems

The WHO Regional Office for Europe's guidance on HHAPs published in 2008 stressed the key role of heat–health warning systems in serving as information tools to identify and predict weather conditions that may adversely affect health in a specific geographical setting (Matthies et al., 2008). This chapter gives a brief overview of the nature of heat–health warning systems; presents the results of a recent survey carried out by WHO on heat–health warning system implementation in countries; and gives insight into innovative aspects, research gaps and future perspectives. Key aspects of warning system development for HHAPs are discussed in detail in the WMO/WHO (2015) joint publication *Heatwaves and health: guidance on warning-system development*.

## 3.1.1 Elements of heat–health warning systems

Heat–health warning systems in the context of HHAPs should take into account the effects of temperature and other weather parameters on a specific population, using evidence from the epidemiological literature related to the location of interest and defining response-specific thresholds. When this is not possible, meteorological definitions of a heat-wave can be used – for example, percentiles (90th, 95th, 99th) of the temperature indicator variable or bioclimatic indices that are assumed to be the threshold above which heat becomes a risk factor for health. Forecast data can then be used to predict risk-related weather conditions and alert decision-makers, who can implement a range of preventive actions, as defined in each HHAP, with the aim of reducing the health impact of hot weather and heat-waves.

Key aspects of a heat–health warning system, as noted in both WHO and WMO/WHO guidance (Matthies et al., 2008; WMO & WHO, 2015), are:

- accurate forecasts of temperature and weather parameters;
- identification of risk conditions for health (scientifically sound threshold levels);
- graded levels of alert/warning;
- a definition of an information network for dissemination of alerts;
- timely communication of warnings and public health recommendations, produced jointly by the agencies involved (weather and public health services), in a user-friendly manner.

Heat–health warning systems have been developed using various exposure indices of heat stress. These range from single meteorological variables – usually temperature parameters (such as mean, minimum and maximum) – to bioclimatic indices of different complexity, which combine a number of parameters such as temperature, humidity, wind speed and solar radiation to represent the perceived temperature or human-heat budget models (models based on adult physiological characteristics) (WMO & WHO, 2015). A combination of indices and approaches have been developed across Europe to set thresholds (Matthies et al., 2008; Lowe, Ebi & Forsberg, 2011; Bittner et al., 2014; WMO & WHO, 2015; Casanueva et al., 2019).

Several studies have compared indices and their performance (Hajat et al., 2010; Zhang et al., 2012; Burgstall et al., 2019), but the choice of the index ultimately depends on the purpose of the warning and the public health measures put in place in the local context. The key aspect in the context of an HHAP is to ensure that warning systems accurately identify days with a high health risk and are used to drive specific prevention measures and emergency actions (Matthies et al., 2008; WMO & WHO, 2015). A multisectoral approach is essential in the warning system design phase, as weather forecasters and modellers need to know:

- what the health sector and emergency services need in terms of lead time of a forecast;
- when the forecast run has to come out in order for them to activate response measures;
- what each warning level should include (such as intensity of heat, persistency and seasonality).

Exchange of information and know-how on the different components by all sectors are also vital.

As noted in the 2008 WHO guidance, warning levels should be set to take into account local health risks, warning system characteristics (lead times, persistency) and the interventions triggered when warnings are issued (Matthies et al., 2008). Warning levels are currently set very differently across Europe (Lowe, Ebi & Forsberg, 2011; Casanueva et al., 2019). They are denoted either with a colour scale (green, yellow, orange, red) as for other national alert systems – as for extreme weather, flooding, forest fires and natural hazards – or numerically (0, 1, 2, 3, 4).

How levels of warning can modulate actions by different stakeholder groups is illustrated in Table 2, which sets out an example from the *Heatwave plan for England*, published each year by Public Health England on behalf of the National Health Service (NHS) and Department of Health and Social Care, and the Local Government Association (PHE, 2020). It shows activities modulated by level of risk for specific stakeholder groups at different levels; these are intended to guide the development of local preparedness and response measures, tailored around local organizational frameworks. This approach can also be extended to include indications and responses for vulnerable groups by different stakeholders.

## Table 2. Example of preparedness and response actions modulated by warning level

| Stakeholder group | LEVEL 0<br>Long-term planning<br>(All year) | LEVEL 1<br>Heat-wave and summer preparedness programme<br>(1 June–15 September) | LEVEL 2<br>Heat-wave is forecast: alert and readiness<br>(60% risk of heat-wave in the next 2–3 days) | LEVEL 3<br>Heat-wave action<br>(Temperature thresholds reached in one or more regions) | LEVEL 4<br>Major incident: emergency response<br>(Declared by central government in the event of severe or prolonged heat-wave affecting sectors other than health) |
|---|---|---|---|---|---|
| **National level:**<br>**NHS England, Public Health England, Department of Health and Social Care, Met Office, other government departments** | Cooperate with partner agencies to prepare for and mitigate the impact of heat-waves.<br>Improve resilience of vulnerable communities and individuals.<br>Ensure local programmes that include housing, environmental and infrastructure improvements are set up.<br>Engage with communities and the voluntary sector.<br>Update and revise Public Health Outcomes Framework indicators. | Work with other agencies to coordinate heat-wave plans.<br>Raise awareness and maximize dissemination.<br>Ensure care homes and hospitals engage in preparing for heat-waves.<br>Engage with communities and the voluntary sector.<br>Ensure institutions are aware of heat-wave guidance.<br>Ensure organizers of mass events consider heat risks. | Met Office: send a Level 2 alert to a list of organizations and Category 1 responders.<br>Central government departments: disseminate information through their networks and front-line communication systems.<br>The Department of Health and Social Care: disseminate alert information to other government departments and briefs ministers.<br>NHS England: take action to prepare for a heat-wave.<br>Public Health England: disseminate advice to the public and health care professionals.<br>Public Health England: monitor syndromic and mortality surveillance. | Met Office: send a Level 3 alert, as with Level 2.<br>Central government departments: disseminate information, as with Level 2.<br>Met Office: continue to monitor and forecast temperatures in each area, giving details on duration, intensity and geographical extent.<br>NHS England: muster mutual aid when requested by local services.<br>Public Health England: monitor syndromic and mortality surveillance and produce a weekly report for inclusion within a daily heat-wave output. | Central government: implement national emergency response arrangements. Responses involve:<br>• national government departments<br>• executive agencies<br>• public sector bodies, including the health sector<br>• the voluntary sector.<br>Public Health England: monitor syndromic and mortality surveillance and produce a weekly report for inclusion within a daily heat-wave output |
| **Professional staff** | Develop systems to identify and improve resilience of high-risk individuals.<br>Request an housing health and safety rating system assessment from environmental health experts for clients at particular risk.<br>Encourage walking and cycling in urban areas. | Identify high-risk individuals and raise awareness of heat-related risks and prevention among carers.<br>Include heat–health risk in care records and consider changes in care plans. | Check that high-risk individuals have visitor/phone call arrangements in place.<br>Reconfirm key public health messages to clients.<br>Check clients' room temperature if visiting. | Visit/phone high-risk individuals.<br>Reconfirm key public health messages to clients.<br>Advise carers to contact a GP if they have concerns about clients' health. | Continue actions as per Level 3 unless advised differently. |

**Table 2 contd**

| Stakeholder group | LEVEL 0<br>Long-term planning | LEVEL 1<br>Heat-wave and summer preparedness programme | LEVEL 2<br>Heat-wave is forecast: alert and readiness | LEVEL 3<br>Heat-wave action | LEVEL 4<br>Major incident: emergency response |
|---|---|---|---|---|---|
| **Care homes and hospitals** | Establish long-term preparedness plans.<br>Initiate environmental improvements.<br>Prepare business continuity plans.<br>Raise awareness among partners and staff on health impacts. | Ensure continuity plans are in place.<br>Identify/create cooling rooms.<br>Install thermometers where vulnerable individuals spend more time. | Undertake indoor temperature measurement for all areas where patients reside.<br>Ensure cool areas are below 26 °C.<br>Review and prioritize vulnerable individuals.<br>Ensure sufficient cold water and ice are available.<br>Consider weighing clients regularly to identify dehydration.<br>Reschedule physiotherapy to cooler hours of the day.<br>Ensure sufficient staffing.<br>Communicate alerts to staff and make sure that they are aware of heat-wave plans.<br>Implement business continuity plans. | Activate plans to maintain business continuity – including a possible surge in demand.<br>Measure indoor temperatures for all areas where patients reside.<br>Ensure staff are trained on heat response.<br>Monitor vulnerable individuals closely.<br>Reduce internal temperatures.<br>Ensure discharge planning takes home temperatures and support into account. | Continue actions as per Level 3 unless advised differently. |
| **Community groups** | Develop a community emergency plan to support vulnerable neighbours.<br>Carry out impact assessments on community venues.<br>Support subjects at risk. | Trigger the development of a community emergency plan.<br>Help raise awareness about health risks. | Check up on at-risk individuals.<br>Consult weather forecasts and warnings and act accordingly.<br>Keep stocked up with food and medications.<br>Monitor ambient room temperatures. | Activate community emergency plans.<br>Check on those you know are at risk. | Continue actions as per Level 3 unless advised differently. |
| **Individuals** | Improve shading and cooling.<br>Install insulation to reduce indoor heat.<br>Identify cool areas inside the house. | Acquire information on health risks.<br>Look out for vulnerable relatives and neighbours. | Check weather forecasts and warnings.<br>Check ambient room temperatures where disabled or vulnerable individuals reside.<br>Look out for vulnerable relatives and neighbours. | Follow key public health messages.<br>Check on those you know are at risk. | Continue actions as per Level 3 unless advised differently. |

*Source:* adapted from PHE (2020).

### 3.1.2 Forecast models and lead times

In terms of weather forecast models, a recent review of heat–health warning systems in Europe provided an update on models used, lead time, temporal and spatial resolution of models and lead bodies in charge (Casanueva et al., 2019). The WMO/WHO (2015) publication *Heatwaves and health: guidance on warning-system development* provides details of forecast models and methodologies developed around the world to define heat–health warning systems.

The spatial resolution of models goes from under 2 km to 16 km, depending on whether they are regional/national downscaled or local models or European scale models. Models are heterogeneous across Europe and mostly reflect national meteorological service availability and the best compromise between forecast predictive power, spatial coverage needed and timeliness of forecast run for HHAP purposes. In several countries a combination of forecast models is used: regional models that have a finer spatial resolution to capture geographical differences in a more accurate manner for forecasting the short term (1–7 days) and ensemble models, such as ECMWF, for longer lead times or as a complementary tool. A crucial aspect is that the accuracy of meteorological forecasts should be part of the design of a heat–health warning system (WMO & WHO, 2015), as well as the scope of the forecast and its use for public health warning and response measures. It is worth noting there is a trade-off between lead time and model accuracy: as a rule of thumb, as lead times are extended, forecast accuracy is reduced – especially as it moves from short time frames into medium-range forecasts (two weeks to a month).

The lead time is crucial for the health sector to be prepared to cope when a heat-wave is coming and to ensure that prevention and emergency measures are in place and operational if and when populations are affected. Different measures require different timings for preparation and becoming operational: heat–health warning systems and HHAPs should consider this when defining warning levels. Furthermore, considering the short lag between exposure to extreme heat and worsening of health conditions and even fatality, the process of warning notifications should be timely (Díaz, Linares & Tobías, 2006; Lowe, Ebi & Forsberg, 2011). Lead times for notifying of extreme heat risks, as previously reported in other reviews or surveys (Lowe, Ebi & Forsberg, 2011; Bittner et al., 2014), are between two and eight days.

Moreover, in the last 10–15 years great efforts and advances have been made in weather and climate modelling and forecasting the subseasonal-to-seasonal time range, which corresponds to forecasts beyond two weeks but less than a season (typically 3–4 months) (Brunet et al., 2010; Vitart, 2014). In essence, the main advantage here is that the gap between short-term and medium- to long-term forecasting has been filled, thus providing skilful forecasts of extreme weather risks that can inform decisions in different sectors – including health. Forecast information at different timescales with different lead times is relevant for different decision-makers and for planning of prevention and response measures in the context of HHAPs. An example is the "Ready-Set-Go" concept, using forecasts from the weather to the seasonal scale, proposed by the Red Cross/Red Crescent Climate Centre and the International Research Institute for Climate and Society for application in heat prevention (Vitart & Brown, 2019):

- Ready: seasonal and subseasonal forecasts are used to update contingency plans, train volunteers and enable early warning systems;
- Set: submonthly forecasts are used to alert volunteers and warn communities;
- Go: weather forecasts are used to activate volunteers, distribute instructions to communities and evacuate.

## 3.2 Status of heat–health warning systems

A first comprehensive review of heat–health warning systems across Europe (Lowe, Ebi & Forsberg, 2011) found that 12 countries had a warning system in place (Belgium, France, Germany, Hungary, Italy, Netherlands, North Macedonia, Portugal, Romania, Spain and Switzerland, and the United Kingdom). The review provides information on exposure variables considered, threshold levels and forecast lead times, as well as geographical coverage (national, regional) and lead bodies. A survey carried out a few years later (Bittner et al., 2014) showed a slight increase to 16 in the number of countries with an operational heat–health warning system as part of their HHAP (Austria, Belgium, Croatia, England (United Kingdom), France, Germany, Hungary, Italy, Luxembourg, Monaco, North Macedonia, Netherlands, Portugal, Spain and Switzerland). A more recent study also identified 16 heat–health warning systems through a review of the literature, a web search and a questionnaire (Casanueva et al., 2019).

WHO's 2019 survey of heat–health action planning also comprised a series of questions on warning systems (Table 3).

The survey results show that heat–health warnings systems are the core element of HHAPs most widely considered to be "fully implemented", with 16 countries responding that a warning system is in place – fully or partly implemented.

Heat–health warning systems are typically operational between May and September, while a review of the system and updates (such as modelling and dissemination network), if carried out, is done in the remaining months. The majority of the alert systems are developed and managed by national meteorological services, which are also in charge of issuing the heat warning and informing the agency leading the health response (75% national public health agency or ministry of health, 19% regional health agency, 6% national environmental agency). Collaborative processes for setting up warning systems and defining thresholds

**Table 3. Questions on heat–health warning systems in the WHO survey**

| Question | Summary of answers by responding countries with national HHAPs |
|---|---|
| Which agency issues meteorological heat warnings? | • 13: meteorological agencies<br>• 4: others |
| How many days in advance are heat warnings sent to the agency in charge of the health response? | • Between one and five days in advance |
| Which agency leads the health response to heat? | • 12: national public health agency or ministry of health<br>• 3: regional health agency<br>• 1: environment agency |
| How many alert levels are there and when are they are triggered? | • Starting from baseline (0 – no alert) level, an additional 2–5 levels, with different criteria for activation including simple measurement of maximum daily temperature or meteorological indices |
| How many days in advance is the heat alert issued to the public? | • Between one and five days in advance |
| How many days in advance is the heat alert issued to key stakeholders (hospitals, nursing homes, etc.)? | • Same as to the general public |

and warning levels should be promoted between meteorological and health services and other key institutions involved in the HHAP, to better tailor warnings around its scope and use. Warnings are disseminated through information networks comprising the general public and operational stakeholders (health authorities, social services, hospitals, nursing homes, municipalities, emergency services, GPs, vulnerable groups and so on).

Dissemination of warnings is another crucial aspect for the effectiveness of HHAPs. The WMO/WHO 2015 guidance illustrates the various factors to consider when communicating heat–health warnings with a focus on warning contents, the use of appropriate language for each audience and the effective dissemination of warnings to all users. Details on communication can be found in Chapter 4.

## 3.3 Innovations and future perspectives

### 3.3.1 Increasing lead times, seasonal forecasts and future climate impacts

The issue of extending lead times of weather forecasts and the use of subseasonal or seasonal climate models is of great importance for public health response planning and management before the summer season. Use of monthly and seasonal probabilistic forecasts may assist public health administrators in decision-making in the preparatory phase and during the summer season. To improve preparedness and response, institutions involved in HHAPs can use monthly and seasonal probabilistic forecasts, requesting information (maps and data) on temperature trends and the likelihood of above- or below-average temperatures (minimum, mean, maximum, heat-wave days) or other variables (pressure and precipitation). These can give an indication of how the season will compare to the average climate, giving health services and all actors involved in HHAPs the opportunity to undertake better planning and resource allocation in advance (WMO & WHO, 2015; Lowe et al., 2016).

The trade-off is that the longer the lead time, the lower the skill (measure of the accuracy and/or degree of association between predicted value and observed value) of forecasts; this makes probabilistic forecasting less reliable for public health services. With seasonal modelling skill constantly improving (especially in latitudes where heat-waves are an issue for health such as the Mediterranean (Vitart, 2014)) and better interdisciplinary communication, collaboration and knowledge bases, however, the utility of these forecasts is not only understood but also appreciated by stakeholders and responders. The availability of seasonal forecast products to all users has been greatly improved recently through the C3S Climate Data Store platform (see Box 1 in Chapter 1) – an example of the multimodel system that combines different model forecasts into one, giving more reliable and accurate forecasts.

Seasonal time series availability and improved seasonal climate-prediction products offer the opportunity to develop heat–health warnings at longer monthly and seasonal timescales (WMO & WHO, 2015). A few recent studies have looked at the possibility of using these forecasts to develop seasonal health warning models using mortality data. For example, Lowe et al. (2016) used apparent temperature forecasts at different lead times (from one day to three months) to produce subseasonal (1–18 days) and seasonal (1–3 months) probabilistic mortality forecasts at a regional level for Europe. For some areas of Europe, excess mortality was detected with some certainty even at monthly scales. As expected, however, as lead times became longer, the skill of the mortality forecast decreased considerably.

Lastly, the C3S European health service (ECMWF, 2020) has defined a series of exposure indicators related to health impacts. Among the indicators available on the Copernicus platform are future projections of the number of heat-wave days, based on both standardized and HHAP specific heat-wave definitions, with different climate change scenarios. This is a useful tool for public health and environmental stakeholders involved in planning adaptation policies to anticipate future risks associated with heat-waves.

### 3.3.2 Information tools to improve dissemination

Since the set-up of HHAPs and heat–health warning systems, great effort has been focused on improving dissemination of information and the utility of the advice provided. Communicating risks and giving behavioural advice is considered a key element of the effectiveness of an HHAP, as noted in the 2008 WHO guidance (Matthies et al., 2008). Recent years have seen a shift from traditional communication tools such as television, radio and newspaper-based information to web and social media (Facebook, Twitter) sites, and alternative means of communication such as heat warning-dedicated mobile applications, infographics and videos (discussed in more detail in Chapter 4). These tools extend the dissemination of warnings and improve population awareness of health-related risks and prevention measures to adopt. They also assist with timely delivery of information to the general public and to stakeholders who have to activate response and emergency measures. Box 3 gives an example of a mobile application that provides personalized heat–health risks, recommendations and information on cooling spaces within a city.

#### Box 3. Extreme Temperature Alerts for Europe (EXTREMA): an emergency notification system for extreme temperatures

The EXTREMA project, funded by the European Commission, has created an innovative mobile application for the public and an administration web service dashboard for local municipalities. It aims to increase citizen awareness and reduce their exposure to heat risk, as well as supporting local authorities with implementation of HHAPs. The mobile application aims to inform individuals of their heat–health risk (no/low/increased/high risk), taking into account the user's profile characteristics (age, presence of chronic disease associated with a greater risk during heat-waves, use of medication), in real time.

The mobile application uses satellite thermal images and numerical weather predictions, alongside a set of predefined thresholds from published epidemiological evidence, to estimate heat–health risks at each location. It also provides health recommendations and information on cooling centres or spaces managed by each city authority (such as community centres, parks or hospitals if necessary), as well as routing directions. It supports multiple profiles, allowing users to check on family members (children and elderly people) at multiple locations.

Through the web dashboard city authorities can manage information on cooling centres, such as updating opening hours, adding new centres or providing other relevant information (entrance fee, contacts, capacity). The dashboard also provides current and previous day alerts (based on severe weather information from the Network of European Meteorological Services) and real-time maps of the extreme temperature hazard in the city, with a spatial resolution of 1 × 1 km, updated every five minutes. It thus helps city authorities to manage their response actions better during extreme heat events. EXTREMA is currently operational in Athens, Greece; Mallorca, Spain; Milan, Italy; Paris, France; and Rotterdam, Netherlands.

*Source:* National Observatory of Athens (2020).

### 3.3.4 Warning messages and systems customized for vulnerable subgroups

In recent years, with the identification of diverse vulnerable groups, customized warning messages with advice on what to do during a heat-wave have been issued with alerts during heat-waves to ensure a customized response (Price et al., 2018; PHE, 2020). Automated phone warning systems have recently been introduced as an alternative way of communicating warnings to vulnerable subgroups and improving coverage. A recent study conducted in Montreal, Canada, issued warnings via automated telephone calls and gave heat protection messages (Mehiriz et al., 2018). The study also carried out an evaluation of the system – results suggest an improvement in individual adaptation to heat and a reduction in the use of health services by subjects included in the study. Use of tools like this can improve dissemination to vulnerable subgroups, while reducing costs.

Such systems should be promoted within HHAPs to ensure a better response, especially among the most vulnerable subgroups. Furthermore, ad hoc heat–health warning systems for vulnerable subgroups are being developed. For example, Morabito et al. (2019) developed a heat–health warning system for outdoor workers, taking into account personalized local heat stress risk, based on workers' characteristics and the outdoor working work environment. The warning system provides weekly and monthly forecasts.

### 3.3.5 Integration with other environmental exposures

Several extreme weather and environmental exposures that have a negative impact on health occur concurrently, and often affect the same set of vulnerable subgroups. They are dealt with separately, however, often duplicating actions that could be combined. For instance, in some cases separate warning systems are managed by the same or other environmental agencies; different prevention plans are in place; time is spent identifying vulnerable groups, which may be the same – such as elderly people with pre-existing cardiorespiratory diseases; and surveillance and evaluation are done independently. Better cooperation and intersectoral collaboration are needed in devising multi-exposure systems. The core components of such systems should follow HHAPs with alert systems, prevention and response measures, surveillance of health effects and evaluation (Linares et al., 2020).

In recent years, the epidemiological evidence on the synergistic effects of temperatures and air pollution has become more consolidated (Chen et al., 2017; Li et al., 2017; Analitis et al., 2018; Scortichini et al., 2018a), showing an increase in health effects when both temperatures and levels of ozone or particulate matter smaller than about 10 μm in diameter ($PM_{10}$) are high. Weather conditions such as stable atmospheric circulation regimes in summer are associated with high temperatures and the build-up of air pollutants. Several countries (Belgium, Hungary, Italy, North Macedonia, Portugal, Switzerland and the United Kingdom) account for air quality in HHAPs either by formally including air pollution alerts or by providing advice related to both heat and air pollution, as briefly described in the Lowe, Ebi & Forsberg (2011) survey and reviews.

### 3.3.6 Evaluations and updates of heat–health warning systems within HHAPs

To date, information on formal evaluations of European heat–health warning system and HHAP effectiveness is limited (Toloo et al., 2013; Martinez et al., 2019). As noted in the 2008 WHO guidance, evaluation of the plan as a whole, as well as its components, is important to support decision-makers in selecting the most appropriate measures and improving heat plan effectiveness (Matthies et al., 2008). Heat–health warning systems should also be evaluated in both process and outcome indicators (WHO Regional Office for Europe, 2011; WMO & WHO, 2015). It is important that the evaluation process is formally defined and that results are written up and disseminated to core participants in the warning system and HHAP. Evaluations will help build confidence in the system and improve the knowledge base among the different stakeholders.

Key aspects to consider when evaluating the effectiveness of a warning system, as described in the WMO/WHO 2015 guidance, are simplicity, acceptability, timeliness, sensitivity and specificity (Table 4). In terms of process evaluation of warning systems, all the operational phases should be evaluated to assess whether implementation has been achieved successfully and what can be improved. This should include warning dissemination and reaching all relevant institutions (coverage and timing), the quality of information provided (levels of warnings, bulletins) and understanding the system and how it is considered useful to the relevant stakeholders.

How actions are modulated based on warning levels and the specific actions required at each level of warning by stakeholders is another crucial aspect that affects the effectiveness of HHAPs. Questionnaires and face-to-face seminars have been carried out to assess perception of risk, level of awareness and understanding of warning systems, alongside potential changes in response modes during heat-waves by health and social services (Matthies et al., 2008; Abrahamson et al., 2009; Matthies & Menne, 2009; Toloo et al., 2013; Wolf et al., 2014; Takahashi et al., 2015; Price et al., 2018; Vu, Rutherford & Phung, 2019). To date, response to and knowledge of risk and response measures and adaptation among the general public and stakeholders is heterogeneous. A recent systematic review underlines the need for further research in different contexts to assess the effectiveness of the different components of HHAPs and their formal uptake, to improve response (Vu, Rutherford & Phung, 2019).

Outcome evaluation, on the other hand, entails the assessment of measurable impacts. This should be done routinely to monitor and improve model performance and keep track of potential changes in population response. Model performance in terms of meteorological forecasts and warning levels (sensitivity, specificity, hit and miss rates) should be carried out on a regular basis. It should also consider the health outcome data (mortality, morbidity) on which the warning system model is based, to assess whether health impacts (excess deaths, increases in ER visits, calls to emergency and health services) change when warnings are correct or when forecast are wrong and a warning might be missed.

**Table 4. Criteria for evaluating a heat–health warning system**

| Criterion | Description/factors to consider |
|---|---|
| Simplicity of the warning system and its operation | • Operational system (data required to issue a warning and institutions involved)<br>• Management (time spent issuing warnings and maintaining the system) |
| Acceptability by stakeholders | • Collaboration between agencies<br>• Participation of institutions and stakeholders<br>• Completeness of response |
| Timeliness of issuing warnings | • Adequacy of timeliness of warnings for different response measures |
| Sensitivity of warnings | • Ability of a warning forecast system to identify warning days (how often a forecast was correct in issuing a warning compared to observed meteorological and/or health data) |
| Specificity of warnings | • Ability of a warning forecast to identify non-warning days, thereby keeping false-positives to a minimum |

*Source:* adapted from WMO & WHO (2015).

Several studies have examined changes in health effects relative to risk estimates or quantified the change in excess mortality and morbidity during extreme events over time (Bassil & Cole, 2010; Benmarhnia et al., 2016; de'Donato et al., 2018; Weinberger et al., 2018; Martínez-Solanas & Basagaña, 2019). These mostly focus on mortality as health outcome because mortality data are more robust and are collected routinely in a timely manner, and the evidence on health effect estimates is more consistent in the literature. A quasi-experimental approach has recently been adopted to assess changes in heat-related mortality in response to the introduction of heat plans in Montreal, Canada, and the Republic of Korea (Benmarhnia et al., 2016; Heo et al., 2019).

Outcome evaluation has generally been carried out more in terms of the HHAP as a whole and not just the warning itself; this is discussed in more detail in Chapter 9. This exercise is also useful when considering potential modifications to warning system thresholds or response measures associated with warning level actions over time. A study conducted in Italy showed a greater reduction in heat-related deaths for extreme temperatures when Level 2 and Level 3 warnings are issued, compared to Level 1 pre-alert days (de'Donato et al., 2018). The authors suggest that public health prevention and response measures during pre-alert conditions are less stringent and may be adopted with less attention; they therefore need to be revised and improved. Research from Adelaide, Australia, considered changes in both morbidity (ambulance calls and ER visits) and mortality effects in two summers: before and after the introduction of a warning system and prevention plan (Nitschke et al., 2016). The study showed a reduction in morbidity outcomes, while mortality remained unvaried.

Intermediate benefits such as behavioural changes at the individual or community levels are also important. These provide useful insight into the effectiveness of measures and warnings in changing population perception of risk, knowledge and measures adopted. Community questionnaires have been carried out on the perception of heat-waves, warning systems and prevention measures (Sheridan, 2007; White-Newsome et al., 2011; Nitschke et al., 2013; 2017; Vu, Rutherford & Phung, 2019). A recent review of heat–health prevention measures and adaptation among elderly people reported that further action was needed to translate knowledge/warnings into heat-adaptive behaviours (Vu, Rutherford & Phung, 2019). Although knowledge of the heat warnings was widespread, changes in behaviour or knowledge of what to do were less common (Sheridan, 2007; White-Newsome et al., 2011). Perception of risk among vulnerable subgroups and stakeholders is reported in detail in Chapter 4.

Finally, economic evaluations using cost–benefit analyses are also an important aspect of evaluating a warning system. Studies have estimated that heat–health warning systems are highly cost-effective, with the benefits in terms of lives saved outweighing the running costs (Ebi et al., 2004; Chiabai, Spadaro & Neumann, 2018). The costs and benefits of a warning system provide policy-makers with an economic perspective of the HHAP; this enables them to plan funding and resources formally for it in a systematic way, thus ensuring its continuity and improvement over time by the core bodies involved.

Another issue that not been formally addressed in HHAPs to date is updating warning systems in relation to organizational changes, new forecast models and warning thresholds – in response to climate change (rising temperatures) and changes in population response (adaptation and vulnerability) (Hess & Ebi, 2016). When and how often this should be done is far from simple. Responses to WHO's 2019 survey of heat–health action planning show that while around 60% of respondents stated that they update the national HHAP every year or every 2–5 years, it is not clear what the update entails, or whether a formal process is in place. A limited number of countries stated that they had updated or were in the process of updating thresholds since the initial set-up of the warning system.

Several studies have shown a change in the temperature–mortality association (Guo et al., 2014; de'Donato et al., 2015; Scortichini et al., 2018b) in recent years, in response to the introduction of HHAPs or changing temperatures. These are suggestive of a shift in the curve and potential variation (rise/decline) of the threshold. On the other hand, if the curve has shifted, showing some acclimatization or adaptation – potentially also thanks to HHAPs and measures in place – if thresholds are changed (increased) and prevention is no longer carried out at lower temperatures, the mortality impact might rise again. Fluctuations in the temperature–mortality association over time and factors affecting these dynamics should be considered when updating and revisiting warnings.

Future estimates of the impact on mortality in the light of climate change have given an idea of the potential added health impact (Martinez et al., 2016; Kendrovski et al., 2017; Guo et al., 2018; Vicedo-Cabrera et al., 2018). Furthermore, the ageing of the European population and rising levels of noncommunicable diseases and comorbidities are likely to increase the pool of vulnerable individuals, thus also influencing temperature–mortality response and threshold levels (Wolf et al., 2014; Martinez et al., 2019). The iterative management approach suggested by Hess & Ebi (2016) could be a useful system when planning the monitoring and evaluation of warnings, taking into account the dynamics.

## 3.4 Conclusion

Heat–health warning systems are a key component of HHAPs, as they inform local populations and stakeholders about the health risks associated with heat. They thereby raise awareness and ensure timely activation of prevention measures and emergency protocols. Threshold levels should be based on health risks and not only on meteorological conditions. The 2019 WHO survey showed a progressive increase in the number of European countries with a fully operational heat–health warning system as part of their HHAPs.

Efforts have been made to enhance alert systems (with better forecasts and longer lead times) and to improve dissemination and communication. Formal evaluations of warning systems, including both process and outcome indicators, should be carried out on a regular basis to improve the effectiveness of warnings.

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# Chapter 4. Heat-related health information plans: communicating heat risk

## Summary

The communication of adequate information and advice to stakeholders and the public, and their perception and uptake, are crucial to the effectiveness of an HHAP. This flow of communication, along with complementary bottom-up feedback, needs to be organized in a heat-related information plan.

The scientific evidence from the last decade suggests that the basic content of public health messages within HHAPs does not need to change substantially. Communication channels have changed radically in recent years, however, with a fast transition to web-based and mobile platforms. Most countries in the WHO European Region with an operational HHAP have embraced such channels for their communications. While that transition facilitates dissemination of and access to information among the general public, it also raises concerns about inequalities in access to information, since various groups who may be vulnerable to heat – such as elderly people and those with low socioeconomic status – may be comparatively excluded from such means of communication.

In addition, recent research has linked the frequently observed failure of messages to prompt protective action with a low risk perception of heat among the general public and vulnerable groups. To make heat–health messages more effective, better understanding is needed of risk perceptions and biases at the local level. On that basis, language and formats can be tweaked and HHAPs can better target their warnings and information to their various audiences.

## Key messages

- Appropriate communication on heat and health risk to stakeholders and the public is crucial for prevention, as is their ability to respond.
- Messages and warnings work best when tailored to their intended audiences, ideally based on evidence of their actual vulnerability, risk perceptions and health behaviours.
- Heat risk communications and advice work best when grounded on factual evidence of the risk perception and attitudes to health protection of the local population.
- Health authorities can further sharpen the tailoring of their messaging by combining various sources of information about health vulnerability to heat.
- The scientific evidence behind commonly given heat–health advice needs to be evaluated.

- Countries have generally shifted their HHAP communications towards web-based and mobile technology platforms, and it is important that such transitions do not exclude vulnerable groups less familiar with such information technologies.
- The health risks of heat are systematically underestimated by the general public, vulnerable individuals and possibly health practitioners.

## 4.1 Introduction: heat risk communications

Effective communication of adequate information and advice to stakeholders and the public to enhance their ability to respond and protect themselves from the health effects of heat is arguably the most crucial element of prevention. Thus, adequate prevention is supported by the ability of HHAP administrators, implementers and policy-makers to deliver useful, timely, accessible, consistent and trustworthy information to their target audiences, and especially to high-risk populations.

The WHO Regional Office for Europe's guidance on HHAPs published in 2008 paid strong attention to communication, and the main principles enumerated there still stand (Matthies et al., 2008). In essence, these are that:

- communications and associated messaging need to be planned in advance;
- communication is a dialogue, whereby the ability of communicators to change behaviours is based on an understanding of the beliefs and concerns of the audience;
- trust is crucial to effective risk communication with the public, and needs to be built from the start through transparency and timeliness;
- all key stakeholders need to be able to communicate consistently.

Based on a two-way communication model, from the top down and from the bottom up, the 2008 WHO guidance recommends a heat-related information plan as a core element of an HHAP (Matthies et al., 2008). The plan should specify what is communicated, to whom, how and when.

Bottom-up communication content typically includes event reporting, counts or censuses of vulnerable groups, availability of resources such as cooling centres and transportation of vulnerable people, surveillance data, implementation problems and specific needs for assistance. This should be communicated in a context of coordination with the main implementers of the plans, key stakeholders and the media. Bottom-up information flow is covered further in Chapters 7 and 9.

Top-down (from HHAP managers) communication content typically includes the health risks of hot weather, roles and responsibilities for the actors of the plan, behavioural advice for groups at risk, and guidance for professionals and institutions. The plan creators should consider, among other things:

- the channels, timing and language of communication – these may vary between target audiences;
- the information relevant to each audience;
- the risk perception of target audiences.

The following sections summarize operationally relevant considerations for each of these areas.

# 4.2 Channels, timing and content of heat risk communications

### 4.2.1 Channels for heat risk communications

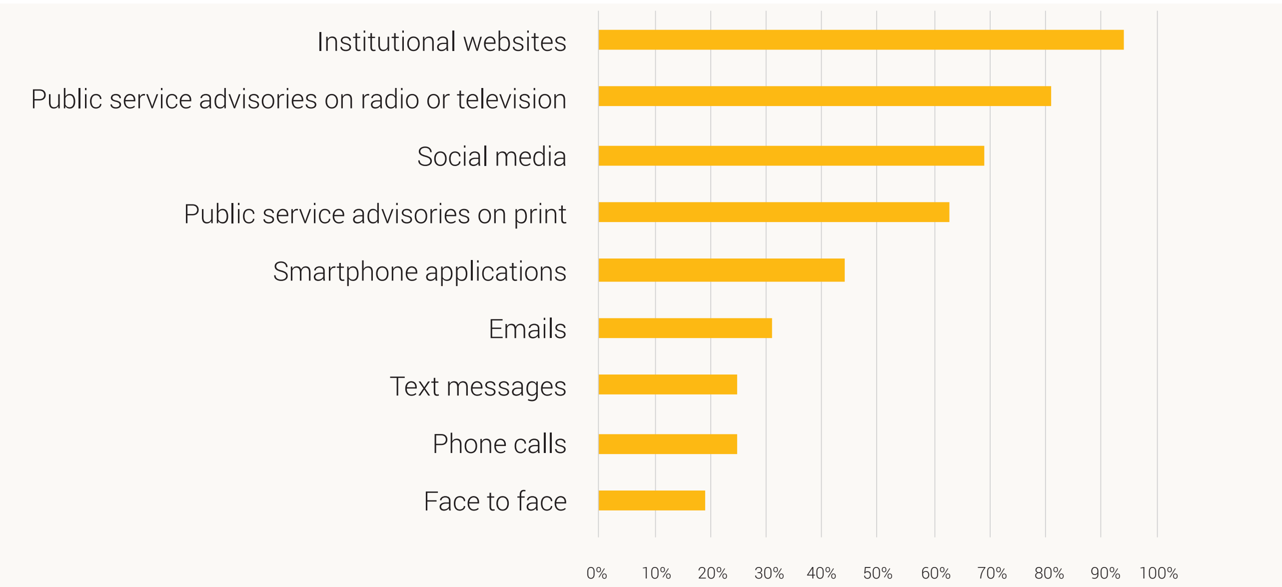
Against a theoretically optimal outreach to all at-risk populations and relevant audiences, the communication options for HHAP managers are largely dictated by the availability of resources. This limitation, however, is changing as technology advances and becomes more affordable in countries at various stages of economic development.

For instance, a review by Koppe et al. (2004) highlighted that most existing heat–health warning systems in Europe at the time relied on issuing a passive warning through the mass media to the general public and/or a direct one to local public health agencies. This situation has changed significantly in the past 15 years. Now, many HHAPs use different channels for communication of heat warnings and relevant information, including the internet, mobile applications and social media. Most European heat–health warning systems provide plenty of information through their websites, mobile apps and social media (such as Twitter), although mass media such as television and radio still play a major role (Casanueva et al., 2019). Brochures, flyers and newsletters are still sent to hospitals, nursing facilities and GPs as common practice.

The results of WHO's 2019 survey of heat–health action planning from 16 HHAPs found that 75% had a fully implemented heat-related health information plan and 25% a partly implemented one. Moreover, when the respondents were asked to highlight what worked well in their respective systems, they mentioned communication and dissemination of warnings as one of the most effective aspects of the HHAP. Most HHAPs delivered advice to vulnerable groups on how to protect themselves from heat via institutional websites (over 90%), followed by public service advisories on radio or television (over 80%) and social media (almost 70%; mostly Facebook and Twitter) (Fig. 7).

HHAPs use a variety of approaches and systems for information dissemination. Box 4 summarizes one approach used in Italy.

**Fig. 7. Channels through which advice is delivered to vulnerable groups**



### Box 4. Warning dissemination in the Italian HHAP

The Italian HHAP provides information on timeliness and targeted dissemination of warnings at the local level to allow all services to act in good time. It aims to raise awareness of heat risks and provide advice to the public, health care professionals, emergency services and local authorities. Various communication channels have been introduced to improve dissemination and ensure that the information needed to modulate prevention actions is accessible.

At the national level, warning bulletins for each city are available on the Ministry of Health website, via the mobile application "Caldo e Salute [Heat and Health]" (Ministry of Health, 2018) – which is freely available for mobile devices – and, during heat-waves, via the Ministry of Health Twitter account. The application also includes information on local prevention measures, referring to existing resources such as brochures and factsheets, local heat response plans, contact numbers and helplines and the national guidance document. A reference centre (civil protection, municipality, local health authority or other) is identified for each city, which is in charge of local dissemination of city-specific bulletins through the information network and via email. At the beginning of each summer a workshop is organized by the Ministry of Health to inform local stakeholders, giving updated information on the plan and new findings on prevention measures and vulnerable subgroups.

Information on health risks and prevention measures is also issued to the general public and at-risk subgroups through mass media communication campaigns, local authority websites and flyers. This happens at the beginning of the summer, but further specific advice may be disseminated during heat-waves. Additional elements of communication within the Italian HHAP include information delivered through telemonitoring by volunteers or social workers to elderly patients with social frailties, and capacity-building and awareness-raising for social and health workers, delivered via seminars/workshops, distribution of specific guidelines and meetings.

### 4.2.2 Timing of heat risk communications

Some heat-related information may not be delivered in relation to a specific heat risk episode, but rather in advance of the warm season, periodically during the season or in specific settings. Other communications may be packaged within warnings of impending heat events, whereby various audiences are made aware of potential or actual harm and what to do to protect themselves or others (Casanueva et al., 2019).

In terms of timing of the flow of information within the system and outside it, WHO's 2019 survey of heat–health action planning showed that the agency issuing the alert (generally the meteorological service) informed the agency leading the health response (generally a national public health agency) with an average lead time of four days. The heat risk communication itself was given to the public and to key stakeholders (hospitals, nursing homes) typically 1–3 days in advance.

### 4.2.3 Heat risk communication language and content

Warning messages delivered to the public are critically important in getting people to take appropriate action to protect themselves from heat. The WMO/WHO (2015) publication *Heatwaves and health: guidance on warning-system development* recommended taking the following into account when composing a risk communication:

- clear definition of the components of the message;
- simplicity of the message;
- personalization of the message and description of the actions required;
- prioritization of the order of importance of the information;
- use of plain language and illustrations for those who may have difficulty reading;
- inclusion of a statement of recommended action;
- ensuring that shortening of the message by broadcasters does not distort its meaning.

That such messages include recommended actions is especially important, since most health-protective behaviour has to come from individuals and families. A message that effectively describes a danger but offers no suggestions for protection tends to be denied or reinterpreted by recipients in ways that may increase the likelihood of harm or injury. Even taking all these factors into account, it is advisable to test messages on focus groups. The Red Cross/Red Crescent further suggested that a warning should address questions regarding timing, location, scale, impact probability and response (Singh et al., 2019).

The WMO/WHO 2015 guidance explored extensively the various factors to consider in communicating heat–health warnings. These include, among others, the decision to issue a warning, how to structure warning contents, the language adequate for each audience, criteria and thresholds for issuing warnings, how to disseminate them effectively, and coordination with users. No substantial body of recent relevant evidence exists for the WHO European Region that would justify re-exploring these factors in this publication.

Casanueva et al. (2019) noted that all information and warnings are issued in the local language of each responding country. Three countries (Hungary, Sweden and Switzerland) provide notifications in both the local language and English, and the HHAP in France also produces flyers and radio spots in English. Nevertheless, there is no indication that multilingual messaging is frequent, and this may be an important limitation – especially for countries that receive large inflows of tourists in summer (such as those in southern Europe). To this may be added the pockets of at-risk population groups who do not speak – or are not fully fluent in – the language of the country or region they live in. In various studies where it was assessed, knowledge of risks and responses was lower for foreigners, whether tourists (Cuesta et al., 2017) or migrant workers (Messeri et al., 2019). The lack of availability of HHAP information in languages other than the local one contrasts with other areas, in which public health has a long and fruitful history of risk communication through translated materials, visual displays and other means.

Hajat, O'Connor & Kosatsky (2010) evaluated the scientific evidence for commonly offered heat protection advice, and made recommendations about the optimum clinical and public health practice. The study concluded that the following actions are supported by scientific evidence:

- increasing fluid intake during periods of hot weather;
- ensuring that susceptible people stay in a cool or air-conditioned environment during periods of hot weather;
- wearing loose-fitting clothes and taking frequent showers or baths;
- reducing normal activity levels during hot weather, alongside improving awareness of the inherent risks of activity during hot weather, and the symptoms of heat exhaustion and heatstroke;
- physicians making pre-seasonal recommendations to patients taking drugs that may impede heat loss about how to monitor themselves.

Patients aged 65 years and over with chronic circulatory and respiratory conditions are at greater risk from heat than others. The evidence points to increased cardiovascular complications and heart failure following a 1 °C increase in temperature (Bunker et al., 2016).

Advice not well supported by scientific evidence included: avoiding the use of electric fans; avoiding consumption of any type or amount of alcohol without distinction;[1] and avoiding consumption of even small amounts of caffeinated drinks because of possible diuretic effects. The level of evidence required for advice, the content of the advice itself and how it fits within local guidelines and regulations, however, are determined by the relevant authorities (Hajat, O'Connor & Kosatsky, 2010).

Examples of heat-wave and COVID-19 communication in the WHO European Region are shown in Box 5.

### 4.2.4 Audiences for heat risk communications

Audience-tailored advice is generally better received than general advice in all risk communications. Based on the responses to WHO's 2019 survey of heat–health action planning, most national/federal public health agencies provide information tailored to specific vulnerable groups, including but not limited to elderly people, those exercising outdoors, carers (of children and adults) and workers. Evidence supports the notion that intensive preventive information targeted towards vulnerable populations improves protective behaviours (Nitschke et al., 2017).

The specific audiences listed in the 2008 WHO guidance and the 2011 associated supporting materials (Matthies et al., 2008; WHO Regional Office for Europe, 2011) are still relevant, as are the types of message and recommendation tailored to them (Table 5).

Another audience that should be considered and is not covered in WHO HHAP guidance is school managers and school-related communities – in particular on account of extreme heat episodes that may occur during the school season (such as in June or September). If sensible precautions are taken, children are unlikely to be adversely affected by hot conditions; however, teachers, assistants, school nurses and all child carers should look out for signs of heat stress, heat exhaustion and heatstroke (PHE, 2015).

A recent review (Casanueva et al., 2019) of heat–health warning systems (the weather-based alert component of HHAPs) analysed 16 systems and did not find significantly different types of information from those featured in Table 5. Within these categories, a plethora of advice is provided both generally and specifically to vulnerable groups. A comprehensive review of such advice is beyond the scope of this report, and partial inventories have been published elsewhere (Casanueva et al., 2019; Lowe, Ebi, & Forsberg, 2011).

Segmentation of audiences for targeted advice needs to be refined further than simply grouping for age or other factors shared by many: this approach may miss households who struggle with multiple and interlaced social vulnerabilities, including poor-quality housing, living in "hot spot" suburbs (urban heat islands caused by lack of vegetation), low socioeconomic status and health problems (Hanson-Easey et al., 2019). Segmentation of audiences for tailored messaging needs to be sharpened to afford those who are most vulnerable with much-needed support and information. To achieve this, additional sources such as census data on socioeconomic status and housing, and other information available to health authorities within the existing privacy regulatory environment should be used.

In addition to information for the public and vulnerable groups, HHAPs usually also deliver targeted advice, guidance and instructions to stakeholders in the plan, including doctors, nurses, pharmacists, nursing homes managers, health care

[1] Note: there is no safe level for drinking alcohol. For more information, refer to WHO guidelines and other materials (WHO, 2020).

## Box 5. Heat-waves and COVID-19 communication in the WHO European Region

In addition to the COVID-19 pandemic, the year 2020 has seen some of the highest temperatures on record, both within the WHO European Region and globally (ECMWF, 2020). Even in the context of a pandemic, adequate media coverage of other public health risks – including high temperatures – is necessary to ensure the effectiveness of prevention. Warnings should integrate concomitant risk factors and information on response measures and adaptation amid the epidemic and heat (Martinez et al., 2020; Golechha & Panigrahy, 2020).

The WHO Regional Office for Europe has adjusted its regularly issued summertime advice to minimize the adverse health effects of hot weather, integrating it with advice on protection from COVID-19. It includes recommendations to spend 2–3 hours of the day in a cool place while respecting physical distance, and to protect oneself and others by washing hands regularly, wearing masks where necessary, coughing into a folded elbow and avoiding touching the face. The advice is summarized in a fact sheet (Fig. 8), available in 10 languages (WHO Regional Office for Europe, 2020), which was promoted by a broad communication and outreach campaign (GHHIN, 2020a). Medical and public health professionals were asked to be prepared to protect the public effectively from both COVID-19 and the health consequences of heat exposure (GHHIN, 2020b). Simultaneously, various countries in the WHO European Region reviewed their HHAPs in the light of the restrictions in place from the pandemic and its responses (Santé Publique France, 2020; PHE, 2020). Operational implications for the impacts of COVID-19 and related heat–health responses are explored further in Box 11 in Chapter 7.

**Fig. 8. Health advice for hot weather during the COVID-19 outbreak**


*Source:* WHO Regional Office for Europe (2020).

**Table 5. Audiences and types of information set out in WHO guidance documents on heat and health**

| Audience | Type of information |
|---|---|
| General public | • How to keep the home cool<br>• How to keep out of the heat<br>• How to keep the body cool and hydrated<br>• How to help others<br>• What to do if you have a health problem<br>• What to do when others feel unwell<br>• How to protect your health from vegetation fires during heat-waves |
| Vulnerable groups[a] | • Practical tips for specific groups<br>• First aid treatment<br>• Important contact details for social and medical services |
| GPs and other medical professionals | • Risk factors for heat illness and mortality<br>• Health conditions that greatly increase the risk of health effects from heat<br>• Mild and moderate heat illnesses and their management<br>• Management of life-threatening heatstroke<br>• Adverse effects of medication during hot weather<br>• Considerations regarding drinking advice during hot weather and heat-waves<br>• Proactive preparation for heat-related illness and risks<br>• Education, counselling and information for patients |
| Retirement and care home managers | • General public precautions<br>• Reducing indoor temperatures and cooling<br>• Monitoring and reducing residents' heat-related risks<br>• Standards for occupational safety during heat-waves |
| Health authorities | • Protecting health from vegetation fires during heat-waves<br>• Standards for occupational safety during heat-waves<br>• Interventions in the built environment to protect health from heat<br>• Communicating heat risks and prevention |
| Employers | • Standards for occupational safety during heat-waves |
| City planners | • Interventions in the built environment to protect health from heat |

[a] *For more information on vulnerable groups see Chapter 6.*
*Sources:* Matthies et al. (2008); WHO Regional Office for Europe (2011); WMO & WHO (2015).

administrators, hospital managers, social services and schools. In some cases, instructions and guidance for these key stakeholders are compiled in a practical information package. The HHAP of the Netherlands (RIVM, 2015), for instance, maintains a "heat toolkit", with information and communication tools including frequently asked questions and answers, brochures and sample letters, among others. The plan comes into effect when a period of sustained heat is expected, meaning that it is necessary to take preventive health measures for vulnerable groups.

Several tools and packages are available on how to communicate about extreme heat. Alongside the relevant WHO materials cited above, the Health Canada (2011) toolkit and the Red Cross/Red Crescent materials (Singh et al., 2019) are of particular note.

## 4.3 Heat risk awareness, perception and adaptive capacity

The relevant accounts of evidence since the publication of the 2008 WHO guidance (Matthies et al., 2008) have demonstrated clear indications of a disconnect between the actual hazard posed by heat-waves and high temperatures (measured by objective indicators such as attributable mortality) and the perceived risk thereof. Moreover, this disconnect is observed (although the evidence is still patchy) across the board, including among the general public, vulnerable individuals and health practitioners.

### 4.3.1 Awareness of risks and responses to heat among the general public

Most studies and reviews have concluded that public awareness of the risks of heat to health is relatively high in places that are periodically affected by hot spells. Bassil & Cole (2010) reviewed 14 studies from Canada, the United States and four European countries and found that awareness of the risks, as well as of recent heat warnings, was "nearly universal" in the general public. This awareness varied across a number of factors including age and ethnicity, however, and it was not clear that the results applied to vulnerable groups.

Knowledge among the general public about the risks and adequate responses to heat, as well as risk perception, seems to vary widely and to be to some extent location-dependent, even if risks are comparable. For example, Van Loenhout & Guha-Sapir (2016) found more knowledge about risks and protection in Brussels, Belgium, than in Amsterdam, Netherlands, and Cuesta et al. (2017) similarly found more knowledge and risk perception in Lisbon, Portugal, than in Madrid, Spain. The four locations have HHAPs in place and public knowledge about them was far from widespread (57% was the highest proportion of respondents familiar with the plan). The Cuesta et al. study showed that practical concepts used in approaches to extreme heat – such as knowledge of risk groups and protective measures – were widely recognized, whereas less than a third of respondents had knowledge about the existence of a national heat plan.

Awareness and knowledge of the risks of heat, however, do not equate to self-perception of being at risk or ensure that protective action will be taken. In fact, most studies show that while heat awareness and knowledge may be high among the general public, the perception of risks from heat is generally low. This is not only a phenomenon limited to the WHO European Region. A large survey in the United States (Howe et al., 2019) found risk perceptions that were widely disconnected from actual risks. For example, populations in warm climates tended to have higher heat risk perception, although populations in cooler climates might in fact be at higher risk because of lack of acclimatization and poorly adapted housing and infrastructure.

One significant predictor of heat risk perception seems to be age, though the direction of the association varies. While in Australia Akompab et al. (2013) found that older people had a higher risk perception of heat, Howe et al. (2019) found that older populations (thus at higher vulnerability) had lower risk perceptions than younger populations. This finding of lower risk perception by older populations has been observed in several settings, including France (Box 6), Germany (Beckmann & Hiete, 2020) and the United Kingdom (Abrahamson et al., 2009).

### 4.3.2 Understanding the risk signature of heat among vulnerable groups

The way people reason practically about specific risks is sometimes referred to as a "risk signature". This has often been found to be unconnected to the magnitude of the hazard: subjective perceptions of risk are often relatively unrelated to

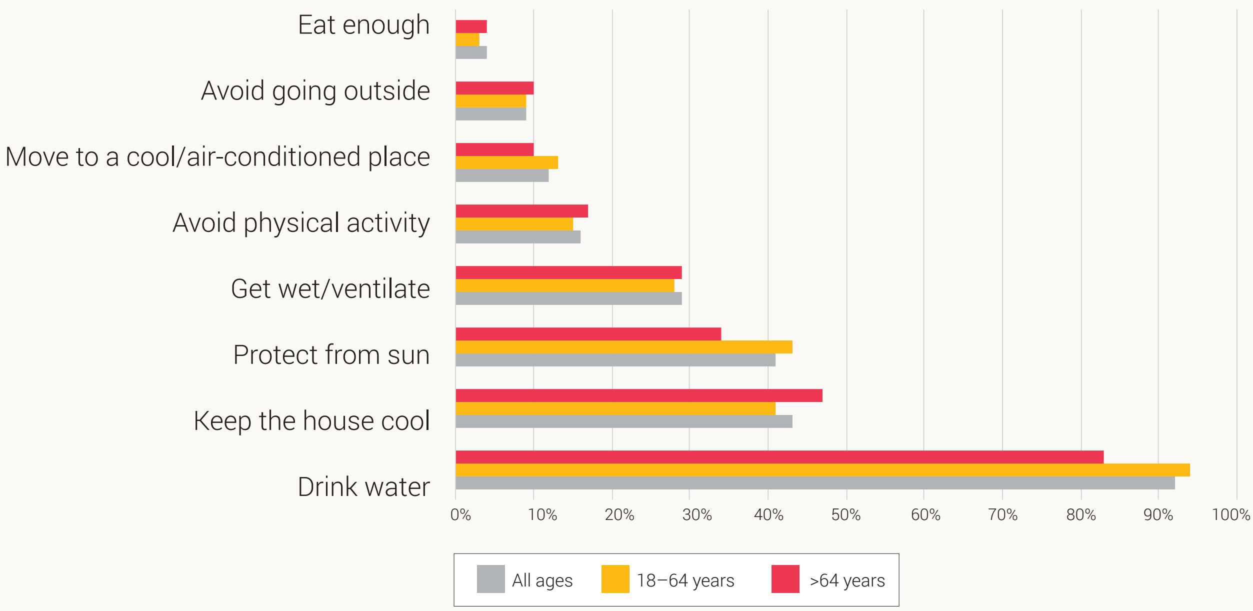
## Box 6. Assessment of risk perception of heat, knowledge, practices and means of action in France

Since 2004 France has had a national heat-wave plan to protect the population, with a focus on the most vulnerable people. The plan is led by the Ministry of Health, and advice is widely distributed each summer among the population and local actors. At the local level, many stakeholders (such as department prefects, regional health agencies, cities, NGOs and health and social workers) are in charge of action in the field (Laaidi et al., 2019).

The efficiency of the HHAP relies on implementation of preventive measures by the population and stakeholders, and this depends on their risk perception, knowledge, practices and means of action. The national authorities therefore assessed such factors in two studies –among the population and among local stakeholders. In 2016, phone interviews were conducted among a sample of 2504 people aged over 18 years, with a focus on 935 people aged over 65 years. These revealed:

- low understanding of some of the health effects of heat, and their severity;
- a lack of knowledge about vulnerable groups beyond elderly people and infants;
- a very low self-perception of risk, even for elderly people – only 4% of people aged over 65 years thought that they were at high risk during a heat-wave;
- good knowledge of prevention attitudes and good follow-up of recommendations (Fig. 9).

### Fig. 9. Proportions of the French population declaring that they adopt preventive measures during heat-waves




Among local stakeholders, a qualitative study was conducted in six French cities (Laon, Lyon, Nantes, Nice, Paris and Strasbourg), including small-group interviews among nurses, carers and workers in the homes of vulnerable people. Individual face-to-face interviews were also carried out with institutional (mayors, prefects, regional health agencies, local centres for social action and information) and other

**Box 6 contd**

stakeholders (emergency physicians, social associations for vulnerable people, child care centres, schools, day care centres). For most interviewees, the heat-wave plan provided a regulatory framework that helped to formalize practices, set up partnerships to act efficiently in emergency conditions and mobilize actors each summer.

Local stakeholders tended to downplay the risks, not least because of the reduced availability of staff and hospital/shelter beds in summer. They also felt that it was difficult to tailor general prevention to specific needs (for example, people with certain diseases cannot drink a lot) or to convince vulnerable groups to change behaviours. Local stakeholders provided practical recommendations, including better targeting of specific populations at risk; simplification of materials for actors in the field; reinforcement of human resources in hospitals, homeless shelters and nursing homes during warm seasons; and reinforcing collaborations between actors at the local level (Laaidi et al., 2018).

their actual probabilities (Song & Schwarz, 2009). Most often, risk perceptions are determined by a complex combination of media accounts, everyday experience and overall risk aversion patterns, along with several other variables such as sex, age and ethnicity.

Risk psychologists and communicators know that the two factors that most often influence perception of a risk are familiarity and dread (Slovic, 2010). Familiarity refers (in lay terms) to how frequently one is exposed to a certain concept, not to actual knowledge of it. It is related to whether a risk is observable, its effect is immediate, and one knows when one is exposed. Dread refers to subjective characteristics of a risk, such as being seen as "uncontrollable, catastrophic, hard to prevent, fatal, inequitable, threatening to future generations, not easily reduced, increasing, involuntary, and threatening to the person evaluating the risk" (Steul-Fischer & Heideker, 2015). Much as with alcoholic drinks, heat is a familiar and low-dread risk; both are systematically underestimated. Moreover, the evidence shows that positive feelings about hot summers may undermine the willingness of vulnerable populations to protect themselves against heat, and even that the language used in warnings may in fact evoke positive feelings towards hazardous heat (Bruine de Bruin et al., 2016; Lefevre et al., 2015). Risk communications cannot motivate action without an understanding of the emotions elicited by a risk, and risk-related emotions are rarely affected by statistics (Slovic & Ball, 2011). Adequate heat risk communications should tackle the familiarity, low-dread factor and misleading positive feelings about extreme heat proactively.

In relation to the risk signature of heat, comprehensive studies of the risk perception of climate change show that the general public in several (mostly high-income) countries does not associate climate change with health risks (Akerlof et al., 2010; Berger, Lindemann & Böl, 2019). Moreover, there is clearly a significant distance between the perception of the global severity of climate change and the perception of the personal threat derived from it (Sun & Han, 2018). Unlike with heat, however, populations vulnerable to climate change do perceive themselves at a higher risk from it (Akerlof et al., 2015; Lee et al., 2015). Thus, the notion of linking climate change and heat risk communications could be considered on a case-by-case basis.

Effective risk communications about heat should be based on a factual understanding of the knowledge, attitudes and behaviour of high-risk groups and their carers, as well as their understanding of the risks associated with heat-waves, the responses needed, and their experience of actual heat-wave measures (WMO & WHO, 2015). This understanding can only be acquired through qualitative research, including questionnaires, focus groups, face-to-face or remote interviews and other validated quantifiable methods. Moreover, heat–health recommendations may require customization beyond mere translation in order to amplify their reach and effectiveness; such a need was observed in the Russian Federation (Smirnova et al., 2015) and is probably present in several other countries in the WHO European Region.

Several studies have shown relatively low perception of risk from heat by those most vulnerable to it (Abrahamson et al., 2009; Bittner & Stößel, 2012; Akompab et al., 2013; Van Loenhout & Guha-Sapir, 2016; Cuesta et al., 2017; Howe et al., 2019). This pattern is not universal; some vulnerable groups – such as people with chronic heart and lung disease risk illness – have been found to have greater risk perception and to act accordingly (Kosatsky et al., 2009). The low self-perception of risk among various vulnerable groups, including elderly people and those in poor health, observed in Europe and elsewhere is, however, of particular concern. It highlights the possibility that while plans and alert systems may raise awareness, they may not be able to prompt self-protective actions.

The notion that vulnerable groups may not consider themselves at risk matters a great deal for public health action to prevent heat-related health impacts. The theories of health promotion and behaviour suggest that those most likely to adopt such measures are also those who feel most threatened. Moreover, awareness does not necessarily equate with perceived threat, as the study in Box 6 shows. In addition, further barriers to effective protection from this low risk perception exist for vulnerable groups. Most notably, the cost of engaging in protective measures against heat – such as the energy costs of air-conditioning – is among the obstacles that prevent the population from taking action (Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016).

Researchers have analysed the factors influencing risk perception of heat and the adoption of protective behaviours systematically and found them to be highly context-specific. For instance, in Portugal a survey revealed better practices to protect against heat among those who had obtained information on time (Carvalho et al., 2014). The results observed in France (Bassil & Cole, 2010) showed an association during heat alerts between higher level of change in practice and awareness and practices among the public. In Lisbon, Portugal, and Madrid, Spain, locals were significantly more knowledgeable about certain extreme heat-related risk groups than foreigners, despite having lower educational levels. This could be explained by their being more exposed to local media and better targeted by local campaign messages (Cuesta et al., 2017). Having strong networks (relatives, friends and neighbours) does not necessarily contribute to more accurate risk perception and better self-protection (Abrahamson et al., 2009; Wolf et al., 2010). Other factors, such as higher education or greater income, may be more associated with efficient health-protective behaviours (Akompab et al., 2013).

Understanding the psychology of people's reactions to and beliefs about weather is important in efforts to make heat risk communications more effective. A study in the United Kingdom (Lefevre et al., 2015) found that positive associations with warm weather made heat warnings less effective. A study of large urban settings in the United States found while that vulnerable populations often recognized heat's potential health threats, they relied on experiences of having lived in or visited warmer climates as a heat-protective factor. The institutions responsible need to identify policies that promote safety during heat-waves and hot weather, and that welcome vulnerable individuals to cool places, including ones that may not be official cooling centres (such as libraries and parks) (Sampson et al., 2013).

Recent research reinforces the importance of social processes in enhancing or limiting resilience measures towards climate change adaptation.

The need for social responses requires policy interventions with more effective communication to ensure behavioural change and better resilience to climate risks (Howarth et al., 2019). These processes influence the uptake of protective behaviours, some of which can be targeted by education and outreach. For instance, social norm campaigns to increase the acceptability of free use of cool spaces such as banks or supermarkets without purchasing anything were found useful in Japan (Martinez et al., 2011; Boeckmann, 2016).

Feelings of self-efficacy among those addressed by heat–health behaviour change advice may also need to be strengthened. Heat education campaigns could profit from strong theoretical frameworks grounded in behaviour change theory (Lorencatto et al., 2013; Michie et al., 2011; 2013), as used in other behaviour change interventions such as smoking cessation or increasing physical activity (Jepson et al., 2010).

Heat–health behavioural guidance should also be grounded on an accurate understanding of motivations behind risky behaviours (Ban et al., 2019) and possibly risk denial as a coping strategy (Bittner & Stößel, 2012). Ideally, understanding of specific risk signatures should be derived from the processes of monitoring and evaluating HHAPs (WMO & WHO, 2015), ensuring that the perspectives of vulnerable groups are adequately integrated into the system (Mayrhuber et al., 2018).

### 4.3.3 Risk perception among health practitioners

There are indications that the risk perception of heat among health care providers themselves may be significantly lower than it should be, given the objective risks faced by their patients (Abrahamson & Raine, 2009; Herrmann & Sauerborn, 2018). A lack of awareness of heat warnings among health professionals, including nurses in care homes, has been reported (Bittner & Stößel, 2012). Research has also found gaps in knowledge (Ibrahim et al., 2012; Valois et al., 2016) and a lack of awareness of existing heat–health plans among hospital front-line staff (Boyson, Taylor & Page, 2014).

While the evidence is limited, an unrealistically low risk perception, lack of awareness or gaps in knowledge about heat risks or plans by practitioners could severely hinder the implementation and effectiveness of HHAPs. The reasons are clear: for some of those most vulnerable to heat (such as older, socially isolated patients), visits to the GP may be a rare instance of social interaction. Moreover, GPs are arguably the most trusted source of health advice and a key element of HHAP advice dissemination. Effective dissemination of heat-related health advice is simply unfeasible without the full assistance of health care professionals. This highlights the need for engagement of medical associations and other relevant bodies in disseminating the relevant information and offering capacity-building opportunities, as well as provision of adequate resources for such involvement.

## 4.4 Conclusions

A well developed heat-related information plan remains a central piece of any effective HHAP. The main target audiences, types of message and principles of risk communication outlined in earlier WHO guidance remain relevant (Matthies et al., 2008; WHO Regional Office for Europe, 2011; WMO/WHO, 2015). The scientific evidence base of commonly used specific information in advice and warnings should, however, be evaluated systematically. Evidence from the last decade shows generally good awareness but a low risk perception of heat by the general public, vulnerable groups and possibly health care providers. Psychological mechanisms and the familiarity and low-dread factor of heat may hinder the effectiveness of heat risk communications.

The survey results confirmed generalized use of web-based and mobile-based technologies for information dissemination, which were not widespread at the time of the 2008 WHO guidance. It is therefore crucial to gain better research-based understanding of the knowledge, attitudes and behaviour of high-risk groups and their carers when designing information and communication campaigns. Such improved understanding, adapted and customized to local settings and audiences, should inform heat-related health information plans.

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# Chapter 5. Reductions in indoor heat exposure: types of intervention and evidence of effectiveness

## Summary

Most Europeans spend most of their time indoors, where exposure to overheating tends to occur. A substantial proportion of the housing stock throughout the WHO European Region may be susceptible to overheating. Understanding of the thermal comfort needs of those most vulnerable to heat is still poor, and data on the real-time correlation between outdoor and indoor temperatures in residential settings are lacking. This is of concern for vulnerable population subgroups, for whom combinations of housing characteristics, occupancy profiles, behaviours, lack of access to cooling options and other factors severely increase their risk of heat-related health impacts.

Several technical solutions exist for passive cooling, in both new constructions and retrofitting, but these are often not feasible or affordable for vulnerable groups. For many within those groups, access to adequate cooling can be considered a potentially life-saving medical necessity; yet access to the protection afforded by air-conditioning – the most prevalent cooling technology – remains unequal and hindered by summertime energy poverty. Balancing its many society-level drawbacks against its protective benefits requires a nuanced policy approach towards air-conditioning.

## Key messages

- A significant share of hazardous exposure to heat happens indoors.
- Much is still unknown about the relationships between outdoor and indoor temperatures, and between indoor temperatures and the thermal comfort of vulnerable individuals.
- Indoor exposure to overheating occurs through a combination of building and dwelling characteristics, occupancy profiles and behavioural factors.
- While some of the characteristics of a building that can lead to overheating cannot be modified (such as location) or are cumbersome (like building envelope changes), others may only require minimal retrofitting, and could even be installed by dwellers.
- Passive cooling interventions can afford health protection from heat while minimizing energy consumption.
- A wide range of active cooling technologies are available, but air-conditioning is becoming

the de facto technology for protection from overheating.

- Air-conditioning has a number of drawbacks, including equity of access and environmental and social impacts, and may be a clear example of maladaptation to climate change.
- While other options become available, the protective benefits for vulnerable groups of air-conditioning systems need to be ensured, while increasingly sustainable technologies are promoted.

## 5.1 Introduction

Reduction of indoor heat exposure ought to be a central factor to consider in any effective HHAPs in the WHO European Region. By some estimates, the population of the EU spends 90% of their time indoors on average (Sarigiannis, 2013). Moreover, time spent at home in Europe increases with age, with people aged over 65 years spending around 20 hours a day at home on average – fully six more hours per day than people in their twenties (Eurostat, 2020a). Thus, the individuals most vulnerable to heat spend more time at home, including the hottest hours of the day (Taylor et al., 2016). Unsurprisingly, heat-related mortality tends to happen disproportionately at home (Joe et al., 2016).

Against this background, however, most HHAPs (and their related heat–health warning systems as discussed in Chapter 3) are organized around outdoor temperatures. Whenever indoor heat indices are taken into account, these are typically developed for healthy working populations, and are thus barely applicable to most groups vulnerable to heat.

At the time of publication of the WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008), data on how housing quality and characteristics modify the relationship between outdoor and indoor temperatures were limited. Even less evidence was available on the links between indoor heat and health. The guidance thus listed a summary of tentative recommendations for the short, medium and long terms. These were not based on a formal assessment of the evidence, and could be grouped into four main categories:

1. behavioural advice;
2. access to cooling technologies, services or spaces;
3. modifications of housing characteristics and buildings, with an emphasis on passive cooling;
4. urban landscape management.

Categories 1 and 4 are considered elsewhere in this report: behavioural advice for protection from heat is covered in Chapters 4 and 6, and urban landscape management is explored comprehensively in Chapter 8.

Lacking sound evidence in the European context for categories 2 and 3, the 2008 WHO guidance explored passive cooling as a key element to exploit within possible modifications of housing to protect health from heat. A decade on, this chapter explores three main areas of relevance for the reduction of indoor heat exposure in the light of the latest evidence. First, it examines the relationship between outdoor and indoor temperatures and health, including the acceptability and suitability of different ranges of indoor temperatures for various population groups. Second, it considers the possibilities of housing and dwelling modification for passive cooling. Finally, it investigates the effect that the accessibility and affordability of different cooling services and technologies may have on protecting the public and vulnerable groups from hazardous heat.

## 5.2 Indoor temperatures and health

Leaving aside occupational exposures (see Chapter 6 for more information), the evidence on associations between temperatures experienced at home and health impacts is scarce. So scarce, in fact, that the recommendation of the WHO housing and health guidelines (WHO, 2018) regarding maximum indoor temperatures is a conditional one. While the guidelines recommend developing and implementing strategies to protect populations from excess indoor temperatures, they do so based on the proven association of outdoor temperatures with morbidity and mortality; and on the correlation between outdoor and indoor temperatures.

Because of the scarcity of research directly linking indoor temperatures and health impacts, the guidelines assessed the certainty of the evidence that reducing high indoor temperatures would reduce morbidity and mortality as "low to very low". Although the evidence base is still not comprehensive, a variety of studies and large projects have allowed a corpus of knowledge to be built, with implications for health protection from heat.

### 5.2.1 The correlation between outdoor and indoor temperatures, and the risks of indoor overheating

While there is a general correlation between outdoor temperatures and indoor temperatures in buildings, this includes very wide variability, greatly influenced by the shape and materials of the building; its orientation, ventilation and shading; and the orientation of the apartments and apartment locations within the building, among others (Mavrogianni et al., 2010; White-Newsome et al., 2012; ZCH, 2015). Some evidence suggests that the relationship between indoor and outdoor temperature is linear at both moderate and high levels of heat (Smargiassi et al., 2008), and that this is especially true in naturally ventilated buildings (Kenny et al., 2019). On the other hand, a study of occupied urban houses in the United Kingdom during a heat-wave demonstrated that indoor temperatures can vary considerably across homes, as well as across rooms within homes, resulting in different peak temperatures and levels of discomfort (Wright, Young & Natarajan, 2005).

Temperatures also tend to increase with elevation (floor number) and proximity to the centre of the urban area (usually a proxy for less green space) (Lundgren-Kownacki et al., 2019). In the United Kingdom a recent study of the housing stock found bungalows and top-floor apartments to be most vulnerable to overheating, along with more modern airtight terraced dwellings (Taylor et al., 2016). It also found that – even without taking into account the urban heat island effect[1] – overheating vulnerability is likely to be higher in urban locations owing to the predominance of apartments and terraced buildings relative to rural areas. Day-to-day variations in outdoor temperatures also play an important role in the evolution of indoor temperatures (Smargiassi et al., 2008). Given the delay (sometimes called inertia) associated with heat storage inside a home, indoor temperature reflects the outdoor temperature during the preceding 24–72 hours much more than the actual (real-time) outdoor temperature (Wright, Young & Natarajan, 2005; Smargiassi et al., 2008).

The risks from indoor overheating result from an interaction between the susceptibility of a dwelling's occupants to heat, their behaviour (including occupancy patterns), the building's location and its characteristics (Bundle et al., 2018). In addition, the combination of time spent indoors and the proportion of time when dwellings experience

[1] An urban heat island happens when a city experiences temperatures that are significantly warmer than nearby rural areas. The phenomenon is explored in more detail in Chapter 8.

overheating are critical factors. A representative study in the United Kingdom found that, among homes that experienced overheating, 39% experienced it 1–4 days per week and 22% every day (BRE, 2013). This suggests fairly constant exposure to overheating during normal summer periods, rather than only during heat-waves. While behavioural factors and advice are covered elsewhere in this report, it is important to keep them in mind when discussing physical and built environment factors. Modifications of the broader urban environment for passive cooling are covered in Chapter 8.

Overheating has been observed even in recently built or refurbished homes in temperate climates (Dengel & Swainson, 2012; Tillson, Oreszczyn & Palmer, 2013; Ji et al., 2014; Morgan et al., 2017). For instance, meta-analytic data in the United Kingdom indicated that 57% of bedrooms and 75% of living rooms in low-energy modern houses are classified as overheated (McGill et al., 2017). Estimates in the United Kingdom suggested that more than 20% of households are affected by overheating (ZCH, 2015), highlighting that these dwellings are vulnerable during times of high heat. A review by Kolokotsa & Santamouris (2015) reported on various studies in the United Kingdom with similar findings, as well as on the results of the Large Analysis and Review of European Housing and Health Status study undertaken by WHO. In this 3373-house sample study in France, Germany, Greece, Hungary, Italy, Lithuania, Portugal, Slovakia and Switzerland, 9% of people reported that their house had a permanent heat-related problem during the summer period, while 13% declared that overheating may happen sometimes. A study of eight buildings in Berlin, Germany, during summer 2013 and 2014 found that indoor heat stress was experienced on 35% of all days (Walikewitz et al., 2018). Kownacki et al. (2019) concluded after a comprehensive review that the characteristics of most buildings in Scandinavia make them likely to experience a strong correlation between outdoor and indoor temperatures. Although mostly drawn from studies in the United States, evidence suggests a higher likelihood of dangerous exposure to heat in areas of lower income and low quality housing (Uejio et al., 2011; 2016; Roberts & Lay, 2013).

The temperature inside buildings rises particularly during heat-waves, when the outdoor temperature remains high for several days and the temperature during the night does not drop enough for buildings to cool down (Morgan et al., 2017). For instance, Sakka et al. (2012) investigated indoor thermal conditions in 50 low-income non-air-conditioned houses in Athens, Greece, during the extremely hot summer of 2007. They found that for almost 85% of the hot period, indoor temperature exceeded 30 °C, and that periods of about 216 continuous hours above 30 °C and six days above 33 °C were recorded in many buildings. Similarly, a study monitoring indoor temperature in homes around London during a heat-wave reported that 33% of bedrooms reached uncomfortable night-time temperatures of 26 °C or greater (Mavrogianni et al., 2010). These high indoor temperatures can continue for several days after the end of a heat-wave (Vant-Hull et al., 2018).

Longer and/or more intense heat events lead to greater increases in indoor temperatures, as well as prolonged duration of peak indoor temperature, and heat-waves occurring towards the end of the summer lead to exaggerated impacts in indoor temperature owing to the natural and progressive build-up of heat in the building over the period (Sakka et al., 2012). This is particularly true in homes lacking air-conditioning (AC), where indoor temperature can be much higher than outdoors (White-Newsome et al., 2012), leading to adverse health outcomes (Vant-Hull et al., 2018). For instance, a study assessing homes of people aged over 65 years in the United States showed that the maximum indoor temperature was 34.8 °C, reaching 35 °C in individual rooms, during a period when the peak outdoor temperature (measured at a nearby airport weather station) was 34.3 °C (White-Newsome et al., 2012).

Despite the acknowledged importance of indoor thermal data for prevention of the health impacts of heat, availability of such information is low globally – even more so when referring to real-time data (ZCH, 2015; Van Loenhout et al., 2016). Existing HHAPs throughout Europe therefore use outdoor environmental parameters to define heat-related health risks (Casanueva et al., 2019). Despite its limitations, the existing knowledge can be applied to heat–health action planning. For example, the German Meteorological Service extended the existing heat–health warning system with a thermal building simulation model to consider heat load indoors (Matzarakis, 2017). The model considers behavioural factors, building factors and weather to predict indoor overheating. While it is limited to the worst-case scenario for indoor conditions and estimated by air temperature only, it constitutes a useful example of practical considerations of indoor temperatures in an HHAP.

### 5.2.2 Indoor thermal comfort

An environment that is comfortable for one person may be too hot or cold for someone else. A number of factors can affect an individual's thermal comfort, including environmental conditions (such as air temperature, humidity, radiant temperature and air velocity) and personal factors (including health status, age, sex, level of acclimatization, hydration status and level of fatigue). For instance, people who live in hot and humid regions are more likely to tolerate these conditions than people who do not (Baccini et al., 2008). Compared to their younger counterparts, older adults are less sensitive to thermal stimuli and have a tendency to feel cooler during exposure to heat. As the body ages, changes in its thermoregulatory and cardiovascular function undermine its ability to dissipate heat when in a hot environment (Kenny et al., 2016). These differences are detectable in adults as young as 40 years old (Larose et al., 2013), and substantial differences become apparent in most individuals after their mid-50s (Flouris et al., 2017). Also, people's perception of and sensitivity to high temperature change with age (Flouris, 2011; Flouris & Schlader, 2015). Hence, older people may deem an environment to be thermally comfortable when, in fact, it may risk their health (Kenny et al., 2015; Flouris et al., 2017; Vellei et al., 2017). The thermal comfort needs of other vulnerable groups, such as children, chronically ill people, those taking certain medications and pregnant women (with elevated core body temperature) are also understudied and poorly understood. Their additional risks and vulnerabilities are explored further in Chapter 6.

The challenge for controlling indoor conditions, particularly during heat-waves, is also linked with the thermoregulatory function of vulnerable populations. Recent evidence from both Europe (Vellei et al., 2017) and the United States (White-Newsome et al., 2012) suggests that overheating occurs frequently in households with vulnerable occupants, even when protective measures (such as AC) are available. It also indicates that availability of an AC system does not appear to affect indoor temperature of homes with vulnerable occupants – one suggested explanation is inability to afford energy expenses. At the same time, vulnerable occupants in overheated households report feeling cooler than their non-vulnerable counterparts (Vellei et al., 2017). The reluctance of elderly people to use cooling measures such as AC may be caused by an age-related reduction in the ability to sense rising body heat (thermal sensation) (Flouris, 2011; Flouris & Schlader, 2015), which places them at high risk of heat-related injury or death as they are less likely to initiate behavioural actions for heat mitigation. This is particularly important because even small elevations above normal summer outdoor temperatures can raise indoor temperatures to levels that can adversely affect elderly people living in temperate climates.

Van Loenhout et al. (2016) found that living room and bedroom temperatures were associated with substantial increases in reported heat annoyance, thirst, sleep disturbance and excessive sweating in a sample of elderly residents in the Netherlands. These self-perceived symptoms increased further with rises in indoor temperature (33% increase in heat annoyance and 24% increase in sleep disturbance) than with similar rises in outdoor temperatures (13% and 11%, respectively), empirically backing the intuitive notion that indoor temperatures are important for reducing heat-related health impacts. Similar studies found a highly complex relationship between outdoor temperatures, indoor temperatures and heat perceptions – again heavily mediated by dwelling characteristics and behavioural adaptations, among other factors (Franck et al., 2013).

With these considerations in mind, Table 6 presents recommendations from various relevant organizations for indoor environmental conditions in homes. While the upper threshold for indoor temperature is typically set at or near 25 °C (95% confidence interval (CI): 24.5–26.3 °C), the lower threshold for indoor temperature was raised from 15 °C in the 1960s to 18 °C in the 1980s, and to ≥19 °C in the last 15 years, with an all-years average of 20 °C (95% CI: 17.7–22.1 °C). The limited recommendations for relative humidity suggest a lower average threshold of 35% (95% CI: 25.2–44.8%) and an upper average threshold of 62% (95% CI: 58.4–64.9%).

**Table 6. Recommendations for indoor temperature and relative humidity**

| Organization | Publication | Recommendation | Note |
|---|---|---|---|
| WHO | *The physiological basis for health standards for dwellings* (Gomorosov, 1968) | 15–25 °C | Based on energy expenditure being at the minimum and thermal sensitivity being at the maximum within this range |
| | *The effects of the indoor housing climate on the health of the elderly* (WHO Regional Office for Europe, 1984); *Health impact of low indoor temperatures* (WHO Regional Office for Europe, 1987); *Indoor environment: health aspects of air quality, thermal environment, light and noise* (WHO, 1990) | 18–24 °C | Based on minimal risk to the health of sedentary people (such as elderly people) in houses at this range |
| European Commission | *Energy performance of buildings: ventilation for buildings* (CEN, 2019). | 22–27 °C | Bedroom temperature during the summer |
| International Standardization Organization | *ISO 7730:2005 – Ergonomics of the thermal environment* (ISO, 2005) | 19–24.5 °C<br>40–60% | Based on typical levels of body activity and occupant clothing of 0.5 clo (clothing insulation units) in the summer and 1.0 clo in the winter |
| Passive House Institute | The passive house planning package (Passive House Institute, 2012) | ≤25 °C | Home considered overheated if the recommendation is exceeded for >10% of the year |
| Chartered Institution of Building Services Engineers | *Guide A: environmental design* (CIBSE, 2015) | 23–25 °C | Operative summer temperature for living spaces |
| | | >25 °C | Exposure for less than 5% of the occupied time |
| | | >28 °C | Exposure for less than 1% of the occupied time |

**Table 6 contd**

| Organization | Publication | Recommendation | Note |
|---|---|---|---|
| United Kingdom Department of Health | *Heating and ventilation of health sector buildings* (Department of Health, 2007) | 23–25 °C | Operative summer temperature for living spaces |
| | | >25 °C | Exposure for less than 5% of the occupied time |
| | | >28 °C | Exposure for less than 50 hours of occupied time |
| American Society of Heating, Refrigeration and Air-conditioning Engineers | *Standard 55-2017: thermal environmental conditions for human occupancy* (ANSI/ASHRAE, 2017) | 19.5–27.8 °C | Home indoor temperature |
| | *Standard 62.1-2016: ventilation for acceptable indoor air quality* (ANSI/ASHRAE, 2016) | ≤65% | Home indoor relative humidity |
| United States Environmental Protection Agency | *A brief guide to mold, moisture, and your home* (EPA, 2016) | 30–60% | Home indoor relative humidity |

## 5.3 Passive cooling at the building scale

Certain characteristics of a building or the dwellings therein can lead to overheating. Some of those (such as location) cannot be modified, or face significant barriers to modification. For example, significant modifications to a building envelope or insulation may be technically complex, expensive or simply unfeasible under building regulations. Others, like shading or shutters, can be achieved through minimal retrofitting, and could even be installed by dwellers.

The literature on engineering and architectural solutions for housing modifications against overheating accrued since the publication of the 2008 WHO guidance (Matthies et al., 2008) is extensive. Within it, the corpus of evidence on passive cooling solutions is also enormous, covering every technical aspect from construction to environmental sustainability and economic feasibility. A taxonomy of types of passive cooling interventions in buildings is provided by Chetan et al. (2020).

Analysing the physical effects of all passive cooling interventions on indoor temperatures is beyond the scope of this report, and comprehensive reviews are available in the engineering, architecture and urban management literature. This chapter therefore provides a succinct summary of operationally relevant evidence on selected strategies to modify such characteristics and their potential effects in reducing indoor heat exposure. Where available, evidence on health-protective effects is provided.

### 5.3.1 External shading and shutters

Shading can be a highly effective option for decreasing internal heat exposure, and it is often possible for occupants at the room level to install it. Shading can be implemented externally through overhangs or shutters, and internally through blinds or curtains. Use of shutters, blinds and curtains is effective in reducing overheating, and external shutters are more effective than internal ones, especially for south-facing living rooms (Porritt et al., 2012).

Hamdy et al. (2017) modelled the impact of climate change on the overheating risk in dwellings in the Netherlands, and concluded that correctly operated solar shading devices can significantly reduce overheating in all scenarios. A study in the United Kingdom (Taylor et al., 2018) estimated that external shutters may reduce heat-related mortality by 30–60%, depending on weather conditions, while shutters in conjunction with energy-efficient retrofitting may reduce risk by up to 52%. This protective effect against heat-related mortality during periods of high summer temperatures may, however, be limited under extreme temperatures. Moreover, the technology has the potential downside of decreasing the quality of natural day lighting. The authors suggest installing shutters in dwellings inhabited by the most heat-vulnerable populations (for example, in nursing homes) as a realistic option, and note that building regulations changes for energy efficiency should require retrofitting to be combined with shading or passive cooling strategies to reduce overheating risk. Technology and materials science are increasing the heat-protective potential of shutters. For example, phase change materials (see section 5.3.2) are already being tested in window shutters to reduce the solar heat gain (Alawadhi, 2012; Silva et al., 2015).

### 5.3.2 Insulation and reduction of internal heat load

Unlike shading, insulation cannot be assumed to protect against heat in most situations. In fact, while increased insulation can reduce overheating in well designed buildings, it can increase it in poorly designed ones (Pyrgou et al., 2017; Fosas et al., 2018). Porritt et al. (2012) modelled the effect of passive cooling interventions for typical United Kingdom dwellings in different orientations and occupancy profiles, using weather data from the 2003 heat-wave. The results showed that interventions on exposed wall surfaces, such as coating with solar reflective paint and external wall insulation, were very effective, as was controlling ventilation to prevent excess warm outside air entering the dwelling during the hottest parts of the day. Internal wall insulation was less effective, however, even producing an increase in overheating for some scenarios, although it could function and even reduce energy costs when adequately combined with other interventions. Moreover, evidence is increasing that passive houses (a voluntary standard of super-high energy-efficient housing) and other super-insulated dwellings are already at risk of overheating in northern latitudes in Europe. The recently reviewed relevant literature (Morgan et al., 2017) showed such instances of overheating in Denmark, Estonia, Sweden and the United Kingdom (both south and north, in Scotland).

A promising set of technologies for the reduction of heat load are based on the application of phase change materials to buildings. These can change their status (for example, from solid to liquid), absorbing or releasing heat in the process. Incorporated into walls, floors and ceilings they can be used to improve thermal comfort indoors while reducing energy consumption, and specifically for cooling purposes (da Cunha & de Aguiar, 2020).

Another intervention is reducing the heat contribution of appliances and heat sources within buildings, which is substantial within the WHO European Region (Elsland, Peksen & Wietschel, 2014). This is a greater problem in workplaces and offices, where the presence and use of appliances (particularly lighting) and information technology equipment is typically heavier. Moreover, since these non-domestic buildings tend to be air-conditioned, their cooling loads have a highly significant effect on the energy use of urban areas, even causing blackouts during heat-waves (Jenkins, 2009).

### 5.3.3 Green roofs and walls

Very few studies have looked at the health risk reduction potential associated with heat reduction from green roofs or facades. A complete review of various technologies (Buchin et al., 2016) assessed the indoor heat reduction potential of non-irrigated green roofs and facades as low. Irrigation makes a great difference in the heat mitigation performance of the green roofs by increasing evapotranspiration. Non-irrigated green roofs provide less overall protection than cool roofs combined with insulation (Coutts et al., 2013), and they require much more maintenance.

As with other technologies, however, performance can vary widely with different designs and quality of buildings (Macintyre & Heaviside, 2019). Kolokotsa, Santamouris & Zerefos (2013) examined various configurations of green and cool roofs under the prevalent climatic conditions in London and Crete, and found that both could contribute considerably to improvement of the urban environment while simultaneously decreasing energy demand. In addition, green roofs may have other health benefits related to the mitigation of air pollution (Rowe, 2011), noise reduction (Van Renterghem & Botteldooren, 2009) and well-being/psychological benefits (Lee et al., 2015; Nurmi et al., 2016; Cinderby & Bagwell, 2018). Conversely, the choice of plants strongly determines their long-term viability, as well as potential health disbenefits such as increased allergenic pollen exposure.

### 5.3.4 Overall potential of housing modifications against overheating

The literature shows that generalizations about housing modifications to prevent overheating are challenging. There is no one-size-fits-all solution, though some patterns are clear from the last 12 years of published evidence. In general, preventing heat gains is much more efficient than dissipating heat into the environment. In most cases, rather than single interventions, the optimum can be achieved through combinations of interventions for specific settings; these must be designed to take into account not only the dwelling construction details but also the type of occupants and their corresponding occupancy profiles. From the perspective of HHAPs, it is more realistic to promote passive cooling options that can be undertaken by room occupants at no or low cost, such as shading. Adequate ventilation, also an important passive cooling strategy, is explored in section 5.3.5.

Traditional (often called “vernacular”) architectural solutions for cooling may hold potential for health protection, although the need for more research is clear. In a case study of the potential of vernacular architecture for passive cooling in Évora, Portugal, researchers found differences of up to 16 °C between indoor temperatures and peak outdoor temperatures, illustrating the potential of such approaches (in this case, high thermal inertia, use of light colours and courtyards) to decrease the energy consumption required by active cooling (Fernandes et al., 2015). A recent case study of traditionally built dwellings in downtown Seville, Spain, found that they could not guarantee thermal comfort conditions without mechanical cooling, however, although the study also found that adequate shading and ventilation could greatly reduce the need for AC in the dwellings (Caro & Sendra, 2020).

The progressive accumulation of evidence and knowledge in this area is setting the basis for a much deeper discussion among researchers and practitioners about the roles of building insulation, building envelopes, building design, ventilation possibilities and shading in general, given the key role these factors play in thermal comfort and heat stress (Loughnan, Carroll & Tapper, 2015; Hatvani-Kovacs et al., 2018, Park et al., 2020). Factors like the degree of home maintenance and housing material quality have been shown to play a crucial role in modulating the effects of heat-waves (López-Bueno, Díaz & Linares, 2019), and should also be part of the discussion.

A range of regulatory and other barriers (for instance, lack of specialized technical knowledge and/or standard operating procedures for inspection against overheating risks) may constrain effective action on preventing building overheating as a public health risk, however (Environmental Audit Committee, 2018). A recent study noted that building policies and regulations have largely focused on sustainability or energy efficiency of buildings without sufficient consideration of health impacts, leading to unintended health consequences and a lack of resilience of the housing stock resilient to future climate change (Carmichael et al., 2020). While much knowledge has been gained about this area in the last decade, empirical evidence of the role these factors play in thermal comfort and heat stress for vulnerable groups is still scarce.

### 5.3.5 Natural ventilation

Natural ventilation refers to supplying air to and removing air from homes without using mechanical systems. It is a very effective passive cooling strategy – especially for the warmer climates of southern Europe – that can reduce buildings' cooling requirements and improve the thermal comfort of occupants (Schulze & Eicker, 2013). As the flow of external air to an indoor space is driven by environmental pressure differences, natural ventilation in buildings can be achieved by wind-driven and/or buoyancy-driven ventilation. Wind-driven natural ventilation is achieved by forming openings on the perimeter, which permit airflow (caused by differences in pressure created by wind) to pass through the building. Buoyancy-driven natural ventilation is achieved by temperature differences between the interior and exterior of the building, causing directional buoyancy force.

Despite its vast potential for improving thermal comfort and reducing heat-related mortality without the disadvantages of mechanically-driven cooling technologies, natural ventilation can be complex and challenging. A recent study in Germany simulated various natural ventilation strategies and showed that opening the windows when the outside temperature is lower than the inside temperature is the ideal natural ventilation solution and can achieve a comfortable indoor climate (Rosenfelder et al., 2016). The same study reported, however, that natural ventilation strategies should be selected based on practicality and occupant characteristics and lifestyle, and noted that in Germany they can sometimes lead to days with cold stress even in summer months.

The total daily duration of natural ventilation is important for keeping the internal home temperature at a comfortable level. Further, natural ventilation is inappropriate for short-term cooling (such as when a building is occupied only for a few hours in the middle of the day) because the building mass must be cooled when the outside air temperature is still relatively low (Rosenfelder et al., 2016). Another challenge of natural ventilation relates to the complex and turbulent flows inside and around buildings, which can diminish effective ventilation rates, particularly in urban areas (Omrani et al., 2017). Finally, natural ventilation is influenced by a number of other parameters, including facade design (such as window size/shape/location and window opening type/angle), occupant characteristics and the indoor and outdoor environment (for example, indoor air quality, placement of furniture, outside air quality and noise) (Roetzel et al., 2010). With the caveats of the particularities of the locale, buildings and other factors, the best timing for natural ventilation is generally found to be in the morning and during the night (Schulze & Eicker, 2013). For purposes of thermal comfort,[2] daytime ventilation is suitable only when indoor comfort can be experienced at outdoor air temperature. Night-time ventilation is especially suitable for situations when daytime ventilation is not possible (as when outside temperatures are too hot) and it works best when night-time temperatures are substantially lower than daytime temperatures (Guedes, 2013).

[2] Natural ventilation is also important for indoor air quality.

## 5.4 Access to cooling technologies, services and spaces

While the conversation about cooling has traditionally tended to focus on the use of built-in or portable AC devices, the technical literature is increasingly considering cooling as a service that can be obtained through various means, including on- and offsite services, and different categories of products.

### 5.4.1 Electric fans and personal cooling systems

Using electric fans against the heat has been widespread practice at both the individual and institutional levels for a long time, but whether it does more good or harm overall is still uncertain. Generally, fans have been found to fit best in hot and dry environments if the air temperature is not much above 40 °C (Jay et al., 2015). A Cochrane review (Gupta et al., 2012) concluded that the current evidence does not resolve uncertainties about the health effects of electric fans during heat-waves. People making decisions about electric fans should therefore consider the current state of the evidence base and local policy or guidelines when deciding whether or not to use or supply them.

Another technological set of possibilities is “personal cooling systems” – a wide range of devices and systems that are receiving increasing attention in research, with recognition of their ability to improve some degree of thermal comfort in a cost-effective way. These may include shade structures, water-based cooling, smart textiles, ventilated clothing, personal ventilation, personal humidifiers, fans, AC and cooling clothes using air or liquids (Lundgren-Kownacki et al., 2019). Several studies have evaluated the most effective body segments for localized cooling to promote thermal comfort and sleep (Wang et al., 2017; Lan et al., 2018).

Evaporative cooling has a positive cooling effect, especially in dry conditions, although its effectiveness is highly dependent on the outdoor climate and it can cause problems related to mould. In general, it has been considered a moderately effective strategy for heat exposure reduction, with the advantage that it does not require any special installation (Buchin et al., 2016). Most studies evaluating personal cooling systems, however, have so far focused on laboratory experiments or workplace settings, or even emergency response situations. These are not representative of the bulk of population groups vulnerable to heat, which generally have a different and not well studied sensitivity to heat and thermal comfort. To illustrate how poorly understood the differences are, a comprehensive systematic literature review focusing on the differences in temperature of thermal comfort between younger adults and older people (Baquero Larriva & Higueras García, 2019) found a wide range of estimates, from 0.2 °C to 4 °C. This highlights the heterogeneity of studies and the need for further research before considering a selection of cooling options for elderly people. There is therefore a need for further research on the health-protective potential of these devices for use at home and/or by vulnerable groups.

### 5.4.2 The role of AC: health-protective effects

Despite its drawbacks (see section 5.4.3), AC remains a crucial technology for protecting vulnerable groups from high temperatures, as well as for refrigerating essential medicines and other health-protecting technologies (such as technology-based health information systems). Centralized or decentralized, in institutions, cooling centres and homes, AC may de facto be providing a significant proportion of the protection from overheating in the built environment across Europe. Buchin et al. (2016) rate AC as the most effective strategy for indoor hazard reduction potential, and several studies have found that for buildings without AC –

the norm in most of central and northern Europe – there is a strong correlation between the outdoor and indoor temperature (Lundgren-Kownacki et al., 2019).

Although no robust estimates have been made of how much AC has reduced heat-related mortality, it can reasonably be assumed to have played a role in the overall decreasing trend of heat-related mortality in recent years in Europe. Several EU countries made AC mandatory in various types of institution, including nursing homes, in the aftermath of the 2003 heat-waves (Klenk, Becker & Rapp, 2010). The Lancet Countdown on health and climate change (Watts et al., 2018) estimated that global AC use in 2016 may have reduced heat-wave-related mortality by 23% compared to a complete absence of AC. There are several caveats to that estimate, however, including the current validity and representativeness of the evidence used for calculation of the relative risk (Bouchama et al., 2007). Even accounting for such caveats, insufficient discussion is taking place on access to and use of AC to afford significant protection from heat-related health effects. How that AC is accessed and used is an important related conversation, framed within its drawbacks and possible solutions.

One way to provide access to AC during episodes of extreme heat is to provide cooling rooms or centres (publicly accessible air-conditioned spaces). Although the use of air-conditioned public facilities as cooling centres is assumed to be relatively widespread in Europe, no significant body of scientific evidence on the matter exists. Moreover, most of the published literature focuses on urban settings in the United States.

There are serious concerns about the accessibility of such spaces for vulnerable populations. Transportation is typically considered to be a barrier for those trying to go to cooler places (Sampson et al., 2013; White-Newsome et al., 2014). Relatively compact urban settings in Europe probably mean that distances to the nearest cooling centre may be less of an issue than in the United States – the average distance in New York State was over 3 km (Nayak et al., 2019). Nevertheless, even average walking distance (typically under 1 km) can be simply unfeasible without aid or transportation for those with impaired mobility, for whom maximum walking distances without a rest are often recommended not to exceed around 100 m (O'Flaherty, 2018). Additional concerns include the availability of staff or volunteers to run these spaces; the extent to which such spaces are welcoming of homeless people or people with a mental illness; and the threat that concentrating people in a single place raises the chance of severe risks if electricity or transport networks fail (Bolitho & Miller, 2017).

Cooling centres are typically part of locally deployed heat–health strategies, along with extended opening hours for swimming pools, parks and homeless shelters; ensuring water to public fountains; and misting machines, among others. Data on the scale of deployment of such cooling spots are difficult to compile nationally or supranationally, but specific local level examples abound. During the heat-waves of summer 2019, Paris city authorities identified 922 cool islands, including 218 accessible at night, which could be found in real time through a mobile phone application called EXTREMA (Ville de Paris, 2019). The use of shopping malls as either officially sanctioned or de facto public cooling centres is not well documented in the scientific literature in Europe, though examples exist in the United States and Japan. Some evidence exists that the deployment of cooling centres reduced heat-related mortality in the United States (Eisenman et al., 2016), but more research is needed on whether and how these cooling efforts provide actual risk reduction.

### 5.4.3. The drawbacks of AC from a public health perspective

This section details a number of drawbacks to AC, including the risks of inequitable access and energy poverty, societal and individual dependency leading to loss of resilience, increased energy consumption and blackouts, waste heat, local air pollution and greenhouse gas emissions.

Ensuring access to AC in an equitable and effective way for those who may need it most is one of the main pitfalls of this technology, at least from a public health standpoint. Those most vulnerable to heat tend to concentrate within the urban core, in housing that is on average more conducive to overheating. At the same time, they are often less able to afford the costs of AC (purchase, installation, maintenance and running costs). This results in deep income-related inequalities in being able to afford the protective effect of AC against heat (Ito, Lane & Olson, 2018). The running costs of AC may become unaffordable even for households who may have been able to afford the equipment and installation, representing an additional type of fuel poverty to that of unaffordability of heating. There is some indication that those at high risk from heat who have AC at home do not use it systematically during hot spells (Lane et al., 2014).

Summertime energy poverty is an overlooked and poorly understood phenomenon, including in Europe. No region-wide information is currently collected on whether dwellings are equipped with AC facilities or whether they are comfortably cool during summer, although it used to be collected. In data from 2012, people in all EU countries reported difficulties in maintaining comfortable levels of cooling during summer, with wide variation from a low of 3.3% of the population in the United Kingdom to a high of 49.5% of the population in Bulgaria (Thomson et al., 2019). The definition of energy-poor and/or vulnerable households is essential for policy targeting and should be tailored to the local context, in terms of income, climate, housing quality and the structure of energy costs. Country-specific data for the EU are set out in Table 7.

People on low incomes had less comfortably cool homes in 26 of the 28 EU countries across 2007 and 2012, and a substantially lower proportion of homes with AC in 27 countries. As electricity prices (excluding taxes and adjusted for inflation) continue to rise in the EU (Eurostat, 2020b), summertime energy poverty may be further aggravated.

Inequalities may even occur within households (with elderly or chronically ill people overexposed) or in a gender-biased manner, with women in some cases spending more time at home and/or engaged in activities that increase heat exposure, such as cooking (Lundgren-Kownacki et al., 2018). Despite the falling relative prices of AC (as with any other developed technology), there are no solid grounds to believe that affordability of use may improve for vulnerable populations. Further, the poorer segments of society may be less likely to work in air-conditioned places, thus not attaining the workplace protection from heat that others may get.

Another drawback of increasing use of AC for protection from heat is the loss of ability to manage high temperatures without it, at both the individual and societal levels. There is some indication (more evidence is needed) that spending a majority of time in air-conditioned environments may impair people's natural heat acclimatization, and that re-acclimatization may depend on the time unexposed, to some extent (Ashley, Ferron & Bernard, 2015). Moreover, such AC dependency may also become psychological (Santamouris, 2012), leading to systematic over-cooling (Brager, Zhang & Arens, 2015).

At the societal level, building cities dependent on AC for their cooling may leave residents unprotected during grid overloads and blackouts, which are in turn more likely with increasing cooling energy demands. Without regulatory provision, there may be little incentive for promoters to build in a less AC-dependent manner. Traditional urban forms and building designs for dealing with heat – as well as traditional knowledge about dealing with hot conditions – may be lost, thereby reducing resilience to unforeseen eventualities (such as blackouts) during heat-waves.

Extreme weather – including heat-waves – increases unpredictability for power generation

**Table 7. Proportions of population for AC and comfortably cool indicators**

| Country or region | Whole population with AC (2007) | Income-poor population with AC (2007) | Dwelling not comfortably cool during summer | | | |
|---|---|---|---|---|---|---|
| | | | Whole population (2007) | Income-poor population (2007) | Whole population (2012) | Income-poor population (2012) |
| EU average | 10.8 | 8.2 | 25.8 | 31.3 | 19.2 | 26.3 |
| Austria | 1.5 | 0.8 | 18.1 | 25.7 | 15.0 | 22.3 |
| Belgium | 3.1 | 1.0 | 14.3 | 21.9 | 12.7 | 21.0 |
| Bulgaria | 8.4 | 1.1 | – | – | 49.5 | 70.7 |
| Croatia | – | – | – | – | 24.2 | 32.0 |
| Cyprus | 77.1 | 52.5 | 40.9 | 47.3 | 29.6 | 34.4 |
| Czechia | 0.9 | 0.1 | 39.1 | 44.4 | 21.8 | 27.6 |
| Denmark | 5.7 | 4.0 | 17.7 | 22.4 | 11.6 | 11.9 |
| Estonia | 1.9 | 0.6 | 23.3 | 22.8 | 23.3 | 26.3 |
| Finland | 19.2 | 9.9 | 20.3 | 20.3 | 25.2 | 27.8 |
| France | 5.2 | 4.2 | 29.0 | 30.6 | 18.9 | 24.8 |
| Germany | 1.8 | 0.7 | 22.7 | 30.0 | 13.6 | 21.4 |
| Greece | 52.8 | 33.3 | 29.4 | 37.3 | 34.0 | 48.9 |
| Hungary | 4.5 | 1.5 | 28.5 | 27.6 | 25.8 | 32.8 |
| Ireland | 0.4 | 0.2 | 7.8 | 9.9 | 4.0 | 4.4 |
| Italy | 25.1 | 15.1 | 33.4 | 43.8 | 26.3 | 37.9 |
| Latvia | 1.8 | 1.4 | 39.4 | 46.0 | 29.9 | 31.7 |
| Lithuania | 2.1 | 0.7 | 33.1 | 22.8 | 24.6 | 21.4 |
| Luxembourg | 5.2 | 0.9 | 17.9 | 30.9 | 10.2 | 14.1 |
| Malta | 55.7 | 42.2 | 16.0 | 20.1 | 35.4 | 40.1 |
| Netherlands | 6.4 | 3.2 | 18.2 | 24.5 | 17.7 | 22.9 |
| Poland | 0.9 | 0.5 | 41.2 | 47.1 | 25.3 | 28.2 |
| Portugal | 7.2 | 2.6 | 42.4 | 51.2 | 35.7 | 41.4 |
| Romania | 5.3 | 0.6 | – | – | 22.6 | 21.5 |
| Slovakia | 1.0 | 1.8 | 37.5 | 39.1 | 21.0 | 23.4 |
| Slovenia | 12.0 | 5.9 | 21.0 | 25.1 | 17.3 | 21.4 |
| Spain | 38.2 | 32.7 | 25.9 | 31.2 | 25.6 | 33.1 |
| Sweden | 15.2 | 14.3 | 11.1 | 12.5 | 7.6 | 9.9 |
| United Kingdom | 1.9 | 1.8 | 10.8 | 11.4 | 3.3 | 4.3 |

*Source:* Eurostat (2012).

and consumption, affecting operations, price volatility and ultimately energy security, including for vulnerable groups (Añel et al., 2017). On hot days in locations where AC is highly prevalent, cooling can use more than half of peak electricity demand (Waite et al., 2017). Thus, increased electricity demand from AC can lead to blackouts, in turn increasing the risk of overheating, in a vicious circle. Moreover, electricity companies may respond by upgrading infrastructure, creating a risk of rising energy costs, thus making it increasingly unaffordable for vulnerable groups.

Beside the risk of blackouts and the associated lack of cooling services and increased heat exposure, increased energy use during heat-waves is known to increase tropospheric ozone, furthering health impacts (Añel, 2016). The predicted effect of climate change on energy consumption is mixed, however. Increased demand of energy for cooling will be somewhat compensated in the WHO European Region by decreased demand for heating. Eskeland & Mideksa (2010) predicted that in countries like Cyprus, Greece, Italy, Malta, Spain and Turkey the net effect of increased cooling will outweigh decreased heating consumption, whereas in most of the EU the opposite is projected.

A further drawback is that most AC devices produce waste heat while cooling indoor air. This is typically expelled to areas surrounding the building, and can significantly affect the microclimate in those areas, as well as more widely in urban settings. The effects of AC waste heat are particularly evident during night-time, when they exacerbate the nocturnal urban heat island effect and increase cooling demands (Salamanca et al., 2014). For a city like Paris, for instance, increases range from 0.5 °C currently to potentially 2 °C under a doubling of AC use in the city (de Munck et al., 2013). AC heat waste is also estimated to be contributing to London's urban heat island (Iamarino, Beevers & Grimmond, 2012; Bohnenstengel et al., 2014). Under some scenarios, and driven by current trends in energy demand, anthropogenic heat flux could increase by 10–12% in Europe (Lindberg et al., 2013).

The relationship of AC with air pollution and its health effects is complex, with two main causal pathways in opposite directions. On one hand, there is evidence that the use of AC could lower the short-term effects of PM smaller than about 2.5 μm in diameter ($PM_{2.5}$) by reducing the penetration of outdoor pollutants into homes, compared with homes using open windows for cooling (Bell et al., 2009). On the other hand, AC use in combination with reduced ventilation and/or inadequate maintenance can increase indoor air pollution (Lundgren-Kownacki et al., 2019). In 2016 AC accounted for 10% of global electricity consumption and 18.5% of electricity used in buildings. The number of premature deaths due to $PM_{2.5}$ exposure attributable to AC was 1088 in the EU and 749 in the USA (Watts et al., 2019).

AC also produces a significant amount of greenhouse gas emissions, contributing to global warming in two ways. Many AC devices use hydrofluorocarbons, a type of chemical which, when leaked to the atmosphere, traps several times more heat than $CO_2$. In a "business as usual" scenario, these emissions may amount to 1–2 gigatons of $CO_2$ equivalent per year by 2050, resulting in a large climate warming potential (Velders et al., 2015; Purohit & Höglund-Isaksson, 2017).

Moreover, AC often runs on electricity generated by burning fossil fuels, which releases both local air pollutants (such as $PM_{2.5}$ and nitrogen dioxide) and carbon dioxide ($CO_2$) into the atmosphere. $CO_2$ emissions from AC use tripled from 1990 to 2016, and the International Energy Agency calculates that the share of cooling in total $CO_2$ emissions of the power sector worldwide could double from 8% in 2016 to 15% in 2050, even accounting for more efficient AC devices (IEA, 2018). AC devices sold in the EU, for example, are on average more efficient than those sold in the United States or China (the main consumers of AC worldwide). Despite its global warming potential, AC sales and use are increasing rapidly. At current growth rates, 1 billion AC units could be installed globally in the next decade (IEA, 2018). The use of energy for space cooling more than tripled between 1990 and 2016, and is growing faster than for any other end use in buildings. The rising responsibility of AC in global warming represents yet another vicious circle in this technology: as temperatures rise, more AC use will further exacerbate warming rates.

Being a protective mechanism against heat exposures aggravated by climate change, AC can be categorized as an adaptation strategy. It is generally a kind of autonomous (not institutionally planned or directed) kind of adaptation, mainly undertaken and paid for by individuals and families. At the societal level, however, it is also a clear example of potential maladaptation (actions that could result in increased vulnerability or risk from climate change, now or in the future). Without a change of incentives, climatic and socioeconomic factors would usually work in favour of AC rather than other more sustainable and safer solutions, such as thermal insulation (De Cian et al., 2019).

The prospect that AC may de facto become the main means of protection from heat is highly worrying from the perspective of adaptation to climate change. Its various drawbacks, combined with the fact that it is more often than not unavailable to the very groups that it should protect, make it a clear case of potential maladaptation (Farbotko & Waitt, 2011). In general, there are solid arguments for steering away from AC as a main pillar of HHAPs beyond ensuring protection for vulnerable groups.

### 5.4.4 A nuanced policy approach towards AC

Despite the clarity and importance of the drawbacks set out above, public health authorities have a responsibility to acknowledge that current heat-related mortality can be prevented, and that AC can contribute significantly to that prevention. This discussion must be intrinsically related to the existing inequalities in access to cooling, with wasteful and inefficient AC being the norm rather than the exception. Ito, Lane & Olson (2018) propose various interventions to increase access to AC for those who need it most, including

- facilitating access to, financing of and knowledge about AC for vulnerable populations;
- addressing energy insecurity, including during summer;
- identifying particularly vulnerable individuals for whom AC amounts to life-saving medical equipment;
- addressing inequities in cooling use, discouraging demonstrably excessive AC use in public spaces and work settings, with thermostats and other regulating devices.

If, as it seems, AC growth is likely to continue unabated, a nuanced policy approach may be useful. AC does not necessarily need to be carbon-intensive: AC alternatives with lower greenhouse gas emissions include district cooling and solar-powered AC. If the share of electricity produced through renewable means increases, the carbon intensity of AC will decrease. And increasingly stringent energy efficiency standards will also contribute, as will the progressive substitution of hydrofluorocarbons by other chemicals, as promoted by the global Kigali Amendment to the Montreal Protocol. In such a context, the goal would be to ensure the protective benefits for vulnerable groups of increasingly sustainable AC systems, while promoting increasingly sustainable AC technologies. Moreover, stated plans by several countries to improve building codes in the context of their Nationally Determined Contributions under the Paris Agreement would have multiple benefits in addition to heat risk reduction, including reducing $CO_2$ and local pollution emissions, decreasing energy poverty and improving energy security (Davide, De Cian & Bernigaud, 2018).

## 5.5 Conclusions

HHAPs throughout the WHO European Region would benefit from a stronger evidence-based consideration of the factors affecting indoor overheating and possible interventions to address them. Better understanding of the thermal comfort needs of those vulnerable to heat, as well as of the actual correlation between outdoor and indoor temperatures and modulators thereof, is therefore needed. HHAPs include some early examples of modelling and consideration of indoor temperatures, and their transferability should be studied. A wide range of effective passive cooling interventions can afford health protection from heat and should be prioritized on account of their additional benefits for minimizing energy consumption and greenhouse gas emissions.

In addition, ensuring adequate access to indoor cooling is crucial to protect those most vulnerable to heat; yet deep inequalities remain. Addressing those inequalities requires consideration of cooling as a health-protective service and of summertime energy poverty. Given the current increasing trend of residential AC, it must be ensured that those most vulnerable to heat can access the preventive benefits of AC, while minimizing the societal and environmental drawbacks of the technology throughout its life-cycle.

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# Chapter 6. Care for vulnerable population groups: updated evidence on risk factors and vulnerability

## Summary

In the last decade, the quantity of literature on factors affecting vulnerability to heat has greatly increased. It is well established that elderly people are most at risk to extreme heat; other vulnerable groups at greater risk include people with chronic conditions (such as cardiorespiratory diseases, endocrine system disorders, mental health disorders, metabolic disorders and kidney disorders), pregnant women, small children, workers, people living in urban settings in socially and economically deprived environments, migrants and travellers.

HHAPs should identify subgroups at risk, provide tailored advice, implement specific prevention measures and actively monitor those most at risk during heat-waves. To date, most national HHAPs mention vulnerable groups but do not contain actions addressed to them. More effort should be put into raising awareness and promoting active response measures and training of health and social care professionals. Monitoring and evaluation of these measures is also important to assess their effectiveness.

## Key messages

- Evidence on who is most at risk during heat-waves has become more consistent.
- Vulnerable subgroups and their needs change over time and need ongoing monitoring and study.
- Public health prevention and response measures tailored to vulnerable groups need to be promoted – especially active response measures and proactive outreach for vulnerable individuals and their care givers by health and social services when warnings are issued during extreme events.
- Advice for vulnerable individuals should be improved, and health and social care training enhanced to improve awareness of risks and response.
- Actions targeted at vulnerable subgroups should be monitored and evaluated.

## 6.1 Introduction

The main objective of an HHAP in all its operational components is to reduce the health impacts of extreme heat. It is therefore of particular importance to focus on those population subgroups that are most vulnerable to heat as a result of pre-existing health, sociodemographic and environmental conditions. The WHO Regional Office for Europe's guidance on heat–health action planning acknowledged the importance of identifying and localizing vulnerable population subgroups (Matthies et al., 2008), defining this as a core element of HHAPs. Specific information and advice should be issued to these groups to improve awareness of the health risks and help protect them during heat-waves. Health and social services should focus efforts and resources on them, with specific response measures aimed at reducing health impacts.

Initially, the focus was mainly on elderly people, as the literature showing a greater risk of dying during heat-waves among this group was more robust, followed by subjects with chronic conditions (Kovats & Hajat, 2008; Basu, 2009). WHO's 2011 public health advice revised and updated individual (demographic, socioeconomic and health conditions) and environmental risk factors to identify better those most at risk and improve response measures addressed to them (WHO Regional Office for Europe, 2011). In the last decade the scientific literature addressing heat vulnerability factors and estimating the health risks among specific population subgroups has increased exponentially, confirming previous findings and shedding light on new subgroups at risk and potential response measures to protect them (Linares et al., 2020).

Both WHO publications stressed the need for an enhanced and more proactive approach in terms of both awareness-raising and response measures with reference to vulnerable groups. Active surveillance by health and social care services is still lacking and should be promoted at all levels. The 2008 WHO guidance provided examples of vulnerable group selection and identification through registry data and notifications by GPs and health services and gave general recommendations for GPs and retirement and care home medical staff (Matthies et al., 2008). The updated advice set out more exhaustive information on the health risks associated with heat for the different vulnerable groups (WHO Regional Office for Europe, 2011). Examples of specific health measures and practices or actions were not provided, however. To date, formal assessments of actions carried out, along with the coverage and an evaluation of these measures, are limited. This process would be useful not only to provide evidence of what is being done but also to identify best practices and ensure that resources are allocated in an efficient manner.

## 6.2 Heat vulnerability, vulnerable groups and risk factors

Specific vulnerability factors are able to confer a greater risk of dying due to exposure to extreme heat. These may be related to individual (age, gender, health status) or context characteristics, such as social and economic conditions and the environment (including climate, living environment of urban versus rural setting, level of air pollution, green areas, presence of AC and building structure). Vulnerability to heat varies geographically, based on these characteristics, but some common factors confer a greater vulnerability on individuals (Table 8).

**Table 8. Summary of evidence on vulnerable subgroups**

| Subgroup | Relevant studies and factors |
|---|---|
| Elderly people | • Biological mechanisms: Kenny et al. (2010); Stapleton et al. (2014); Flouris et al. (2017)<br>• Epidemiological studies/reviews: Kovats & Hajat (2008); Basu (2009); Bunker et al. (2016); Mayrhuber et al. (2018)<br>• Parkinson's disease and dementia: Linares et al. (2016); Wei et al. (2019) |
| People with cardiovascular disease | • Biological mechanisms: Liu, Yavar & Sun (2015)<br>• Epidemiological studies/reviews of:<br>  • effects of heat on cardiovascular health: Bhaskaran, Hajat & Smeeth (2011); Gasparrini et al. (2012); Yu et al. (2012); Sun et al. (2016); Cheng et al. (2019)<br>  • ischaemic stroke and heat metanalysis: Lian et al. (2015); Wang et al. (2016)<br>  • acute myocardial infarction and heat: Bhaskaran et al. (2009); Bhaskaran, Hajat & Smeeth (2011); Goggins, Woo et al. (2012); Breitner et al. (2014); Kwon et al. (2015) |
| People with respiratory disease | • Biological mechanisms: Kenny et al. (2010); McCormack et al. (2016)<br>• Epidemiological studies/reviews of:<br>  • respiratory mortality: Benmarhnia et al. (2015); Cheng et al. (2019)<br>  • respiratory morbidity: Turner et al. (2012); Anderson et al. (2013); Zhao et al. (2019)<br>  • Chronic obstructive pulmonary disease (COPD) and asthma: McCormack et al. (2016); Zhao et al. (2019) |
| People with mental health disorders | • Biological mechanisms: Stöllberger, Lutz & Finsterer (2009); Thompson et al. (2018)<br>• Epidemiological studies/reviews: Hansen et al. (2008); Page et al. (2012); Thompson et al. (2018)<br>• Increases in ER visits: Wang et al. (2014); Thompson et al. (2018); Basu et al. (2018); Min et al. (2019)<br>• Medication during heat: Martin-Latry et al. (2007); Stöllberger, Lutz & Finsterer (2009); Min et al. (2019) |
| People with diabetes | • Biological mechanisms: Yardley et al. (2013); McGinn et al. (2015); Carrillo et al. (2016); Kenny, Sigal & McGinn (2016); Notley et al. (2019)<br>• Epidemiological studies/reviews: Yardley et al. (2013); Zanobetti et al. (2014) |
| Children | • Epidemiological studies/reviews: Sheffield & Landrigan (2011); Williams et al. (2012); Xu, Etzel et al. (2012); Xu, Sheffield et al. (2012); Xu et al. (2014); Iñiguez et al. (2016); Lam et al. (2016); Stanberry, Thomson & James (2018)<br>• Asthma: Z Xu et al. (2013); Li et al. (2014); Xu et al. (2014)<br>• Bacteria-related gastroenteritis: Xu, Sheffield et al. (2012); Xu et al. (2014); Carlton et al. (2016); Iñiguez et al. (2016) |
| Pregnant women | • Biological mechanisms: Strand, Barnett & Tong (2011); Carolan-Olah & Frankowska (2014); Zhang, Yu & Wang (2017)<br>• Epidemiological studies/reviews: Dadvand et al. (2011); Kloog et al. (2012); Strand, Barnett & Tong (2012); Schifano, Cappai et al., (2013); Vicedo-Cabrera et al. (2014); Vicedo-Cabrera, Olsson & Forsberg (2015); Schifano et al. (2016); Cox et al. (2016); Basu et al. (2017); Ha et al. (2017); He et al. (2017); Khan et al. (2017); Zhang, Yu & Wang (2017); Guo et al. (2018); Asta et al. (2019); Son et al. (2019); Song et al. (2019); Sun et al. (2019); Gronlund et al. (2020); Ilango et al. (2020) |
| Workers | • Biological mechanisms: Jay & Brotherhood (2016); Meade et al. (2016); Ioannou et al. (2017); Quiller et al. (2017); Kenny (2019); Notley, Flouris & Kenny (2019)<br>• Epidemiological studies/reviews: Ioannou et al. (2017); Quiller et al. (2017); Flouris et al. (2018); Marinaccio et al. (2019); Messeri et al. (2019); Schifano et al. (2019) |

Further, the COVID-19 pandemic may augment the health risks from heat among these vulnerable groups (Box 7), as several of the risk factors for severe COVID-19 overlap with key heat risk factors (Wang et al., 2020; CDC, 2020; Singh et al., 2020; Bukhari & Jameel, 2020).

## Box 7. Heat and COVID-19: vulnerable groups

People vulnerable to both COVID-19 and heat include:

- elderly people – especially those who are very old and those with multiple chronic conditions (Armitage et al., 2020; Bunker et al., 2016; Shahid et al., 2020; Wang et al., 2020) or living in nursing homes or residential care facilities without cooling or adequate ventilation (Klenk, Becker & Rapp, 2010; Nanda, Vura & Gravenstein, 2020);
- people with underlying medical conditions, including:
  - cardiovascular disease (heart failure, coronary artery disease or cardiomyopathies);
  - cerebrovascular disease;
  - hypertension;
  - chronic pulmonary disease such as COPD;
  - kidney disease;
  - diabetes;
  - obesity;
  - neurologic conditions such as Alzheimer's disease and dementia;
  - mental health issues (psychiatric disorders, depression) (Benmarhnia et al., 2015; Cheng et al., 2019; Lippi & Henry, 2020; Mantovani et al., 2020; Pranata et al., 2020; Shang et al., 2020; Singh et al., 2020; J Yang et al., 2020);
- people on medication, as some medication for the diseases listed above impairs thermoregulation and perception to risks related to heat exposure (Daanen et al., 2020);
- pregnant women (Zhang, Yu & Wang, 2017; Juan et al., 2020; Z Yang et al., 2020);
- essential (indoor/outdoor) workers exposed to heat (Flouris et al., 2018; Spector et al., 2019; Morabito et al., 2020);
- health workers and staff wearing personal protective equipment (PPE) that may increase thermal stress (Ehrlich, McKenney & Elkbuli, 2020; Morabito et al., 2020; Sud, 2020);
- people who are socially isolated (homeless people, migrants, old people living alone) and those with low income or inadequate housing, who have limited resources and access to care (Armitage et al., 2020; GHHIN, 2020; Martinez et al., 2020);
- people who have – or are recovering from – COVID-19, who may be more vulnerable to heat-related illness.

Heat-related health effects are largely preventable through good public health practice, while following relevant advice. Operational responses and implications for HHAPs related to COVID-19 are reported in Box 11 in Chapter 7. Moreover, it is particularly important that vulnerable subgroups continue to receive the necessary health and social care during the pandemic, and that awareness of risks and responses is enhanced (GHHIN, 2020; Martinez et al., 2020; Wood, 2020).

The WHO Regional Office for Europe has issued health advice for hot weather during the COVID-19 outbreak as described in Box 5 in Chapter 4, as well as guidance for health care of elderly people and management of long-term care facilities during the COVID-19 pandemic (WHO Regional Office for Europe, 2020a; 2020b; 2020c). Some countries have also updated HHAPs to account for the COVID-19 pandemic and to raise awareness of risks among vulnerable subgroups (HCSP, 2020; INSPQ, 2020; KLUG, 2020; PHE, 2020; RIVM, 2020).

### 6.2.1 Elderly people

Ageing affects thermoregulatory capacity and can reduce thermal perception, leading to compromised behavioural responses of elderly citizens to heat stress, and increasing the onset of heat-related illnesses and deaths (Kenny et al., 2010; Stapleton et al., 2014; 2015; Benmarhnia et al., 2015). A systematic review and meta-analysis including 61 studies on vulnerability to heat found the strongest evidence for old age, with an increasing trend in risk as age progresses from 65 years onwards (Benmarhnia et al., 2015). Controlled laboratory studies suggest that the detrimental impact of age on people's capacity to thermoregulate in a hot environment can be detected as early as 40 years, and that these differences become evident in most people by their mid-50s (Flouris et al., 2017).

Elderly people are at particular risk due to dysfunctional thermoregulatory mechanisms (limited sweating and skin blood flow), chronic dehydration, multiple chronic diseases (especially cardiopulmonary disease, diabetes and dementia), use of medications, disability and non-self-sufficiency and possible social isolation (Kovats & Hajat, 2008; Basu, 2009; Hajat, O'Connor & Kosatsky, 2010; Bunker et al., 2016; Mayrhuber et al., 2018). Neurodegenerative diseases like dementia and Parkinson's disease, which are associated with old age, have also been identified as risk factors, with evidence of an increase in hospitalization during heat-waves among patients with these conditions (Linares et al., 2016; Wei et al., 2019). Eurostat (2019) estimates that by 2050 an average 40% of the European population will be aged over 55 years (ranging between 47% in Italy and Portugal and 35% in Sweden). Ageing of the European population and rises in noncommunicable disease prevalence suggest that the number of subjects at risk in this group will continue to increase in the coming years.

### 6.2.2 Children

In summer and during heat-waves infants and children are particularly vulnerable to dehydration and heat stress, due to their greater body surface-to-volume ratio. Furthermore, children have less effective heat adaptation capacity than do adults (Committee on Sports Medicine Fitness, 2000).

Heat has also been associated with an increase in ER visits or hospital admissions for paediatric diseases, respiratory diseases, gastroenteritis, renal diseases and diseases of the central nervous system among children (Sheffield & Landrigan, 2011; Williams et al., 2012; Xu, Etzel et al., 2012; Xu, Sheffield et al., 2012; Xu et al., 2014; Iñiguez et al., 2016; Lam et al., 2016; Stanberry, Thomson & James, 2018). Asthma symptoms – especially wheezing and chest tightness – have been shown to worsen with increasing temperatures (Z Xu et al., 2013; Li et al., 2014; Xu et al., 2014). Bacteria-related gastrointestinal diseases among children are also more likely to increase with high temperatures (Xu, Sheffield et al., 2012; Xu et al., 2014; Iñiguez et al., 2016).

### 6.2.3 Pregnant women

Heat has been identified as a risk factor for adverse birth outcomes such as low birth weight and preterm birth (Strand, Barnett & Tong, 2011; Carolan-Olah & Frankowska, 2014; Zhang, Yu & Wang, 2017). During pregnancy, women may be more susceptible to heat stress due to body weight gain, which increases heat production and reduces capacity to lose heat by sweating. The fetus also adds its body composition and metabolic rate, which further alters the mother's heat stress. Difficulty in thermoregulation and dehydration among pregnant women may cause a decrease in uterine blood flow, which may trigger labour. Furthermore, heat stress may trigger a release of hormones such as cortisol or increase secretion of oxytocin and prostaglandin, which may in turn induce labour and increased uterine contractions (Strand, Barnett & Tong, 2011; Carolan-Olah &

Frankowska, 2014). To date, however, the causes or biological mechanisms associated with preterm births and low birth weight in response to heat are still unclear.

Several studies have shown a significant positive short-term association between exposure to heat and preterm delivery in Europe (Dadvand et al., 2011; Schifano, Cappai et al., 2013; Vicedo-Cabrera et al., 2014; Vicedo-Cabrera, Olsson & Forsberg, 2015; Cox et al., 2016; Schifano et al., 2016; Asta et al., 2019) and in Australia, China, the Republic of Korea and the United States (Kloog et al., 2012; Strand, Barnett & Tong, 2012; He et al., 2017; Guo et al., 2018; Son et al., 2019; Song et al., 2019; Sun et al., 2019; Ilango et al., 2020). A study conducted in the over 400 counties of the United States showed that the fraction of preterm births attributable to extreme heat was 154 (empirical 95% CI: 127, 173) preterm births per million (Sun et al., 2019). Studies conducted specifically on extreme events rather than temperatures increases also found a greater risk of preterm births during heat-wave episodes than non-heat-wave days (Schifano, Lallo et al., 2013; Ilango et al., 2020). Ilango et al. (2020) found that exposure to heat-waves of longer duration had greater effects in California compared to short-lived events; similar findings were observed in Italy when consecutive days of heat were considered (Schifano, Lallo et al., 2013). This aspect is important to bear in mind in HHAP preparedness, warning system advice and action modulation targeted to this specific vulnerable subgroup.

Effect estimates in the various studies diverge due to differences in study design, definition of critical windows of exposure and gestational age assessment, local climate and population adaptation, population characteristics, access to health care and pregnancy health care assistance (Ha et al., 2017; Zhang, Yu & Wang, 2017; Gronlund et al., 2020). Confounders and possible effect modifiers such as air pollution, humidity, maternal age, marital status, ethnicity, socioeconomic status, smoking or drinking status, previous pregnancies, antenatal visits and gestational complications and pre-existing health conditions (such as body mass index, hypertension and diabetes) should also be considered when studying determinants of birth outcomes (Strand, Barnett & Tong, 2011; Basu et al., 2017; Khan et al., 2017; Son et al., 2019; Sun et al., 2019). In a study conducted in the United States, extreme heat was strongly associated with preterm birth in regions with colder and drier climates, and among younger women (Sun et al., 2019). Pre-existing health conditions also influenced the risk of preterm delivery: Basu et al. (2017) found that women with pre-existing or gestational hypertension or diabetes were at greater risk. Similarly, Schifano et al. found that women with chronic disease (especially cardiac conditions) and young mothers (less than 20 years of age) were at higher risk of preterm delivery (Schifano, Cappai et al., 2013; Schifano et al., 2016).

Socioeconomic differences may further contribute to the differential risk of preterm birth when exposed to heat (Dadvand et al., 2011; Strand, Barnett & Tong, 2011; Basu et al., 2017; Zhang, Yu & Wang, 2017; Asta et al., 2019). Son et al. (2019) found a higher risk of preterm delivery among women residing in areas of low socioeconomic status and with low education levels. In urban areas, proximity to green space has been linked to beneficial health effects such as reduced stress, increased social contact and cohesion, increased physical activity and reduced temperature extremes – especially heat and lower air pollution levels (WHO Regional Office for Europe, 2016). Moreover, several studies have looked at the association between green space and preterm births, but results are contrasting: most studies have not found an association with preterm births (Asta et al., 2019; Kloog, 2019), while a beneficial effect on fetus growth has also been shown (Dadvand et al., 2012). These factors are important for heat prevention in order to identify those most at risk that need to be monitored actively with particular attention during heat-waves, as well as to provide accurate advice to improve awareness and preparedness.

### 6.2.4 Workers

In the occupational setting, workers can be exposed to heat for prolonged periods of the day – particularly those whose roles involve manual tasks (physical work) with elevated endogenous (metabolic) heat production. Workers thus experience negative effects of environmental heat stress at lower temperature levels than those eliciting public alerts. Furthermore, protective clothing and PPE required for work safety may hamper natural heat loss. For outdoor workplaces exposure to solar radiation may add to the environmental heat, while for indoor workplaces cooling of large production bays is often not possible, and industrial heat generated by machinery can increase indoor heating. At present, evidence-based recommendations for indoor workplaces or residential buildings are sparse (Kenny et al., 2019). If appropriate preventive action is not taken, however, workplace temperature can increase to dangerous levels. It is therefore advisable that indoor work areas include some form of climate control (AC, electric fans or the opportunity of cooling during breaks if solutions are not applicable at the workstation or are constrained by PPE).

Occupational heat strain (the physiological consequences of occupational (environmental) heat stress) undermines the health and productivity of workers in major industries including agriculture, construction, manufacturing, tourism and transportation (Ioannou et al., 2017; Quiller et al., 2017; Marinaccio et al., 2019; Messeri et al., 2019; Schifano et al., 2019). A recent systematic review and meta-analysis of 111 studies, including more than 447 million workers from over 40 different occupations, estimated that 35% of individuals who frequently work in heat stress conditions experience negative effects of occupational heat strain (Flouris et al., 2018). Workers who are particularly vulnerable to the impacts of heat are those who work under heat stress conditions for prolonged periods, those exposed to high heat in a hypo-hydrated state, those who are older and those with underlying pathophysiological conditions. Field and lab studies have investigated human responses to elevated thermal stress during work using various physiological measures, and it is quite clear that occupational heat stress and strain can negatively affect workers' health, impair their performance capacity and compromise work safety (Jay & Brotherhood, 2016; Meade et al., 2016; Ioannou et al., 2017; Quiller et al., 2017; Notley, Flouris & Kenny, 2019). Kenny et al. (2019) suggest that occupational heat strain has important impacts on health and should be promoted accordingly in the light of climate change and the resulting rise in heat stress in coming years.

### 6.2.5 People with pre-existing conditions

Subjects with **cardiovascular diseases** are at greater risk during extreme heat (Bhaskaran, Hajat & Smeeth, 2011; Gasparrini et al., 2012; Turner et al., 2012; Yu et al., 2012; Sun et al., 2016; Cheng et al., 2019) due to their limited cardiovascular adjustment, which is needed during exposure to heat stress. The mechanisms underlying initiation of cardiovascular disease in response to temperature challenges involve multiple physiopathology regulations (Liu, Yavar & Sun, 2015). Under controlled conditions, heat exposure has been shown to lead to increases in red blood cell counts, platelet counts and blood viscosity, as well as increases in heart rate (Bhaskaran et al., 2009). Temperature-induced damage is thought to be related to heat-mediated dehydration and heatstroke-induced systemic inflammatory response (Liu, Yavar & Sun, 2015).

Heat has also been identified as risk factor for ischaemic stroke, with differences by age and gender in a recent meta-analysis (Lian et al., 2015; Wang et al., 2016). Several studies have shown the effect of heat on acute myocardial infarction hospital admissions and mortality (Bhaskaran et al., 2009; Bhaskaran, Hajat & Smeeth, 2011; Goggins, Woo et al., 2012; Breitner et al., 2014). Kwon et al. (2015) recently focused on the risk factors of this relationship, and found that females, those aged 75 years and over and those with low socioeconomic status were at greater risk. The authors suggested that the lifestyles of subjects with a low socioeconomic status seemed to be more vulnerable to weather, which could affect increased acute myocardial infarction hospital admissions. Furthermore, elderly patients with diabetes were also found to be at greater risk when temperatures increased (Lam et al., 2018).

Several studies have identified individuals with underlying **respiratory diseases**, including COPD, as being at increased risk from the adverse health effects of heat (Kenny et al., 2010; Turner et al., 2012; Anderson et al., 2013; Benmarhnia et al., 2015; Cheng et al., 2019; Zhao et al., 2019). The underlying mechanisms through which high temperatures may increase this risk are not entirely clear. Studies have found that heat is associated with airways and systemic inflammation, and vascular changes may trigger a respiratory distress syndrome through episodes of activation of the complement system (Michelozzi et al., 2009; Zhao et al., 2019). A recent systematic review found a significant effect of heat-waves on total respiratory mortality and COPD mortality but not on morbidity, with contrasting effects in different regions of the world and by morbidity indicator (Cheng et al., 2019). A study on a cohort of COPD patients found that increases in indoor and outdoor temperatures were associated with increases in daily indicators of COPD morbidity, including respiratory symptoms and rescue inhaler medication use (McCormack et al., 2016). Among COPD patients symptoms can worsen in response to the hyperventilation required to disperse heat and the bronchoconstrictive effects of heat (McCormack et al., 2016). Among subjects with asthma it has been suggested that breathing hot humid air may result in bronchoconstriction and increased airways resistance that is mediated via cholinergic pathways (McCormack et al., 2016; Zhao et al., 2019). Furthermore, asthma medication may interfere with the thermoregulatory response, thereby increasing heat stress conditions.

**Mental health and behavioural disorders** such as depression, bipolar disorder, schizophrenia, mental disability and developmental disorders have been associated with a risk of worsening of health conditions during heat-waves or exposure to heat (Hansen et al., 2008; Page et al., 2012; Wang et al., 2014; Basu et al., 2018; Thompson et al., 2018; Min et al., 2019; Mullins & White, 2019). Exposure to high temperatures can cause particular discomfort and heat stress among people with mental disorders – they may become agitated, more aggressive and violent, with an increase in the risk of suicide and conflicts (Wang et al., 2014; Basu et al., 2018; Thompson et al., 2018; Kim et al., 2019; Min et al., 2019). A recent review reported that 15 of 17 studies found a positive and significant association between heat and suicide frequency (Thompson et al., 2018). Several studies have shown an increase in hospital admissions and mortality among subjects with diagnosed mental health illnesses (Hansen et al., 2008; Thompson et al., 2018; Min et al., 2019).

The biological mechanisms include heat altering the metabolites of certain neurotransmitters, such as 5-hydroxytryptamine and dopamine, which are associated with the onset of depression and bipolar disorders (Stöllberger, Lutz & Finsterer, 2009; Thompson et al., 2018). Another important aspect is the use of medication in this group and the role of heat in altering the effect of the drugs; for example, psychotic drugs have side-effects associated with heat (Martin-Latry et al., 2007; Stöllberger, Lutz & Finsterer, 2009; Min et al., 2019). Medication used in psychiatry increases vulnerability to heat-related morbidity by altering the body's thermoregulatory capacity. Furthermore, among this subgroup cognitive awareness of environmental conditions – in this case heat-waves – and the ability to undertake adaptive behaviours such as increased fluid intake or wearing appropriate clothing, especially in those with disabling mental illnesses such as Alzheimer's disease, dementia, senility, psychosis and developmental disorders, may increase the risk of adverse health effects during heat-waves (Hansen et al., 2008; Basu et al., 2018).

Mental health issues are not solely related to elderly people but also apply to younger individuals, increasing the pool of susceptible individuals (Basu et al., 2018; Mullins & White, 2019). In particular, the low perception of risk among this group calls for a more active role from caregivers and health and social services. Prevention measures need to address each subgroup accordingly, in both management and care. Although an association between mental health disorders and heat has been shown, more information on the causes of this are needed. Further research should focus on potential effect modifiers and confounders such as medication history, comorbidities and various social indicators (income, living conditions, AC usage), as well as more precise exposure mapping to better characterize this vulnerable group (Hansen et al., 2008; Wang et al., 2014; Basu et al., 2018).

Exposure to heat has been shown to increase the risk of hospitalization and death among individuals with **diabetes** during heat-waves (Stafoggia et al., 2006; Zanobetti et al., 2014). Patients with type 1 and type 2 diabetes mellitus and the pharmacological treatments they require may cause dehydration, lower skin blood flow and reduced sweating, which could consequently impair thermoregulation during heat-waves (McGinn et al., 2015; Carrillo et al., 2016; Kenny, Sigal & McGinn, 2016; Notley et al., 2019). A recent review addressed how comorbidities such as obesity, hypertension, dyslipidaemia, cardiovascular disease, diabetic neuropathy and skin disorders, as well as medication, may contribute to the level of vulnerability among diabetic patients (Yardley et al., 2013). Ageing can further undermine the ability of diabetes patients to thermoregulate (Carrillo et al., 2016). Performing physical work in the heat is another important challenge for patients with diabetes, as physical activity is recommended for diabetes management. In this regard, the evidence to date shows that exercise heat stress may pose a health concern in diabetes patients (Carrillo et al., 2016; Notley et al., 2019). A recent study in middle-aged well controlled type 2 diabetes patients showed, however, that heat acclimation can offset diabetes-related thermoregulatory impairments and health complications during heat exposure (Notley et al., 2019). Further research examining skin blood flow responses concurrently with changes in core temperature and the role of thermoregulatory responses during physical activity among people with diabetes is warranted to improve the knowledge base and introduce adequate response measures during heat-waves (Yardley et al., 2013; Kenny, Sigal & McGinn, 2016).

### 6.2.6 People affected by food- and waterborne diseases caused by a hot environment

Several studies have shown an association between heat and food- and waterborne diseases from the proliferation of different bacteria in hot environments: the most common health effects are **gastroenteritis and diarrhoea** (Tam et al., 2006; Zhang, Bi & Hiller, 2010; Carlton et al., 2016). A recent systematic review of the association between temperature and diarrhoea in studies in low-, middle- and high-income countries found a significant positive pooled estimate between temperature for both all-cause and bacterial diarrhoea (Carlton et al., 2016). Future climate change – especially associated with an increase in temperatures and changes in frequency and intensity of extreme events – may alter the distribution, survival and virulence of pathogens and changes in host exposure patterns, thus increasing the impact on health and the consequent additional burden to the health system. Advice and prevention on these aspects is limited and needs to be enhanced.

### 6.2.7 Travellers, tourists and migrants

People coming from cool or temperate climates who are not in good physical condition and not acclimatized to the heat may be at greater risk during heat-waves. They may be unaware of health risks and behavioural changes necessary to cope with heat (Hansen et al., 2013; Messeri et al., 2019; Pradhan et al., 2019). Migrant workers, refugees and internally displaced people may have pre-existing and post-displacement vulnerabilities such as malnutrition and untreated chronic medical conditions from limited access to health care and lack of shelter providing adequate protection, predisposing them to a greater risk to heat (Levy & Patz, 2015).

### 6.2.8 People affected by socioeconomic factors

Having low socioeconomic status and/or low income, living alone and being socially isolated were found to be associated with increased adverse health effects during extreme heat (Basu, 2009; Zanobetti et al., 2013; Benmarhnia et al., 2015). A systematic review and meta-analysis reported greater risk among people with low socioeconomic status and poor living conditions and built environment (Benmarhnia et al., 2015). Debate is ongoing around the role of socioeconomic factors in contributing to heat vulnerability, and whether it is solely individual or neighbourhood socioeconomic conditions that have an impact. Individual conditions (education, income and so on) influence health, while attitudes and behaviours diffused between people at the community or neighbourhood level may also influence health education.

The differential vulnerability of populations living in urban areas is also a matter of concern, considering the continual urbanization and urban growth in the WHO European Region. In metropolitan areas the effects of heat on health may be exacerbated by greater socioeconomic disparities, inadequate housing conditions and concurrent exposure to air pollution (O'Neill, Zanobetti & Schwartz, 2003; Reid et al., 2009; Kwon et al., 2015; Taylor et al., 2016; Urban et al., 2016; Willers et al., 2016). A recent study found a strong effect modification by social deprivation; this was greatest among population groups that were simultaneously exposed to high levels of air pollution or other environmental exposures, thus representing so-called environmental injustice (Benmarhnia et al., 2014).

Furthermore, in urban environments, temperatures are higher and the daily thermal pattern is different (less variable) from the surrounding rural areas due to the urban structure and materials that retain heat and alter the microclimate. This phenomenon is known as the urban heat island (UHI) effect. Few studies have accounted for the differential effect of heat within urban areas, mostly due to the limited availability of high spatial resolution temperature data and geocoded health data or data stratified by small spatial units. As expected, warmer inner city central areas of low socioeconomic status have shown greater heat-related effects (Smargiassi et al., 2009; Huang, Zhou & Cadenasso, 2011; Goggins, Chan et al., 2012; Wong, Paddon & Jimenez, 2013; Y Xu et al., 2013). Considering future climate change and the UHI effect in the United Kingdom, two studies estimated that, by 2080, a heat-wave could be responsible for an increase in mortality of around three times the rate observed in 2003, with 278 deaths compared to 90 (Heaviside, Vardoulakis & Cai, 2016; Heaviside, Macintyre & Vardoulakis, 2017). This aspect is important for the promotion of measures to reduce greenhouse gas emissions and to mitigate the UHI effect within cities. Further details on the built environment can be found in Chapter 8.

## 6.3 Identification, surveillance and mapping of vulnerable subgroups

As noted in the 2008 WHO guidance (Matthies et al., 2008), an important preparatory measure of an HHAP is identification and localization of vulnerable subgroups. Once formally identified, specific actions and response measures need to be put in place to protect those most at risk. Raising awareness and providing advice is insufficient for these subgroups: they need to be monitored actively and response measures addressed to them should be enhanced during heat-wave days.

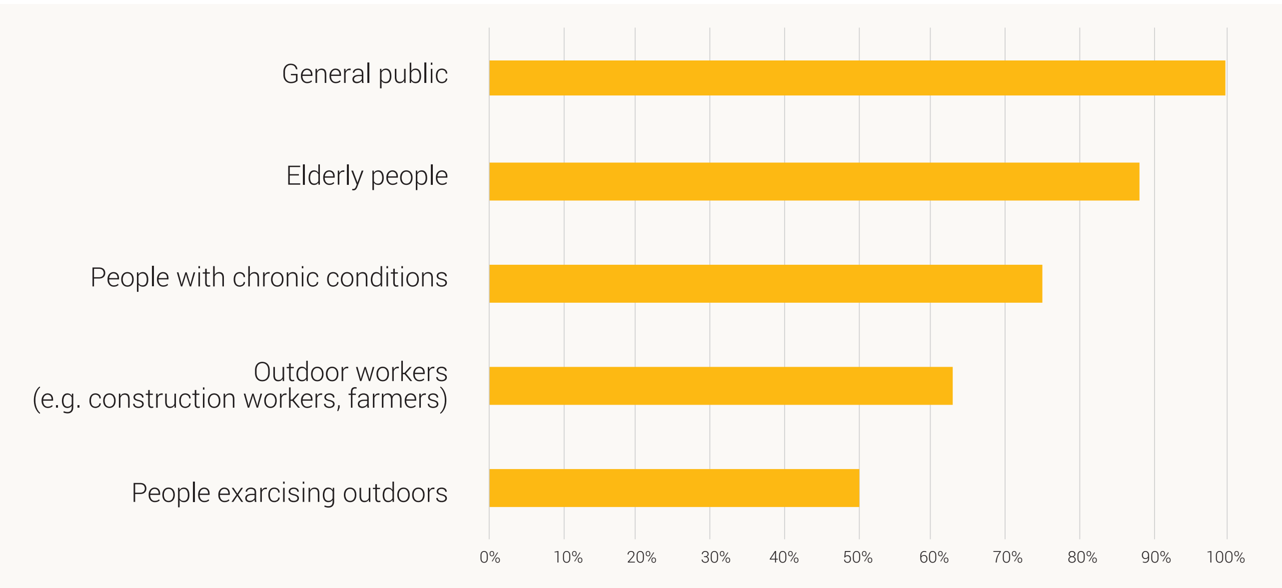
Active surveillance entails the identification of susceptible subgroups through health system registries, population registries and health and social service notifications. Most people suffering from chronic diseases receive specialist care, are partly monitored or traced by health services or are included in health registries.

Ad hoc surveillance systems to monitor the health status of vulnerable subgroups have been implemented throughout the summer to ensure a timely response during extreme events. Integrated syndromic surveillance systems were implemented by Public Health England in the United Kingdom (Elliot et al., 2014). GP active surveillance (home visits and questionnaire) and out-of-hours calls are used in France, Italy and the United Kingdom to monitor vulnerable groups and collect information on their health status during the summer (Michelozzi et al., 2010; Pascal et al., 2012; Elliot et al., 2014). The Italian HHAP, for example, formally requires the drawing up of lists of susceptible subgroups; these are sent to health authorities to implement active surveillance by GPs and social services (Michelozzi et al., 2010; Schifano, Lallo et al., 2013; Liotta, Inzerilli et al., 2018). A susceptibility score is defined at the local level based on individual risk factors associated with heat, using population and health registries (age, sex, health status, use of medication, access to health care services such as hospitalizations, ER visits, specialist care and so on) or through notifications from GPs and social services. Occupational health surveillance systems for sectors most at risk are also implemented to monitor prevalence of occupational heat strain and work injuries related to heat, to improve prevention and response (Casanueva et al., 2019; Morabito et al., 2019).

### 6.3.1 Current status of HHAP responses to vulnerable subgroups

Among the 16 countries that responded to WHO's 2019 survey of heat–health action planning and reported the existence of a national HHAP, 11 (69%) stated that their HHAP fully addresses vulnerable subgroups; the remaining five (11%) had only partial implementation of this component. The survey specifically enquired about how advice is issued to vulnerable subgroups and who is considered vulnerable in the HHAP. Specific vulnerable groups to whom advice is targeted include elderly people in 14 countries (88%), chronically ill people in 12 (75%), outdoor workers in 10 (63%) and people exercising outdoors in eight (50%) (Fig. 10).

**Fig. 10. Vulnerable subgroups targeted in national HHAPs**



Information is issued by all HHAPs to the general public, which is a way of raising awareness both in the general population and among vulnerable groups directly and indirectly through relatives, care givers and friends. Targeted advice is delivered to health care practitioners in 13 countries (81%), nursing homes in 12 (75%), health care administrators in 11 (69%), social workers in seven (44%) and schools in three (19%) (Fig. 11). Results from the survey show that although targeted information to the main vulnerable groups is defined, dissemination of risks and prevention measures is still very much limited to health care workers.

A multitude of means are used in HHAPs to communicate health advice during heat-waves to vulnerable subgroups, as described in Chapter 4. It is worth noting, however, that direct and proactive methods such as face-to-face interactions, direct messages or telephone calls are less used (less than 30%) than more indirect means such as websites and media (over 80%).

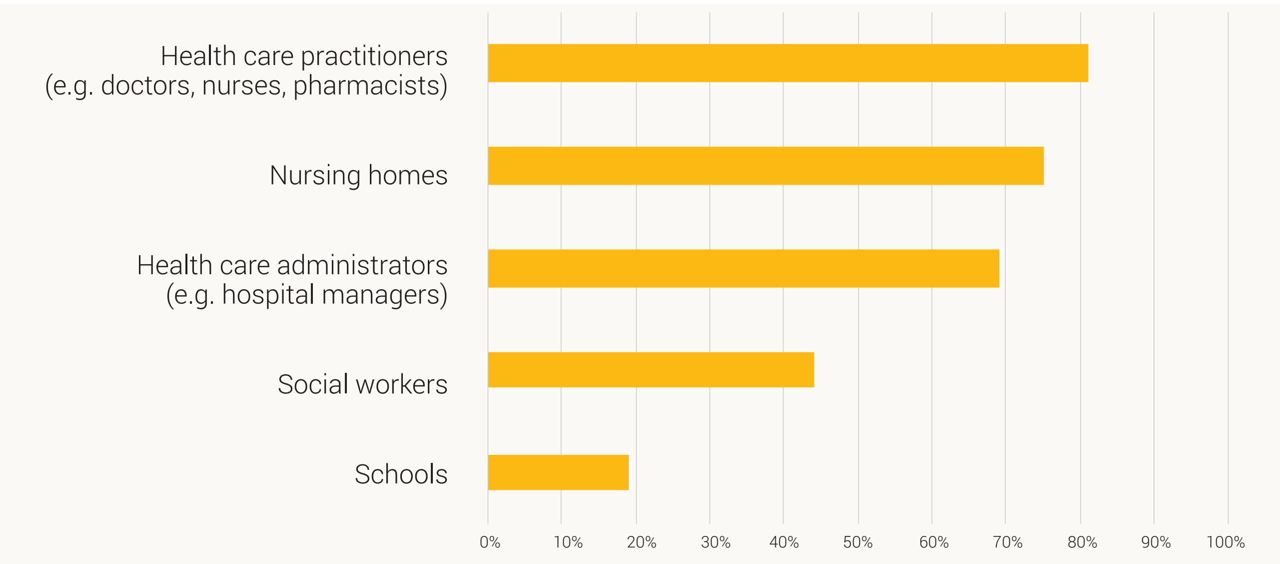
### 6.3.2 Vulnerability mapping in urban areas

Mapping is an increasing popular environmental health surveillance tool. It can identify important health and exposure disparities and help target interventions. Heat vulnerability mapping considers extreme heat risk factors and provides an aggregate measure of risk. Studies published in peer-reviewed journals have identified a series of risk factors that modify the heat–health association. These comprise factors that vary across space and are interlinked, including:

- environmental factors (UHI intensity, green space, air pollution, land use and land cover, building type, access to AC);
- sociodemographic factors (proportion of elderly population, low socioeconomic status, level of education, ethnic minority groups, public housing);
- and health factors (prevalence of chronic disease).

Several studies have developed vulnerability indicators that combine these risk factors and facilitate geographical representation through mapping to identify hotspots and areas most at risk. Satellite data for land coverage or UHI intensity have also been used with vulnerability characteristics from census data in North America and European cities (Reid et al., 2009; Kestens et al., 2011; Steeneveld et al., 2011; Tomlinson et al., 2011; Buscail, Upegui & Viel, 2012; Johnson et al., 2012; Heaton et al., 2014; Wolf, McGregor & Analitis, 2014; Taylor et al., 2015; Lim et al., 2016). Nayak et

**Fig. 11. Stakeholders to whom specific advice on vulnerable subgroups is provided**



al. (2018) defined a heat vulnerability index for New York State at the census tract level made up of four core risk factors: socioeconomic conditions; old age and social isolation; ethnicity, language and social barriers; and environmental exposure and urban design (land cover/land use, building age and so on). A similar model was developed to map at-risk areas in Rennes, France, to help target interventions for the most vulnerable populations (Buscail, Upegui & Viel, 2012). Bradford et al. (2015) defined a similar heat vulnerability indicator to identify the best spots to locate cooling centres according to high risk in Pittsburgh, United States. Taylor et al. (2015) looked at the spatial distribution of heat vulnerability across London, United Kingdom, considering UHI and housing characteristics to account for indoor heat and the importance of this factor when planning urban heat adaptation and mitigation measures (Box 8).

Vulnerability mapping, coupled with identification of vulnerable subjects, can help to guide prevention actions and target interventions at the local and community level, optimizing resources. Furthermore, heat–health warning systems could be spatially graded within urban areas to take heat vulnerability and other risk factors into account.

### Box 8. Vulnerability mapping of excess heat-related mortality in London, United Kingdom

The derivation and combination of different variables for heat risk – age, UHI and dwellings – were integrated and presented over spatial distribution of heat vulnerability across the city of London. Population age and sex data were obtained at the ward level, and sex-specific age-standardized mortality rates in London were modified using seasonal data for England and Wales to reflect summertime mortality rates; the baseline mortality rate for each ward was calculated from these data. Internal temperatures were estimated using an extensively validated dynamic thermal modelling tool. During the study's period a range of 5.8 °C across dwelling types was estimated. The hottest buildings were bungalows built between 1900 and 1918; the coolest dwellings were ground-floor flats in high-rise buildings built after 1990.

The outdoor temperatures used in the models exceeded the temperature–mortality threshold, with a range of 7.4 °C between the hottest and coolest dwellings. The results indicated that top-floor flats and bungalows have a greater overheating health risk. Spatial variation of heat-related mortality was found to reflect background mortality rates due to population age, while dwelling characteristics were found to cause larger variation in temperature exposure (and therefore risk) than the UHI effect. The highest levels of excess mortality were found in areas with larger elderly populations, towards the outskirts of London. The results provide a platform for further work to investigate the effects of climate change, building retrofitting, population ageing and changes to the UHI effect on population mortality due to heat (Taylor et al., 2015).

## 6.4 Prevention measures and guidance

Recommendations accounting for new evidence on vulnerable subgroups should be integrated in HHAPs and included in education and outreach programmes. Health and social care staff should be trained on health risks associated with heat exposure among emerging vulnerable groups in order to respond in an efficient and timely manner.

An Australian survey showed that elderly people are generally resilient, but that interventions addressing multimorbidity, medication interactions and social isolation should be developed. Targeted education for elderly people on adaptation measures and the development of specific policy measures could ensure that the health impacts among this subgroup are reduced (Nitschke et al., 2013). Details of preparedness and response measures from health systems are outlined in Chapter 7. Furthermore, integration with European initiatives like the European Innovation Partnership on Active and Healthy Ageing seems a possible way forward to better address needs for heat prevention among the elderly population in the coming years (Liotta, Ussai et al., 2018).

Since most individuals with mentally illnesses are unaware of the risks from extreme temperature exposure, adequate patient counselling regarding exposure reduction, use of heat shelters in urban areas and preventive measures should be incorporated into outpatient care programmes and outreach groups (Hansen et al., 2008; Wang et al., 2014; Price et al., 2018). Patients with substance use disorders are often hard to reach using public health interventions, and not always in contact with professional health services. Alternative outreach measures need to be introduced to protect these subjects during heat-waves (Page et al., 2012).

With reference to pregnant women, midwives and gynaecologists need to be aware of the risks associated with heat during pregnancy and can advise pregnant women to adopt specific measures such as increasing fluid intake, residing in cool environments and reducing activity levels (Kovats & Hajat, 2008; Carolan-Olah & Frankowska, 2014).

## 6.5 Specific advice for at-risk subgroups

Awareness among vulnerable subgroups of the health risks related to heat is still low and needs to be addressed in HHAPs. The pool of vulnerable subjects changes over time due to ageing, deterioration of pre-existing health conditions or having another comorbidity and worsening of socioeconomic status. This should be addressed in information campaigns and response measures updating current informative material and adjusting prevention measures and actions to account for new evidence on vulnerable groups and local population susceptibility characteristics.

Vulnerable subgroups should be contacted at the beginning of summer, informed about health risks, given guidance on how to cope with heat and advised about the health and social care services available. In several European countries with an operational HHAP, brochures, leaflets and other information material are distributed in health care centres and GP practices. Information is also given to patients during check-up visits, sent via email or post or transmitted via telephone (Lowe, Ebi & Forsberg, 2011; Bittner et al., 2014; Casanueva et al., 2019). Active communication is limited, to date: only a few countries actively contact vulnerable individuals via email, phone calls or text message, as reported in WHO's 2019 survey of heat–health action planning, in Chapter 4 and publications (Lowe, Ebi & Forsberg, 2011). Further details on communication campaigns and informative material can be found in Chapter 4.

With HHAPs, occupational health prevention needs a specific intersectoral and multidisciplinary approach and targeted actions at several levels (individual, enterprise, local and national government) to include workforce categories, employers, unions and health and safety legislation.

Establishing active early warning systems to address occupational heat stress and strain is vital, alongside awareness-raising activities targeting the working population, regular communication about risks and continued monitoring and evaluation of activities (Morabito et al., 2019). Examples of integration of occupation health and worker heat prevention include adopting thresholds for work restrictions and guidance based on meteorological data; engineering solutions, such as cooling, AC and provision of sustainable energy sources; increased use of mechanization to reduce physical workloads; appropriate use of equipment and ventilation systems; and adoption of improved and heat-friendly PPE (Box 9).

### Box 9. Occupational health in North Macedonia: heat-waves and workers' health

A national study carried out by the National Institute of Occupational Health in North Macedonia aimed to assess the attitudes, knowledge and practices of 350 outdoor workers regarding the harmful effects of heat-waves and protection from them. The interview results showed that more than 30% of the participants were not informed about procedures for dealing with the impact of heat-waves on human health. Lack of support by management (36%) and fear of losing their job (34%) were listed as the most significant impeding factors for use of health and safety procedures at work during heat-waves.

This was a trigger to the National Institute of Occupational Health to provide specific recommendations for employers, workers and specialists in occupational health, to ensure proper implementation of the measures proposed in the HHAP for prevention, alongside raising awareness among the working population, regular communication of risks and continual monitoring and evaluation of the activities conducted (EEA, 2014). Occupational health specialists and GPs play an important role in implementation of North Macedonia's HHAP of (Karadzinska-Bislimovska, 2015; Kendrovski & Spasenovska, 2011).

## 6.6 Conclusions

Information campaigns and informative material for vulnerable subgroups should be defined and updated regularly on the basis of new evidence and emerging risk factors. The diversity within vulnerable groups should be acknowledged in both advice tools and information campaigns and in the response measures implemented. Key aspects to promote are formal identification of vulnerable groups, active information and response measures and consistent evaluation of measures put in place targeted at these subgroups. Monitoring of vulnerable groups and health risks associated with heat should be undertaken to account for potential changes over time.

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# Chapter 7. Preparedness: planning for heat–health risks in health and social care settings

## Summary

Progress on prevention and response measures to heat within the health sector has been limited in national and local planning. Most national HHAPs do not include much detailed information or sufficient guidance on the management of heat–health risks in health and social care settings. Some improvement in information for and responses of health and social care staff was observed, as well as preparedness and response in residential care settings due to increased awareness of the vulnerability of elderly people in these settings. Remaining challenges relate to lack of evidence on whether emergency and response measures are followed and effectively implemented; risk perception of patients, who do not feel that heat-waves are a risk for them; and the lack of evidence on response protocols by staff.

Few health authorities have systems in place to monitor overheating in health care buildings or to assess the impacts on staff, patients, visitors and equipment. Research is needed to implement protective measures and effective heat management in the health sector. Solutions to address both short-term risks related to heat-waves and long-term climate change risks, as well as mitigation measures that promote healthy well-being and environmental sustainability, need to be developed.

## Key messages

- With some exceptions, little progress has been made in planning for heat risks to health systems and facilities, such as emergency protocols in response to heat-waves, climate-resilient health care facility design and mapping of health care facilities in regions that experience heat-waves.
- Awareness of the high vulnerability to heat of many people in residential care is increasing.
- Greater effort needs to be put into sharing best practice planning and response measures in the health sector.
- More research is needed on the risks of overheating and adaptive solutions in hospitals, residential care homes and other settings.
- Health sector goals for carbon mitigation are a priority for action, and may affect the identification and implementation of measures to manage heat risks.

## 7.1 Introduction

Heat affects the health of individuals and populations in several ways, not only through direct impacts related to environmental exposure among the population but also by disrupting the ability of health providers and social care systems to perform their core functions. The WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008) identified the preparedness of health care and social services as a core element of an HHAP. It highlighted the need for hospitals, clinics and retirement and nursing homes to define a plan with specific procedures to be adopted against high temperatures, and for health authorities to provide guidance and standards on how to do so. Within that framework, individual elements addressed included:

- preparedness of health care providers and facilities for the hot season, including for adequate treatment and care of heat-related illnesses;
- building modifications and interventions to reduce indoor overheating in health care facilities (such as air-conditioned rooms and wards);
- thermal environment standards for hospitals;
- reductions of the carbon footprint of health care facilities and promotion of environmentally sustainable interventions.

To a large extent, the explorations of interventions to prevent indoor overheating and building envelope modifications in Chapters 5 and 8 are applicable to health and social care systems. Chapter 5 also covers elements of thermal comfort standards, which partly cover the issues of thermal environments in hospitals.

This chapter therefore updates the evidence in two main areas. The first – preparedness for and management of heat events in health systems and social care institutions – is complex and multifaceted, spanning a multitude of elements from clinical guidelines to the complexities of health systems governance in countries. Moreover, this topic has only a weak presence in the formal peer-reviewed scientific literature; a deep exploration would require an extent of primary data collection that is beyond the scope of this publication. Thus, what is presented here is a selection of the peer-reviewed and government literature, illustrating the key aspects where updates have been significant.

The second area – the reduction of the carbon footprint of health care facilities – is conversely a growing field of interest in scientific and technical publications. In this case, the topic has been expanded in scope in accordance with the current mainstream scientific and policy discussion. Specifically, reducing the carbon footprint is integrated within broader efforts of environmental sustainability; the scope is expanded beyond health care facilities to overall health systems; and the climate resilience of health systems is included as a complementary and inseparable part of their overall sustainability, as promoted in the recent WHO guidance for climate-resilient and environmentally sustainable health care facilities (WHO, 2020a).

## 7.2 Preparedness and management of heat events in health and social care systems

Health systems are defined by WHO as "(i) all the activities whose primary purpose is to promote, restore and/or maintain health; (ii) the people, institutions and resources, arranged together in accordance with established policies, to improve the health of the population they serve, while responding to people's legitimate expectations and protecting them against the cost of ill-health through a variety of activities whose primary intent is to improve health" (WHO, 2011). Understood in such comprehensive scope, preparedness of health systems for impacts of heat and extreme high temperatures includes not only health care facilities and personnel but also the networks of utilities, logistics, transport, companies, institutions and social groups that support health system functions. Social care systems similarly encompass a broad range of elements and actors, including nursing and care homes, protection systems for socially disadvantaged groups and homeless people, and community-based organizations operating in the sector, among others. Heat impacts and preparedness are similarly relevant to these broader social care networks.

### 7.2.1 Health systems and heat: preparedness and management

WHO's 2008 and subsequent guidance on heat–health action planning, such as the public health advice factsheets (Matthies et al., 2008; WHO Regional Office for Europe, 2011), elaborate on various types of relevant heat preparedness activities and information for health systems, essentially of three types:

- guidance to health professionals on heat illness risk factors, diagnosis and management;
- guidance to health authorities and residence/care managers on protecting patients, residents and workers from heat;
- guidance to health authorities and residence/care managers on interventions in the built environment to protect health from heat.

Several HHAPs include information on one or more of these areas, as well as specific recommendations or requirements for health systems, hospitals and health care providers for heat preparedness (Casanueva et al., 2019; Mücke & Litvinovitch, 2020). WHO's 2019 survey of heat–health action planning confirms this notion: among the 16 countries that reported the existence of a national HHAP, respondents listed stakeholders to whom targeted advice is delivered, including health care practitioners (81%), nursing homes (75%), health care administrators (69%), social workers (44%) and schools (19%).

The level of implementation of such recommendations may be uneven. Only 44% of respondents considered the core HHAP element of preparedness of health and social systems to be fully implemented. This may, however, not take into account preparedness activities managed and monitored at various subnational levels (several regions and cities in the WHO European Region have their own HHAPs, which include provisions for health and social care preparedness). Moreover, 50% of respondents involved NGO health systems stakeholders such as the Red Cross/Red Crescent in their preparedness and response. The Red Cross, for example, has developed guidance on managing heat-waves (Singh et al., 2019).

Limited progress has been made on resilience in the health sector in response to both significant heat-wave events and the increasing policy need to address climate change adaptation (Paterson et al., 2014; Balbus et al., 2016). This evidence primarily relates to assessments of impacts and response following individual heat-wave events and surveying plans and preparedness measures put in place by health services, hospitals and care homes. Less information is available on the effectiveness of individual interventions or evaluations of specific plans or qualitative research with front-line stuff during and after heat-wave events. A review of HHAP plans in the United States concluded that planning and programming are likely to be most effective if performed in a bottom-up and community-specific manner, and as a collaborative effort among multiple levels of government and local stakeholders (White-Newsome et al., 2014).

### 7.2.2 Heat-waves and hospital care

Extreme high temperatures increase ER and other types of hospital admission for certain disease categories, potentially posing a surge in care needs at a time when health workforce availability may be diminished due to the summer holidays (Gronlund et al., 2014; Hopp, Dominici & Bobb, 2018; Martínez-Solanas et al., 2019). Research in the last decade determined with higher specificity which disease categories are affected by high temperatures and heat-waves. While the increase in respiratory disease admissions is well established, the association between heat and cardiovascular outcomes is weak or non-significant in most studies and only observed among the very old at ages 85 years and over (Hopp, Dominici & Bobb, 2018; Cheng et al. 2019).

A recent study of urgent ER admissions in the Netherlands found that heat increased the relative risk for potential heat-related diseases and respiratory diseases (Van Loenhout et al., 2018). Hopp, Dominici & Bobb (2018) conducted a detailed analysis of the medical diagnoses in hospital admissions that were most influenced by heat, and from 50 outcomes from broad disease groups previously associated with heat-wave-related hospitalizations, they identified 11 diagnoses with a higher admission risk on heat-wave days, including three heat-related illnesses, four fluid and electrolyte disorders, two diagnoses of septicaemia, one of acute kidney failure and one of urinary tract infection. Other recent studies have reported an increase in admissions for mental health outcomes (Thompson et al., 2018). The evolving knowledge about specific heat-related acute effects requiring hospital care may facilitate better planning and preparedness of hospitals for heat.

In addition to the potential increases in hospitalizations, heat-waves cause problems with the functionality of hospitals and the thermal comfort of patients and staff (Matthies et al., 2008; Carmichael et al., 2012). Further studies and documentation on these aspects are needed to ensure that efficient measures are implemented. Reported impacts of heat-waves include:

- discomfort or distress of patients and their visitors;
- discomfort of staff (including occupational health issues – see Chapter 6);
- equipment failure, such as failure of essential refrigeration systems including morgue facilities;
- disruption of information technology services;
- disruption of laboratory services;
- degradation or loss of medicines.

Hospital design and construction influence thermal comfort and ventilation during heat-waves. Hospitals in urban settings may also be affected by UHIs and the presence of green space or blue space nearby (see Chapter 8). In-depth studies of building and ward types have shown that some building characteristics increase the risk of overheating. For example, few hospital wards in northern Europe are air-conditioned; instead, the internal temperature is maintained by natural or mechanical ventilation. Older designs can be more efficient than more modern structures for space cooling (Short et al., 2012; Iddon et al., 2015; Short, Renganathan & Lomas, 2015). Zoning and control of the heating systems, solar gain and lack of effective natural ventilation were identified as the most significant – and common – contributors to overheating in five hospitals assessed in Scotland (BRE, 2018). The Environmental Audit Committee of the United Kingdom Government recently concluded that the risk of overheating in health care buildings was not being sufficiently managed (EAC, 2018). Little information has been published on the prevalence of overheating in relation to hospital design in European countries. There has been considerable progress in research on measures to address overheating buildings (DCLG, 2012; Porritt et al., 2012; Bundle et al., 2018) – widely discussed in Chapter 5 – but not much that is specific to hospital buildings.

There are also occupational heat risks to health care staff during heat-waves. Working under heat stress conditions for prolonged periods is a health concern for health workers (Flouris et al., 2018) (see Chapter 6). Wearing PPE also exacerbates individual heat exposure. This has been a particular issue for health care workers in 2020 during the COVID-19 pandemic (Roberge, Kim & Coca, 2012; Foster et al., 2020; Morabito et al., 2020; Park, 2020). Box 10 sets out an example of how to build resilience of health facilities to cope with heat-waves at the local level.

Several studies have shown that fragmentation of health services is a barrier to effective heat response measures. Although individual service providers may be familiar with severe weather plans and protocols, problems of communication between personnel in different parts of the health and social care system can result in difficulty in implementing such plans efficiently (Dominelli, 2013; Boyson, Taylor & Page, 2014). Systems of service commissioning can ensure that the various agencies delivering health care exercise responsibility for risks associated with severe weather. There may also be gaps in service provision that need to be addressed by individuals (Dominelli, 2013). As heat-waves become more severe, these problems are likely to increase in the future. Few qualitative studies have been undertaken to assess problems during heat-waves among health staff.

### 7.2.3 Social care systems and heat: preparedness and management

It is well established that older people are more at risk from the health effects of heat-waves (see Chapter 6). Epidemiological studies have confirmed that residents in care homes are relatively more vulnerable to heat-related mortality risks (Hajat, Kovats & Lachowycz, 2007; Kovats and Hajat, 2008; Klenk, Becker & Rapp, 2010). A review of heat-wave plans found that relatively few incorporated specific actions for elderly care settings (Okwuofu-Thomas, Beggs & MacKenzie, 2017). A survey in urban areas in Belgium and the Netherlands also found that elderly care organizations were unfamiliar with national heat-wave plans and gave lower priority to heat than to other factors requiring increased response than other public organizations (Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016).

HHAPs may include specific actions for residential care homes. For example, in England (United Kingdom), Italy and Sweden heat plans provide guidance for health and social care workers and information sheets have been developed specifically targeted at residential home managers and workers (PHE, 2020; Ministry of Health, 2015; PHA Sweden,

**Box 10. Building resilience to cope with heat-waves: testing the HHAP in North Macedonia**

In order to strengthen preparedness for crisis situations and heat-wave-related emergencies, a simulation exercise took place in the Strumica region of North Macedonia. The key stakeholders included representatives from the Ministry of Health, the Strumica General Hospital (regional hospital centre), emergency medical services, the Crisis Management Centre, the Red Cross, fire and rescue units, the Ministry of the Interior, the Ministry of Defence and the WHO Country Office.

Prior to the simulation exercise, preparatory meetings were held to establish the parameters, such as expected casualties, trigger indicators for activating the emergency response plan, triage and patient traffic flows and the responsibilities of hospital and emergency medical services staff. The simulation allowed the authorities to test general preparedness and implementation of the national HHAP. The exercise revealed many opportunities related to better management of heat–health risks in the current hospital crisis preparedness plan, including command leadership, preparedness of staff and effective management of incoming patients.

2017). A survey of planning in long-term care homes in the Netherlands found that most institutions had a heat protocol (Kunst & Britstra, 2013).

Further research has been done on indoor temperatures in residential homes. A study in England, United Kingdom (Gupta et al., 2016), found that there was a risk of overheating, especially during short-term heat-waves (2–4 days), with indoor temperatures rising to nearly 30 °C in communal areas in residential homes and residents' rooms. A survey of actions undertaken in care homes in the Netherlands (Kunst & Britstra, 2013) found that outdoor sunshades were used most often to protect residents, but the prevalence of cooling facilities such as AC and rooftop cooling was relatively low (41%). Care managers confirmed the importance of most of the cooling measures recommended by the national heat plan and did not foresee problems with implementation of the recommended measures. Shortages of staff and inadequate expertise, however, together with limited independence of residents, were considered barriers to implementation and to the effectiveness of heat management in residential settings (Kunst & Britstra, 2013).

Important qualitative research has been undertaken in care home settings to determine behavioural and organizational issues that could increase heat risks. A study in three care homes in England, United Kingdom, found several factors that increased heat risks, including fixed daily routines of care home residents making it difficult to accommodate periods of intense heat; management structures and systems that do not always allow front-line staff to alter indoor temperatures; and a culture that focuses on cold as the main climate risk, so that high indoor temperatures are not always considered undesirable by residents or staff (Gupta et al., 2016; Gupta and Gregg, 2017). A study in Germany found that there was a good understanding of risks and responses within nursing homes, but that management of heat risks could be limited by staff shortages (Becker et al., 2019).

The Lazio region's health system in Italy sets out specific guidance to reduce the impact of heat on health among elderly people through the definition of lists of vulnerable subgroups, based on comorbidities and sociodemographic conditions, GP active surveillance and geriatric hospital ward-specific response (Schifano et al., 2009; Michelozzi et al., 2010; de Martino et al., 2019). GP surveillance during heat-waves includes compiling a questionnaire on health status during home visits, requesting additional health and social care, changing medication and referrals to nursing homes where necessary. Geriatric wards have additional beds for vulnerable patients during summer and hospital admittance triage to detect heat-related health effects in elderly people through a multidimensional questionnaire and triage scoring system, which considers health, socioeconomic status and assistance (Michelozzi et al., 2010; de Martino et al., 2019). Throughout the summer, mortality rates and ER admission rates are evaluated among the vulnerable elderly population and also used to evaluate the Lazio regional active surveillance programme at the end of the season.

In another example of subnational action, Sweden's Skåne region's heat-wave plan for elderly care has been used by other regions and municipalities as a foundation for their own health and social care heat preparedness. The health and social preparedness part of the plan consists mainly of a series of checklists aimed at those with responsibilities in the welfare and care systems – specifically nurses, doctors, home care managers and health care professionals. The involvement of social care and nursing staff from the inception ensured the practicality and feasibility of the plan (Belusic et al., 2019).

The fragmented nature of health and social care in many countries can be an effective barrier to effective heat action planning (Kovats & Osborn, 2017). Provision of care services for elderly people in particular is very complex, involving a range of partners and both formal and informal networks of carers (Curtis et al., 2018). Collaboration among government departments and professional institutions is necessary to harmonize and standardize health-related and building thermal comfort-related overheating thresholds, with particular consideration for care settings (Gupta et al., 2016; Kovats & Osborn, 2017).

More research is needed on the risks in hospitals, care homes and community-based care from heat-waves, in terms of risk management, clinical practices and how these relate to building design. Important evidence gaps remain regarding the effectiveness of interventions – especially individual interventions (Mayrhuber et al., 2018). In particular, more evidence is needed regarding behavioural responses to heat-waves, and how people interact with buildings when temperatures increase. Further work is also needed to identify key high-risk areas, such as secure units, where interventions or response measures may be not practical.

## 7.3 Climate resilience and sustainability of health systems

### 7.3.1 Heat preparedness in the context of all-hazards and extreme weather events preparedness

Some of the potential disruptions and preparedness needs for heat-waves are common to other extreme weather events, as recognized by the WHO global strategy on health, environment and climate change. This identifies the goal that "all health care facilities … are resilient to extreme weather events; and capable of protecting the health, safety and security of the health workforce" (WHO, 2020b). In the last decade, the overall thinking and policy and research approaches have transitioned from risk-specific preparedness to comprehensive, all-hazards plans and interventions. The all-hazards approach acknowledges that, while hazards vary in source, they often challenge health systems in similar ways. Thus, risk reduction, emergency preparedness, response actions and community recovery activities are usually implemented along the same model, regardless of the cause. Standard emergency management approaches, such as all-hazards programmes, can be modified to incorporate consideration of extreme events to increase preparedness (Ebi, 2011). Within the overall framework of all-hazards preparedness, the international literature argues specifically for more integrated planning and preparedness for extreme weather (Curtis et al., 2017), on account of the clear interdependencies involved in preparedness and response to various types of extreme weather event.

Countries have aimed to improve emergency planning in health care settings through international initiatives such as the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015). EU countries committed to the principles of the Sendai Framework through the Rome declaration (UNDRR, 2018). In the Ostrava Declaration (WHO Regional Office for Europe, 2017a), Member States in the WHO European Region committed to establishing national portfolios of action on climate change aimed at strengthening adaptive capacity and resilience to climate change-related health risks. The operational implications of the impacts of COVID-19 and related heat–health responses are presented in Box 11.

### 7.3.2 Climate-resilient health systems

The preparedness of health systems for increasingly intense and long heat events can be improved within a larger effort to increase the climate resilience of health systems. The WHO operational framework for building climate-resilient health systems identifies the "building blocks" broadly

## Box 11. Operational implications of the impacts of COVID-19 and related heat–health responses

No conclusive evidence is currently available that either weather or climate has a strong influence on SARS-CoV-2 virus transmission (Bukhari & Jameel, 2020; Chen et al., 2020; Gunthe et al., 2020; Gupta, Raghuwanshi & Chanda, 2020; Jüni et al., 2020; Liu et al., 2020; Luo et al., 2020; Ma et al., 2020; Şahin, 2020; Shi et al., 2020; Tobías & Molina, 2020; Tosepu et al., 2020; J Wang et al., 2020; M Wang et al., 2020; Yao et al., 2020; WHO, 2020c). The COVID-19 pandemic and restrictions put in place to contain it may, however, have contributed to aggravating the health impacts of heat-waves.

Although the evidence is still in the process of being collected and analysed, the pandemic and responses to it may aggravate heat-related health impacts in two main ways. First, as explored in Box 7 in Chapter 6, the groups most vulnerable to heat and those most at risk of severe COVID-19 overlap (Phillips et al., 2020). Second, the physical distancing measures and common space-use restrictions put in place by most countries in the WHO European Region in response to the COVID-19 pandemic may hamper implementation of core heat–health prevention activities and aggravate the population's vulnerability to extreme temperatures (Martinez et al., 2020).

- The effectiveness and outreach of heat warnings and health-protective advice could be diminished in a context of widespread health warnings and information related to COVID-19, as explored in Box 5 in Chapter 4.
- Fear of contracting COVID-19 has reduced or prevented access to necessary health care (Lazzerini et al., 2020). This may also apply to patients experiencing heat-related symptoms – for example, related to pre-existing conditions or interactions with medication.
- The use of public cooling centres may contradict distancing regulations, thus requiring careful planning and management of cooling facilities and/or additional at-home cooling options (Hospers et al., 2020).
- The ability to reach out to and care for vulnerable people (such as those living alone, chronically ill and elderly people) may be impaired if health and social care systems are overwhelmed (Armitage & Nellums, 2020).
- Surveillance systems, a core component of heat plans, may have limited available resources on account of the demands of the pandemic (Ibrahim, 2020; Setel et al., 2020).
- Several climate-influenced exposures (such as air pollution, allergenic pollen and heat) tend to occur concurrently (Linares et al., 2020), and the pandemic situation may further hinder the effectiveness and reach of integrated prevention efforts.
- The use of PPE may require additional assurance of workers' protection against heat risks (Daanen et al., 2020; Morabito et al., 2020).
- Well maintained, regularly inspected and cleaned ventilation and AC systems can reduce the spread of COVID-19 in indoor spaces by increasing the rate of air change, reducing recirculation of air and increasing the use of outdoor air. Systems that recirculate the air (recirculation mode) should not be used (WHO, 2020d).

In the light of the connections identified between the COVID-19 pandemic and its responses and the health impacts of heat and their prevention, it appears prudent to amend HHAPs and their implementation to ensure heat–health protection while the COVID-19 pandemic, or any other pandemic, persists (GHHIN, 2020; Martinez et al., 2020; Morabito et al., 2020).

common to all health systems (leadership and governance, health workforce, health information systems, essential medical products and technologies, service delivery) (WHO, 2015). The recent WHO guidance for climate-resilient and environmentally sustainable health care facilities (WHO, 2020a) builds on this operational framework and provides guidance for action and a set of suggested interventions in four core areas of health care: health workforce; water, sanitation and hygiene and health care waste management; energy and infrastructure; and technologies and products.

As they function, health care systems will suffer increasing shocks and stresses related to climate change – for example, resulting from extreme weather events such as heat-waves and wildfires – which threaten patients, staff and facilities. Thus, the focus of health adaptation to climate change to better manage its impacts is strengthening health systems. Health care facilities need to identify and implement interventions that provide protection from external climate-related shocks and stresses (i.e. to build climate resilience) (Ebi et al., 2018).

A review by Paterson et al. (2014) showed a range of indicators of health care facility resilience to climate change that are relevant to heat-wave planning (Table 9). Other indicators have also been developed for the purposes of measuring adaptation

**Table 9. Indicators of climate resilience in the health sector relevant to heat-wave planning**

| Indicator type | Activities | Indicators |
|---|---|---|
| General resilience | • Assessing the cost–effectiveness of health care facility adaptation to extreme weather events and climate hazards, by quantifying the benefits and costs of implementing new or improved measures to address risks<br>• Ensuring adequate leadership and clear allocation of staff roles and responsibilities | • Governance<br>• Financing<br>• Resources (human resources)<br>• Service delivery |
| Emergency management | • Assessing health risks to staff, patients and visitors from climate-related hazards, including assessments of the effectiveness of existing control measures<br>• Establishing plans specifying how the facility will manage staff-related issues during an emergency (such as when staff are affected while at work or when staff are unable to come to work)<br>• Securing alternative or back-up access to critical infrastructure – such as energy and water supplies<br>• Ensuring sufficient ER surge capacity to manage climate-related emergencies and disasters (including extreme heat events) effectively<br>• As part of the emergency plan, adopting an incident management system, performing rapid needs assessments and implementing incident response plans<br>• Ensuring that coordination and communication mechanisms are in place with external agencies and stakeholders | • Development and implementation of emergency plans<br>• Development of indicators to monitor health impacts and response (injuries, increases in ER visits and hospital admissions) |
| Extreme weather events | • Establishing mutual aid/assistance agreements (mutual aid, transfer of patients, sharing of resources and supplies) with other institutions during response and recovery from an extreme weather event or natural disaster<br>• Ensuring that emergency plans for extreme weather events are consistent with national and local HHAPs<br>• Developing systems with national weather services for extreme weather advisories and warnings<br>• Undertaking ongoing evaluations of heat impact and response protocols<br>• Providing training and exercises on preparing for, responding to and recovering from weather-related emergencies | • Monitoring of extreme weather advisories and warnings<br>• Surveillance of health impacts (non-fatal and fatal outcomes)<br>• Identifying at-risk population subgroups and high-risk areas and settings to better target response measures |

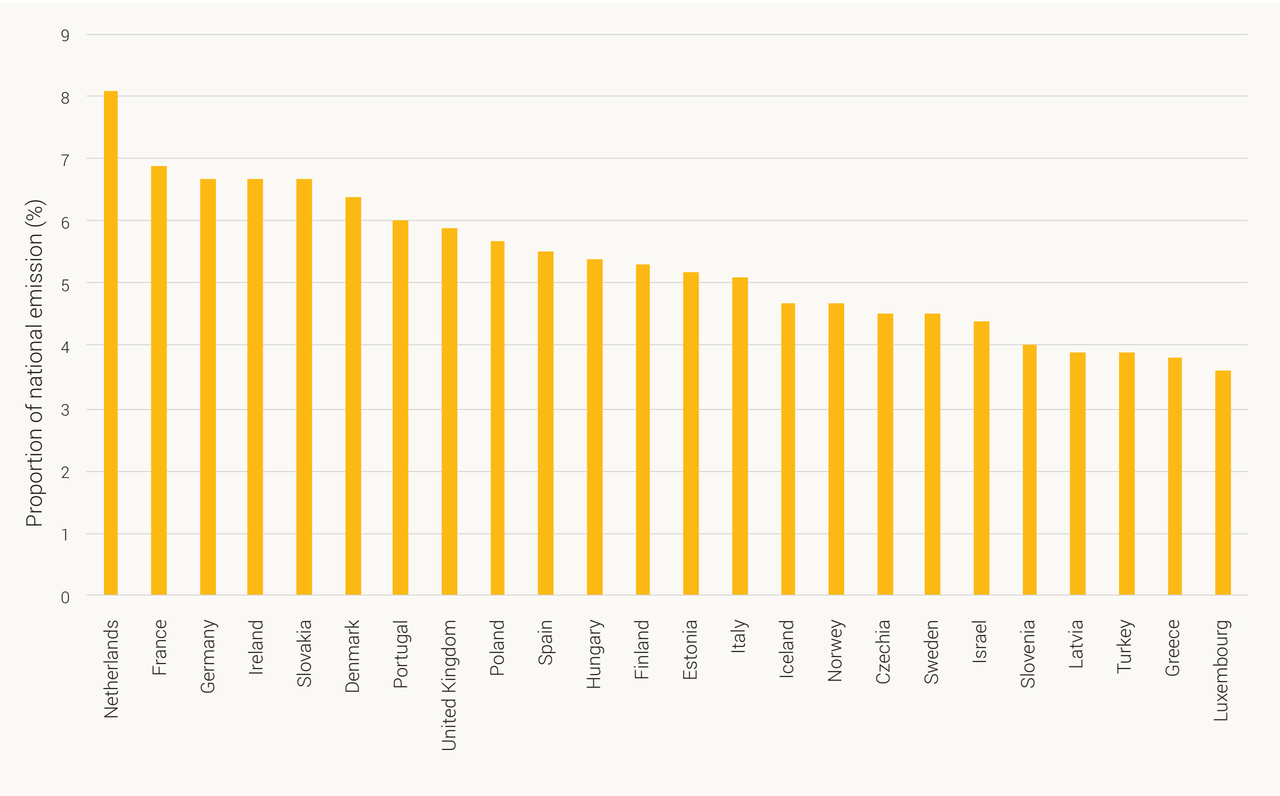
*Source:* adapted from Paterson et al. (2014).

in the health sector to climate change (Committee on Climate Change, 2019). The Pan American Health Organization developed the Smart hospitals online toolkit, which includes guidance documents, training materials, case studies and lessons learned (PAHO, 2017). It was designed for health care facility administrators and technical personnel involved in management, operations and maintenance of health care facilities in the Caribbean. The toolkit includes adaptation measures to improve safety and disaster resilience and green mitigation measures that will improve the environmental performance and sustainability of health care facilities. The United States Centers for Disease Control and Prevention have developed the Building resilience against climate effects framework to support health officials in developing strategies and programmes to help communities prepare for the health effects of climate change (Marinucci et al., 2014). The Canadian Coalition for Green Health Care (2020) has developed the Health care facility climate change resiliency toolkit, which aims to increase awareness of climate change impacts on health care facilities, assess facility resiliency and identify adaptation measures. It includes a facilitator presentation, an online questionnaire on resilience and adaptation tools (Balbus et al., 2016).

While health systems protect people from the health impacts of heat-waves, they also form a large and carbon-intensive part of the economy. As a consequence, they release large amounts of greenhouse gases (Fig. 12) and contribute to both climate change and more frequent and intense heat-waves. Thus, health administrators and authorities are increasingly focusing on addressing climate change through mitigation, and WHO is consequently reviewing the evidence (WHO, 2016), proposing strategic directions (WHO Regional Office for Europe, 2017b) and issuing guidance (WHO, 2020a).

Some examples of carbon emission reduction are presented in Box 12.

**Fig. 12. Health care greenhouse gas emissions as a proportion of national emissions in selected countries (based on availability)**




*Source:* based on data from Pichler et al. (2019).

### Box 12. Low carbon health care against climate change

Reducing the carbon footprint of health systems provides benefits and opportunities for health protection and promotion, financial savings and improved efficiency, as well as reduced environmental risks (Naylor and Appleby, 2013; McGain and Naylor, 2014). In the light of the emerging evidence and clear opportunities in this area, WHO published a review of the scientific literature and strategic guidance for creating environmentally sustainable health systems (WHO Regional Office for Europe, 2016; 2017b), including carbon-cutting interventions.

Hospital care represents a large proportion of health systems' carbon emissions, which can be reduced through improved building insulation and heating, ventilation and AC energy efficiency. Examples include replacing fluorescent lamps with light-emitting diodes, and using solar water-heating systems and lower-carbon fossil fuels such as compressed natural gas for boilers and laundry. Several examples from the WHO European Region are available via the Global Green and Healthy Hospitals network (GGHH, 2020).

In addition, a large share of greenhouse gas emissions in health systems also comes from procured equipment and pharmaceuticals (Eckelman & Sherman, 2016; Eckelman, Sherman & MacNeill, 2018; Malik et al., 2018; Sustainable Development Unit, 2019). The enormous purchasing power of health systems can be leveraged towards lower-carbon alternatives when deemed appropriate and safe. The role of low carbon procurement in health systems is being explored in EU-funded research (EcoQUIP+, 2020) and promoted in the EU through legislation as well as innovation actions such as funding pre-commercial procurement consortia for low carbon health care.

Ultimately, however, a true reduction of health systems' carbon footprint would require moving beyond "green" initiatives towards a deep and long-term redesign of current service models to create sustainable care pathways (Tomson, 2015; Charlesworth & Jamieson, 2019). A clear large-scale example of carbon footprint reductions in a national health system in the WHO European Region is the sustainability portfolio of the United Kingdom NHS, which has cut its carbon footprint by about a third and has pledged to become carbon neutral in 2040 (NHS England, 2020).

## 7.4 Conclusions

Limited progress has been made in national and local HHAPs, particularly in relation to emergency planning in the health sector and long-term measures in health care facilities to improve heat-related responses. A key challenge is the lack of evidence on whether emergency and response measures are followed and effectively implemented, following the challenges related to the patients who do not feel that heat-waves are a risk for them, and, the lack of evidence on response protocols by staff.

Relatively little information is still available on the impacts of heat in health care and social settings, the responses and barriers to effective implementation. In addition, few countries have systems in place to monitor impacts such as overheating or loss of staff time.

Heat is not often seen as a priority within health care planning, especially considering the often limited economic resources, but this may change as the frequency of heat events increases. Increased awareness of the vulnerability of people in residential care has led to some degree of improvements in care in these settings. More research is needed, however, to understand how buildings are at risk of overheating, and to find the solutions to address overheating in hospitals and care homes. Heat risks also need to be managed in the context of increasing demand for carbon mitigation in the health sector via promotion of environmentally sustainable interventions.

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# Chapter 8. Long-term urban planning: reducing heat risks

## Summary

Urban management and planning are key areas for the long-term mitigation of health risks from heat. The urban structure can aggravate heat risks due to the characteristics of the built environment and the UHI effect. Increasingly solid evidence shows that urban green space protects from heat, as do other interventions related to the form, composition and functionality of buildings and urban canyons. Increasing the overall albedo (reflection) of city surfaces, the availability and accessibility of water bodies, and climate change adaptation activities in periurban areas constitute promising alternatives to reduce the effective exposure of city residents to hazardous heat.

Despite their health protection potential, however, urban planning interventions related to HHAPs continue to be infrequent, and they remain the least implemented HHAP core element. A lack of tools for intersectoral action frequently prevents health systems from integrating health protection considerations successfully into mainstream urban planning and management.

## Key messages

- The urban structure, its materials and landscapes can aggravate heat risks.
- Several urban planning and management interventions can contribute to reducing heat risks in cities.
- Urban management interventions such as green spaces, reflective urban materials and modifications to urban form and structure have been proved to reduce thermal stress and should be advocated from a public health perspective.
- Urban greening may also be associated with exposure to health risks, but the evidence on this link is weaker and less consistent than the evidence of its health benefits.
- Heat reduction urban management solutions need to be assessed for local conditions.
- Tools for intersectoral action are lacking to allow public health agencies to influence urban management decisions in order to protect health from heat.

## 8.1 Introduction: urban planning in the WHO guidance on HHAPs

Urban planning and management were recognized jointly as a core element of an HHAP in the WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008). The areas of action proposed within this element were described generically, and included both building-specific and city-level interventions. The latter included:

- increasing albedo of buildings (including cool roofs) and of other urban elements such as pavements;
- urban greening, including green roofs;
- creating water bodies in the city (also known as "blue infrastructure").

Highlighting the urban management component of prevention of the health impacts of heat was fully justified in the guidance, and a further decade of evidence has strengthened the case for city-level interventions against heat exposure – particularly to mitigate the UHI effect. This affects cities worldwide, but is especially prevalent in the dense and heavily populated urban settings that are common in Europe.

A large amount of current evidence is available on what works to reduce heat gains and overheating of the built environment, at least from the physical, engineering and architectural perspectives. The institutions typically in charge of HHAPs, however, are seldom able to promote such changes in cities effectively. Health authorities rarely hold formal competences over housing or buildings other than health facilities. Interventions in the built environment are labour-intensive and costly, often offering scarce incentives or profits for private actors. Formalized health impact assessments of proposed building interventions are still rare within the WHO European Region, yet such systemic interventions would generate significant benefits that would last for decades; they should therefore be implemented whenever urban planning and renewal projects allow.

Unsurprisingly, urban planning is one of the core HHAP elements that has trailed behind others in terms of implementation. Bittner et al. (2014) found greater implementation of the more basic elements (agreeing on a lead body, setting up alert systems and creating health information plans) than of those requiring more resources and longer time periods for implementation (thus requiring broad and long-term political support) or going beyond the competencies of health systems (such as urban management). In addition, urban layouts planned and established decades ago and old building infrastructures may be difficult to adapt and improve in terms of thermal features, which practically restricts urban planning interventions to new developments and urban renewal projects. This situation has not changed significantly: 38% of respondents to WHO's 2019 survey of heat–health action planning said that interventions of long-term urban planning measures to combat heat had been implemented. The survey also revealed that involvement of local authorities (which typically manage urban planning interventions) in HHAPs is still relatively low, particularly concerning specification of local government roles and responsibilities.

This chapter presents a succinct compilation of updated evidence on UHI effects, followed by a description of the main interventions to reduce urban overheating.

# 8.2 Urban determinants of heat exposure and risk

The urban structure can aggravate heat risks, especially during the night due to the absorption and slow release of heat from buildings and other heat-retaining surfaces, the residual heat from energy use and the lack of humidity on the land's surface (Bohnenstengel et al., 2011; Wilby et al., 2011; Heaviside, Macintyre & Vardoulakis, 2017). This phenomenon is known as the UHI effect, and can result in effective night-time air temperature differentials of 3–12 ºC in large cities compared with surrounding rural areas (Memon, Leung & Chunho, 2008), making citizens in the urban areas more vulnerable to the effects of heat (Tan et al., 2010; Burkart et al., 2011).

The intensity of the UHI effect depends on many factors, among which are the local weather conditions, land cover/land use, anthropogenic heat emissions and other microclimatic conditions. As a result, during a heat-wave event, the extremely hot temperatures manifested are not evenly distributed over an urban area. In addition, cities consist of environments that are intensely modified by humans, which may lead to hotspots where the temperature is even higher. Thus, UHIs exhibit strong temporal variations and intra-urban variability (Wilhelmi & Hayden, 2010; Harlan et al., 2013), with higher temperatures determined by urban characteristics such as the use of dark-coloured paving or asphalt, heat generated by vehicles, air conditioners and industrial facilities, and a lack of vegetation.

The effect on local air temperatures of land cover, buildings and impervious and green surfaces has been well documented (Chun & Guldmann, 2014). Expansions of the built-up area to natural surfaces such as vegetation, ground or water trigger changes in the surface energy balance, which may lead to higher surface and air temperatures. Conversely, an increase in vegetated areas and green corridors may lower the heating of urban areas (Bowler et al., 2010; Ng et al., 2012; Yan et al., 2014). The effect of urban geometry (height and mass of buildings) on radiation and airflow also plays a key role in the formation of local climates (Lobaccaro et al., 2019), together with other urban landscape parameters such as surface albedo, mean building height and the sky view factor.

The UHI effect is a result of urbanization and is associated with a range of issues such as increased energy demand and environmental degradation, as well as impacts on human health such as thermal discomfort and increased mortality during heat-waves (Tan et al., 2010; Uejio et al., 2011). Factors like high concentrations of air pollution, wet climates and high humidity can also aggravate the human health impacts of extreme heat in cities (EEA, 2017). The effects of UHIs are significantly increased in parts of cities with high population density, as these tend to lack green spaces (Zhao et al., 2014). As a consequence, not all citizens in an urban agglomeration are exposed to the same heat stress. Their exposure depends on the locations and features of their residence and work address, and their time-activity patterns. Furthermore, some population subgroups (such as elderly people and those with chronic health conditions) are more sensitive to the effects of heat (see further details in Chapter 6).

Another issue associated with urban form, as well as with the use of space, is anthropogenic heat. A lot of common activities and sectors within urban settings can contribute to the UHI effect through waste heat emissions. Beside the waste heat from cooling mentioned in Chapter 5, two other major sources of anthropogenic heat in cities are motor vehicle exhaust fumes and various types of industrial and commercial activities. The effect of this input is much smaller than that of solar heat inputs on the whole, however, and how it translates into increased temperatures in cities depends on multiple factors (Santamouris, 2015).

The study of UHI effects and interventions to minimize them is hampered by a lack of current appropriate urban temperature data. Assessment of the urban thermal environment requires temperature datasets that can capture the diurnal evolution of a city's hotspots. To achieve this, the data must combine high spatial and temporal resolution (Keramitsoglou et al., 2016). Relatively little long-term observational information on the spatial variability of local climates within cities is currently available. The climatological description of a city is often based on one or a few meteorological stations and therefore not representative of the whole. Another issue is that information about the spatial variability in local climate usually applies to a limited period of time. Remotely sensed satellite-derived thermal data of high spatiotemporal resolution have, however, been proposed as a prominent solution to facilitate the study of UHI effects (Pichierri, Bonafoni & Biondi, 2012; Keramitsoglou et al., 2017). Such temperature information could enable assessment of UHIs in real time, and would contribute to the timely generation of relevant higher-value products and services for energy demand and human health studies.

## 8.3 Interventions to reduce urban overheating

### 8.3.1 Urban greening and urban blue infrastructure

Substituting greenery for typical urban surfaces and materials contributes to decreasing the UHI effect. This is indisputable, and the scientific, technical and public health discussion is about how to translate that reduction in heat into a protective factor. In general, evidence is increasing that availability and accessibility of green spaces can reduce the risk of heat-related cardiovascular and all-cause mortality in the vicinity of such spaces (Gronlund et al., 2015; Murage et al., 2020; Gascon et al., 2016). In addition, a multitude of psychological and well-being benefits have also been observed. A full exploration of all the health and well-being benefits of greenness in cities is beyond the scope of this publication, but a comprehensive review was conducted by the WHO Regional Office for Europe (2016).

A multitude of modelling studies link increases in urban green spaces with reductions in effective temperature, and link those with reductions in projected heat-related mortality and morbidity. Studies have predicted health benefits from heat reduction via greening in a multitude of urban settings throughout the WHO European Region (Salata et al., 2017; Pascal, Laaidi & Beaudeau, 2019; Venter, Krog & Barton, 2020). Aside from model predictions, reductions in heat-related health impacts are also observed at the population level. A recent study covering cities across 22 OECD countries (among them 100 cities in eight countries in the WHO European Region) found that those surrounded by a predominantly rural region and those with larger green surfaces showed lower heat-related mortality (Sera et al., 2019).

Much of the evidence on health benefits from urban interventions to reduce the UHI effect is based on modelling rather than epidemiological evidence, however. There is a risk that models fail to capture the complexity of urban interactions, thus limiting their usefulness in practice for public policy design. Studying the actual causal links and evidence-based empirical effects of urban greening interventions on heat-related health impacts is challenging. While landscape and infrastructure modifications such as green and blue spaces, green roofs and others are commonly expected to reduce heat-related health risks, the actual effect of the interventions is difficult to prove (Hondula, Davis & Georgescu, 2018). For example, proximity to urban green and blue spaces was associated (adjusting for confounding factors) with decreased mortality for elderly populations in Lisbon, Portugal (Burkart et al., 2016), and the health benefit was still seen several kilometres away. Similar results were observed in

Spain (de Keijzer et al., 2017); but in both cases, the authors acknowledged that the complexity of the relationships involved made determining a causal relationship difficult.

Green spaces include a wide variety of alternatives, from grass or isolated trees to full urban forests, and consequently provide different degrees of cooling. Vegetation structure, composition and management matter greatly, so great care is required in the planning of urban greening if cooling is one of the main objectives (Vieira et al., 2018). Moreover, different patterns in greening interventions also influence the cooling in adjacent areas (Aram et al., 2019). For example, a study in Leipzig, Germany, found that cooling effects were greater in urban forests than in parks; that cooling increased with increasing size but differently in forests and parks, whereas the influence of shape was the same for forests and parks; and that the characteristics of the green spaces were more important than the characteristics of the residential surroundings in terms of cooling effects (Jaganmohan et al., 2016). More research is needed to determine how those patterns and factors influence the distribution of heat-related health risks.

Urban greening may also be associated with exposure to health risks, including increased exposure to pesticides, allergenic pollen, disease vectors, faecal pathogens in soils and injuries (WHO Regional Office for Europe, 2016). The evidence of health risks from urban green spaces is weaker and less consistent than the evidence of health benefits, however. For instance, some studies found that green spaces are linked to an increased risk of allergies, while others found protective effects (Fuertes et al., 2016; Ruokolainen, 2017). Moreover, with adequate design, management and maintenance, the potential for health risks from green spaces can be adequately minimized.

The current evidence base does not yet allow specific recommendations to be made on how best to incorporate greening into an urban area in a way that maximizes health protection from heat. However, the WHO Regional Office for Europe review (2016) provides directions and examines important factors that can be used in decision-making. While green spaces are by far the best studied type of urban planning intervention against heat, important questions remain, including the following.

- What arrangements and types of urban green space (for example, trees versus grass) are more effective to prevent heat-related mortality and morbidity?
- What is the maximum protective effect that could be expected from large deployments of green spaces?
- What are the potential benefits and costs of alternative interventions, including access to AC and actions targeting the workplace?

In addition to the health-protecting effect of green spaces, an increasing number of studies are focusing on the ecosystem services of blue infrastructure. As with green spaces, a multitude of modelling studies have looked into the benefits of reduced heat load through urban water bodies. The results vary; for instance, small but significant cooling effects of water bodies were calculated for Vienna, Austria (Žuvela-Aloise et al., 2016) but in the Netherlands models suggested that local thermal effects of small water bodies can be considered negligible in design practice (Jacobs et al., 2020). A recent meta-analysis (Gunawardena, Wells & Kershaw, 2017) found that inadequately designed blue spaces may actually exacerbate heat stress during oppressive conditions. Moreover, as in the case of urban greening, some health risks may increase through the use of water bodies. These could include drownings and injuries, recreational water infectious illnesses, excessive ultraviolet light exposure and vector breeding (WHO, 2020). Adequate maintenance, management and safety measures can help reduce most of these risks, however. Box 13 sets out a case study of the influence of existing urban green spaces on heat risks.

## Box 13. The influence of existing urban green spaces on heat risks compared to socioeconomic and demographic factors

López-Bueno et al. (2020) analysed the roles of income level, proportion of the population over 65 years of age, existence of AC units and hectares of green zones simultaneously in the impact of heat on daily mortality in districts in Madrid, Spain, between 2010 and 2013. In the raw primary model analysing the relationship between the pattern of risk and the hectares of green zones found in each district, they observed that an increase in green zones decreased the probability of detecting heat impacts. The effect disappeared in the adjusted model, however, suggesting a complex interaction between urban planning and sociodemographic factors in relation to heat risks to health.

In this study, household income was the strongest predictor of risk. In turn, household income was directly related to availability of AC. Although green zones mitigated the impact of heat-waves, their role was not more determinant than that of income level or AC in homes. Recent evidence shows that as homes install AC systems, the association between green zones and heat mortality becomes weaker, while the association between green zones and energy savings during heat-waves becomes stronger (McDonald et al., 2020). Therefore, the protective effect of green zones is reflected indirectly in terms of the greater need for energy to reach a comfortable temperature in the home. In addition, the presence of green zones reduces the levels of air pollution in cities (Rafael et al., 2020) and contributes to improved physical condition and mental health (Andreucci et al., 2019; Marcheggiani et al., 2019).

### 8.3.2 Pavement and outdoor urban landscape materials

Several of the interventions mentioned at the building scale can also be applied to other surfaces in the urban landscape beyond buildings themselves. This is especially the case for pavements and public surfaces, and in particular for interventions to reduce their ability to absorb and retain heat and to increase their albedo by, for example, using reflective materials or lighter colours. Indeed, large-scale deployments of interventions to increase albedo in pavements could result in important effects to reduce the UHI effect (Akbari, Damon Matthews & Seto, 2012). Some studies suggest that increased rooftop albedo may have a measurable heat-related mortality reduction: increasing rooftop albedo from 0.32 to 0.90 could result in around 45 avoided heat-related deaths per year in New York City (Susca, 2012). Increasing albedo may be an effective city-wide strategy in some types of urban settings for reducing heat-related health risks (Silva, Phelan & Golden, 2010), particularly in areas where substantially increasing green spaces may not be possible. An increase in reflective surfaces at the city level to reduce UHI intensity may have unintended consequences, however, in terms of increasing concentrations of some air pollutants like ozone, a secondary pollutant whose formation is aided by sunlight – both direct and reflected on surfaces (Fallmann, Forkel & Emeis, 2016).

As with other urban level interventions against overheating, material and landscape decisions must be tailored to local circumstances and conditions. All advantages and disadvantages, benefits and costs should be taken into account before undertaking such interventions. The German HHAP (see Box 14) constitutes an example of general recommendations to be tailored to local conditions.

## Box 14. Recommendations for action on long-term urban planning and building in the German HHAP

The German HHAP recommends the following measures related to buildings:

- developing heat protection requirements for buildings (such as thermoglass, integrated lamella blinds in windows, roof overhangs to provide shade and shade on roofs through solar energy installations);
- undertaking technical construction measures – for example, ventilation technology, heating and cooling coils, fans and possibly AC systems, especially in sensitive areas;
- ensuring heat-appropriate planning of new buildings (including consideration of architecture, width/height ratio, street development, orientation and site) in urban and rural areas;
- using construction materials that reduce heat and avoiding materials that store heat;
- installing drinking-water dispensers in buildings and public spaces;
- establishing and using cooling centres – for example, public cool spaces in government offices, shopping malls, church buildings, bookshops and train stations.

It also recommends a number of urban and building planning measures:

- conserving and creating shaded green spaces and parks, preferably with cooling evaporation areas such as bodies of water or water features;
- setting up generous shaded areas (with structural measures such as pavilions, roofing, awnings, sunshades or sails and with landscape planning such as replanting or conserving trees with thick foliage);
- installing humidifiers in outdoor facilities and on terraces;
- reducing heat by creating or keeping clear air channels and areas where cold air is produced;
- reducing the degree of soil sealing in open and public squares to avoid build-up of heat and ultraviolet radiation from reflection;
- encouraging planting of trees and shrubbery, as well as setting up roof gardens (taking care to select plants low in allergens that can tolerate heat and dry conditions);
- installing canopies and roof structures that provide shade, preferably using materials that reduce exposure to ultraviolet radiation;
- installing fixed drinking-water dispensers in public spaces.

Further information can be found on the website of the Centre of Excellence For Climate Change Impacts and Adaptation (KomPass, 2020).

*Source:* BMU (2017).

### 8.3.3 Urban form and structure

The natural and artificial morphology of urban settings influence parameters relevant to their inhabitants' thermal comfort, such as air temperature, relative humidity, wind velocity and others (Lobaccaro et al., 2019). In other words, the political and design decisions that determine changes in the physical form of cities can improve urban microclimates. For example, studies show that the ratio of average height of buildings to the width of the streets between them strongly affects the temperatures experienced by pedestrians, with wider streets generally being warmer in daytime and cooling down more quickly at night than narrower ones, and with upper walls receiving more radiation in daytime but cooling down more quickly than lower walls (Chen et al., 2020; Wai et al., 2020).

Also important are the orientation of the buildings and the streets. A study in Bilbao, Spain (Lobaccaro et al., 2019), found that for the best orientation (that least prone to dangerous overheating: north-west/south-east), the duration of the peak heat period lasted for only one hour, while for the worst orientation (the most heat-prone: north-east/south-west), the thermal discomfort persisted for over 10 hours in all urban canyons. The same study found that within a given type of urban morphology (for example, compact or open-set, low-rise, mid-rise or high-rise), the location and distribution of green spaces can make a significant difference in terms of cooling potential. Solutions connected to increasing wind velocity may be more applicable in warm countries, as creating increasing wind conditions in cities in cold countries might not be optimal in the winter season. Generally, all potential urban management solutions to reduce heat need to be assessed for the local conditions.

A noteworthy avenue for consideration of urban level infrastructure planning is the "superblock" model – an innovative urban and transport planning strategy that aims to reclaim public space for people; reduce motorized transport; promote sustainable mobility and active lifestyles; provide urban greening; and mitigate effects of climate change (Rueda, 2019). In essence, the superblocks would prioritize internal non-motorized transportation, pedestrian areas and green spaces against a looser conventional traffic network. A study in Barcelona assessed that applying this model could avoid 667 premature deaths (95% CI: 235–1098), of which at least 117 (95% CI: 101–37) would be heat-related (Mueller et al., 2020).

### 8.3.4 Reducing UHIs at the regional scale

Interventions beyond the city limits can also contribute to reducing the UHI effect. This, in turn, has two aspects of relevance: interventions beyond the urban landscape itself, regardless of administrative boundaries; and interventions beyond administrative boundaries into (still urban, but less structured) areas of informal growth.

On interventions beyond the city landscape, it is worth highlighting the possibilities of periurban greening, which – alongside its effect of reducing UHIs – can contribute to reducing risks related to other meteorological extremes, such as floods and droughts, and climate change (EEA, 2012). Another example of interventions at the scale beyond city limits is the creation of wind corridors from surrounding green areas into the city, though these may not be suitable in colder countries. Several European cities have included wind corridor considerations into their planning, including Germany and the Netherlands (Filho et al., 2017). This has clear implications for intracity land use, which can have significant impacts on the local intensity of UHIs and related microclimates. Some evidence also exists that, in several cities, the residents who are most susceptible to the health impacts of heat actually reside in the periphery (Depietri, Welle & Renaud, 2013).

While less prevalent and massive than in other regions of the world, informal settlements beyond city limits are not uncommon throughout the WHO European Region. Their lack of planning, poor-quality dwellings and underserved status could make residents more vulnerable in some instances. Evidence on the health impacts of heat in these communities, as well as the potential effectiveness of adaptation – such as the promotion of periurban adaptation – is scarce, however.

### 8.3.5 Reducing heat risks through intersectoral action in urban planning

From the standpoint of public health interventions, the potential to influence urban form decision-making to minimize the health impacts of heat is limited. Those decisions are squarely outside the sphere of influence of the health sector; further, intersectoral coordination mechanisms for public health practitioners to feed health evidence into the decision cycle are rarely in evidence (Rantala, Bortz & Armada, 2014). If urban planning and management includes health considerations via intersectoral action, however, it can make long-lasting differences to health and well-being. At the general urban planning and management level, the inclusion of health in strategic environmental assessments is a good opportunity to influence the urban planning and policy cycle. WHO recommends various entry points for health throughout the strategic environmental assessment process (WHO Regional Office for Europe, 2019):

- at the screening phase – through the active involvement of health impact assessment experts, inclusion of health criteria in screening tools and similar;
- during scoping – by adequately covering health in the terms of reference, including the role and competencies of experts who will conduct the health-related assessment activities;
- during assessment and reporting – ensuring the quality and comprehensiveness of health-related assessments, including stakeholder engagement activities, disclosure of information, methodologies used, credibility of baseline and appropriateness of recommendations;
- in the process of consultation and participation – ensuring that health sector actors and advocates are actively engaged in the policy, planning and programme processes;
- during decision-making – actively engaging health sector actors in decision-making activities;
- as part of monitoring and evaluation – including health indicators in the monitoring and evaluation process.

At the project level, the health impact assessment of urban management interventions probably represents the best opportunity to feed heat and health considerations into the urban management and policy cycle. While still infrequent, Europe has some examples of the health impact assessment of urban interventions being a mandatory document for developers to present to the approving authority.

## 8.4 Conclusions

Modifying the built environment can help to reduce hazardous risks to health from heat significantly. A wide range of interventions is available; the best possible results are typically obtained through optimal combinations of various interventions, tailored to local conditions.

Urban greening is well supported by evidence as an effective strategy to reduce heat-related mortality, although the specific causality of this is poorly understood. Increasing the albedo of pavements and other city surfaces may be an effective complementary strategy. The morphology of urban areas has a clear influence on heat exposure, and although the possibility of successfully advocating modification of such factors is limited, it is important that health authorities and practitioners are aware of possible hotspots based on the relevant variables.

Beyond the city scale, various interventions can be implemented with effects on heat exposure reduction, such as periurban greening, establishment of wind corridors and adequate management of land use. From the standpoint of prevention, adequate intersectoral mechanisms for health authorities to promote these interventions, which lie squarely beyond their competencies, are lacking. Entry points can be found to include heat and health considerations, however, and to make a lasting difference.

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# Chapter 9. Real-time information: surveillance, monitoring and evaluation of HHAPs

## Summary

Monitoring and evaluation are crucial components of an HHAP and, to date, are operational and fully integrated in only a limited number of Member States in the WHO European Region. This limitation is critical, as it hinders formal evaluation of the processes, components and overall potential role and effectiveness of HHAPs in reducing the health impact of heat-waves. The dual use of these surveillance tools – both informing health care systems and stakeholders of current impacts in order to modulate action during extreme events and evaluating the health impacts of action after heat-wave events – is vital for the effectiveness and progressive improvement of current HHAPs and the response measures introduced.

Evaluation entails multidisciplinary and collaborative action between various stakeholders to address the different aspects and components of the HHAP, user needs and caveats. Formal monitoring and evaluation need to be promoted. Health surveillance systems already in place can be adopted to evaluate extreme heat events and to evaluate HHAPs. Best practice evidence and sharing of experiences are vital – both locally and at the European level – to improve HHAP implementation and effectiveness, especially given future warming and increased frequency and intensity of heat-wave events.

## Key messages

- Real-time surveillance is still limited in European HHAPs. It is important to set up near-real-time surveillance systems so that prevention and response can be adjusted, based on health impact response.
- Health surveillance systems currently in place can be adapted for HHAP evaluation.
- Formal, systematic HHAP process and outcome evaluation is still an exception in European countries.
- Monitoring and evaluation should be strengthened to improve understanding of what works and what needs to be improved in HHAPs.
- Further research is needed to identify the potential causal pathways linking preventive actions and actual reductions in heat-related health impacts.

## 9.1 Introduction

Availability of timely health data during heat-waves and emergency situations is essential for an effective public health response. The WHO Regional Office for Europe's guidance on heat–health action planning identified near-real-time surveillance of health outcome data and evaluation of HHAPs as core elements (Matthies et al., 2008; WHO Regional Office for Europe, 2011). The use of consolidated health information systems or ad hoc surveillance systems is important not only to monitor health impacts during and after an event but also to guide decision-makers to adapt and reinforce prevention and emergency measures. Surveillance data may be used to evaluate how the health system and interventions (phone lines, GP visits and calls, ambulance calls, ER visits, bed occupancy and so on) are responding during extreme events and to help redirect interventions. Further, surveillance and health outcome data have been used to evaluate effectiveness of HHAPs in reducing heat-related deaths and improving adaptation and awareness.

How to evaluate an HHAP as a whole and its individual components is far from simple. As stated in the 2008 WHO guidance, it should focus on evaluation of processes and outcomes; it should also be written up and published, and subsequently used to guide HHAP improvements (Matthies et al., 2008).

This chapter gives a brief overview of surveillance systems in place in Member States in the WHO European Region and their current use in evaluating HHAPs. It further focuses on recent evidence on monitoring and evaluation of HHAPs and considers future perspectives and research gaps.

## 9.2 Current status of HHAP surveillance

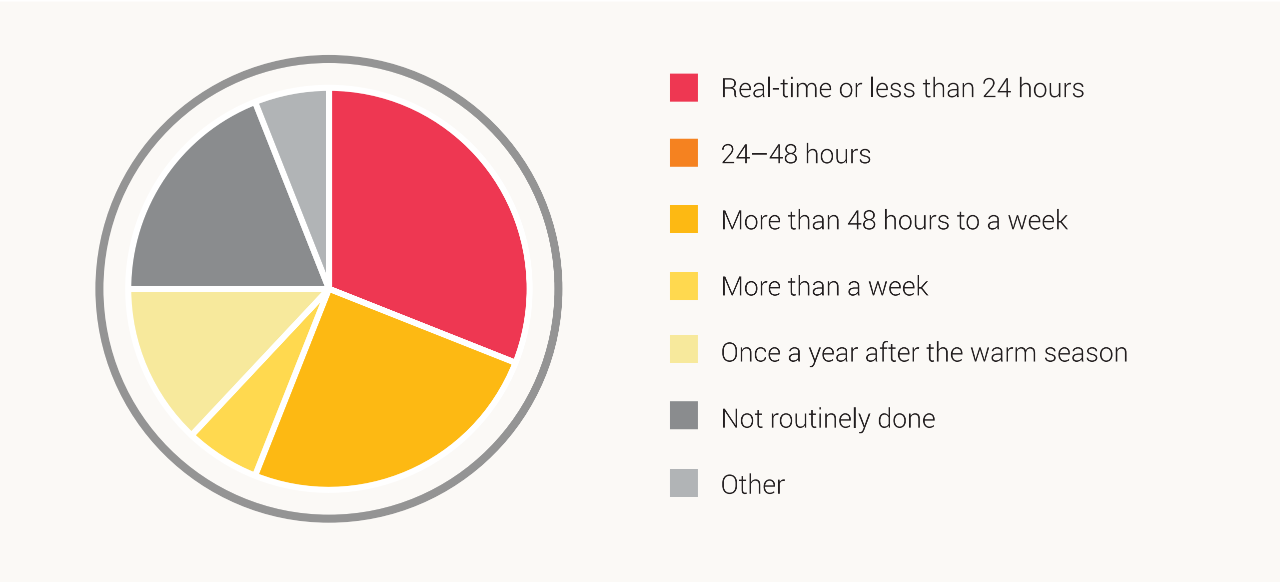
Results from WHO's 2019 survey of heat–health action planning show that real-time surveillance of national HHAPs is still limited: only 25% of countries had fully implemented surveillance and 31% had implemented it in part. Low rates of implementation of monitoring and surveillance were also observed in previous evaluations (Lowe, Ebi & Forsberg, 2011; Bittner et al., 2014). When asked with what frequency surveillance data on heat-related health outcomes were received and analysed, a significant proportion of countries (31%) stated that they had a delay of 24 hours on surveillance data on heat-related mortality or morbidity; 25% had a delay of between 48 hours and a week; and 6% had a delay of more than a week. Further, only 13% of respondents carried out a seasonal evaluation at the end of summer, and almost 20% did not have any surveillance systems in place (Fig. 13).

Unfortunately, the survey did not distinguish what types of outcome data were collected or the different temporal updates of data, which may also differ significantly.

When asked which aspects or elements of the HHAP were least effective or missing, two of the most common responses were lack of surveillance of heat-related health outcomes and lack of formal evaluation of the plans and evidence of their effectiveness.

The limited implementation of surveillance could be related to inadequate resources – both human and financial – available for setting up and running surveillance systems, and technical difficulties, such as data availability, data processing and the statistical analysis required.

**Fig. 13. Frequency of surveillance data retrieval and analysis within national HHAPs**




## 9.3 Health data sources for surveillance and innovations

Following the 2003 heat-wave, when quantifying the impact of the heat-wave became a priority among European countries, health data from information systems and registries were used to monitor and evaluate the impact. The peer-reviewed literature has consistently shown an immediate effect of heat, with an increase in daily deaths on the same day or the subsequent 2–3 days (Basu, 2002; Gasparrini, 2016). Moreover, most of the countries with a surveillance system in place consider mortality data to monitor heat-related health effects.

Morbidity outcome results, suggesting that the impact is immediate, that health conditions worsen very quickly and that vulnerable subjects do not have time to reach health care settings. Increases in cause-specific ER visits were also reported consistently, as were increases in calls to GPs and heat–health helplines during heat-waves, reporting mild to severe heat-related symptoms (Josseran et al., 2009; Michelozzi et al., 2010; Pascal et al., 2012; Elliot et al., 2014).

Several European countries have implemented total mortality surveillance systems, which provide death counts in a timely manner to monitor summer heat-wave health impacts. Countries with rapid mortality surveillance systems to monitor the impact of heat are also included in the European EuroMOMO network for rapid mortality surveillance (Statens Serum Institut, 2020), including France, Hungary, Italy, Malta, the Netherlands, Portugal, Spain, Switzerland and the United Kingdom (England and Wales). The EuroMOMO network was set up to monitor the impacts of influenza and other possible public health threats, and has since also been used to monitor environmental exposures such as cold spells across Europe (Mazick et al., 2012; Vestergaard et al., 2017). It could potentially be extended to monitor the impacts of heat-waves. In addition, some of these countries use mortality surveillance data to evaluate HHAPs (Pascal et al., 2012; Schifano et al., 2012; Tobías et al., 2012; Linares et al., 2015; Green et al., 2016; Ragettli et al., 2017; de'Donato et al., 2018).

England (United Kingdom) and France, for example, have adopted a more inclusive approach, combining both mortality and morbidity outcomes in their heat syndromic surveillance. Public Health England runs the national syndromic surveillance service, which comprises data from four health surveillance systems: telephone health helpline calls (NHS Direct non-emergency medical helpline); GP in- and out-of-hours consultations; ER visits; and more recently also ambulance call data (Elliot et al., 2014; 2015). Daily data are monitored and assessed using epidemiological and statistical processes to detect unusual activity. They are particularly valuable for detecting the impact of seasonal infections and environmental incidents, including extreme heat and cold (Elliot et al., 2014; 2015; Hughes et al., 2014; Morbey et al., 2015). The combined approach facilitates monitoring of a series of health outcomes with different symptom severity: GP calls and NHS Direct helpline calls refer to heat stress, heat- and sunstroke or the impact of heat in general, while cause-specific ER visits account for more severe outcomes.

Similarly, in France the national syndromic surveillance system is used to assess heat-wave impacts and to support HHAP implementation and evaluation. The integrated system includes mortality data, ER visit data and emergency calls to GPs (Josseran et al., 2009, 2010; Pascal et al., 2012). Josseran et al. (2009) developed a set of indicators using ER visit and hospitalization data to monitor and analyse the impact of heat-waves, taking into account old age and cause-specific admissions, and found that dehydration, hyperthermia, malaise, hyponatraemia, renal colic and renal failure increased significantly during heat-waves.

The Italian surveillance system includes near-real time mortality surveillance and sentinel ER visit surveillance. It provides weekly bulletins to monitor the impacts of mortality and extreme weather events (Michelozzi et al., 2010). Mortality related to heat-waves is monitored throughout the summer, with weekly bulletins published on the Ministry of Health website, and an evaluation is carried out at the end of the season to quantify the impact of heat-waves. The Ministry also activates a national health helpline during summer, and calls and access to care are evaluated within active surveillance monitoring plans by GPs and social services (de'Donato et al., 2018).

In Germany a web-based emergency service database, which includes ER visits and emergency calls, was used for real-time surveillance of heat-related morbidity in Frankfurt am Main. Results from recent summers (2014–2018) show a consistent increase in emergency calls for heat-related disease during heat-wave periods (Steul, Jung & Heudorf, 2019).

Data from near-real-time surveillance systems (24–48 hours update) can also be used to guide decision-makers to adapt and reinforce prevention and emergency measures where and when necessary. For example, an increase in GP and heat helpline calls can be of use to indicate an increase in heat-related symptoms and subsequent increases in emergency service and hospital admissions, allowing health services to prepare for the potential added workload and service demands.

In recent years, owing to limited resources and technical expertise, web data and social media messages have been used to define innovative heat surveillance systems. Jung et al. (2019) studied the association between heat-related web searches and social media messages (using Twitter and Google searches) and ER visits and hospital admissions for dehydration, heat-related illness, and cardiorespiratory and renal disease. The authors found a positive association between heat-related illness and dehydration case web data, suggesting that web and social media could be used as alternative syndromic surveillance tools. Furthermore, as social media and web-based tools also provide advice on how to prevent and reduce heat-related symptoms, these tools and search strategies could be used to improve outreach and adaptation.

Another alternative surveillance tool was developed to consider heatstroke internet searches in Shanghai, China (Li et al., 2016). The study analysed the association between heatstroke web searches and heatstroke health outcomes during heat-wave events, and found that the web searches had better predictive power for health risks than temperature during heat-waves. These alternative syndromic surveillance measures are less labour- and resource-intensive than traditional surveillance systems, and may facilitate more timely assessments. Moreover, they provide evidence of social media channels through which advice and adaptation measures are sought by the public, suggesting that public health services should actively engage in these to convey prevention and advice on heat-related risks, especially for vulnerable subgroups.

## 9.4 Use of surveillance data and monitoring in HHAPs

Since the implementation of surveillance systems to monitor heat impacts, the evidence from studies quantifying heat-related impacts has grown substantially in recent years, and has been reported in a timely fashion. Leonardi et al. (2006) analysed NHS Direct calls to evaluate the health impact of the 2003 heat-wave in England and Wales, United Kingdom. The total number of calls and selected cause-specific calls (for fever, vomiting, difficulty breathing, heat- and sunstroke) were studied, and an association with heat was observed, especially among elderly people and children with symptoms of heat- and sunstroke and fever. More recently, syndromic surveillance data were used to evaluate the 2013 heat-wave in England and Wales, reporting an increase in GP and NHS Direct calls, mostly for heat- and sunstroke, during Level 2 and Level 3 warnings (Elliot et al., 2014; Smith et al., 2016). GP in-hours calls doubled in 2013 compared to non-heat-wave summers (Smith et al., 2016). An increase in ER visits was also observed during the 2013 heat-wave, but not for cardiac diagnoses (Elliot et al., 2014).

Josseran et al. (2010) used syndromic data from the surveillance system reporting ER visits in France to evaluate the impact of the 2006 heat-wave. Higher than expected numbers of ER visits for heat-related causes were observed on more than 90% of days on which a heat alert was issued, suggesting the validity of the surveillance in capturing health impacts in a timely manner. The authors also estimated the operational costs of the surveillance system, showing the limited costs compared to other similar systems and suggesting that a formal evaluation was needed to show the overall effectiveness of surveillance systems.

Claessens et al. (2006) defined an indicator based on ER visit surveillance data as an alert system for potential increases in mortality due to heat-waves. The indicator included age (over 70 years), having a fever above 39 °C and being admitted to the ER. Another study looked at whether surveillance data may be useful for policy-makers to support the decision-making process during heat-waves, especially for modifying response measures and emergency protocols or issuing warnings (Pascal et al., 2012). Similarly, the Canadian SUPREME system developed an open-source web application for surveillance and prevention of the health impacts of heat (Toutant et al., 2011). The web tool includes environmental data and heat warning and surveillance data (mortality, hospital admissions, ambulance calls, ER visits and so on) with a cartographic application that allows mapping of vulnerability factors and monitoring of health impacts and exposures. The tool would be of great use for decision-makers in both the preparedness and emergency phases.

It is worth noting, however, that constant and consistent monitoring of heat-wave health impacts across Europe each summer is limited, to date, often focusing only on extreme events and restricted to some countries. Country or regional reports – often in the grey literature, in local languages only or with restricted access – are hard to find, hindering geographical coverage and data availability.

### 9.4.1 Evaluation of HHAPs

Formal and independent evaluation of HHAP effectiveness is important to:

- assess whether policies are valid in reducing health outcomes (mortality and morbidity);
- evaluate whether measures introduced are ethical and reduce inequalities;
- help define elements that need improvement (cost–effectiveness of interventions, reducing practical barriers);
- monitor health impacts and changes over time.

Evaluation of the effectiveness and validity of HHAPs and public health measures put in place helps provide policy-makers with the necessary information to implement state-of-the art action and the necessary resources to reduce heat-related impacts. Evaluation should be provided for in all stages of HHAPs (planning, development, implementation and revision) to ensure that they are not only efficient but also effective in identifying subgroups most at risk, improving awareness and response and reducing heat-related impacts. As noted in the WHO guidance, HHAPs should implement a holistic evaluation framework approach that accounts for both health and social aspects in addressing heat adaptation and response, thereby reducing health inequalities (Matthies et al., 2008; WHO Regional Office for Europe, 2011).

The proposed approach should address both evaluation and monitoring of processes and outcomes, while bearing in mind practical aspects, current operational policies and resource availability. Process evaluation focuses on examining the individual processes of an intervention, while outcome evaluation is the assessment of the effectiveness of the HHAP or specific core element in terms of avoiding or reducing health impacts through the use of health outcome indicators (Matthies et al., 2008; WMO & WHO, 2015). The WHO guidance provided standards for evaluation and key aspects to consider, and stressed the need for constant and systematic monitoring over time to detect changes in health response and ensure improvement of prevention mechanisms (Table 10).

It is important that the evaluation process is formally defined, and that results are written up and disseminated to the stakeholders involved in the HHAP (Morgan, 2006). What data to collect (baseline and during the operational phase) and how to carry out evaluation of the HHAP should be defined before the system is operational; performance standards should be set up and then evaluated in terms of outcome and economic impacts, if possible. Evaluations will help build confidence in the system and improve the knowledge base among the stakeholders (Matthies et al., 2008; Bittner et al., 2014; Boeckmann & Rohn, 2014; WMO & WHO, 2015; Martinez et al., 2019).

### 9.4.2 Process evaluation

When assessing HHAP processes, the focus should be on standards of implementation and examining the process of interventions and actions undertaken by various stakeholders at different stages. Process evaluation determines whether all parties and stakeholders involved have an understanding of their roles and responsibilities, and are able to undertake them during a heat-wave. Information and communication play a central role here in terms of awareness-raising and perceptions of both stakeholders and users. Perception has been widely addressed in Chapter 4, examining both general public and vulnerable subgroup perceptions of risk, their awareness, behavioural changes and response mechanisms. A recent review showed that among the several surveys carried out among the general public and vulnerable groups, although the majority of those interviewed were aware of the risks and heat warnings, this did not translate into action or behavioural change (Bassil & Cole, 2010). Another crucial aspect that emerged was the fact that vulnerable subjects often do not perceive themselves as being most at risk, and hence do not respond accordingly (Abrahamson et al., 2009; Bassil & Cole, 2010; Wolf et al., 2010; Toloo et al., 2013b).

**Table 10. Components of an HHAP evaluation**

| Components of process evaluation | Components of outcome evaluation |
|---|---|
| Key messages provided to the population | Measurement of:<br>• mortality – daily temperatures and deaths before, during and after heat-wave periods; mortality in different settings such as care homes<br>• morbidity<br>• health care utilization<br>• non-health-related outcomes such as productivity and workforce absence<br>• an assessment of the temperature–mortality function<br>• health behaviour changes related to heat |
| Awareness among the population of the HHAP and its messages | Epidemiological studies to estimate heat–health-related effects and potential changes over time |
| Comprehensive warnings issued in a timely manner | Assessment of behavioural changes in response to the plan (intermediate outcomes) |
| Stakeholders following the plan and acting according to guidance | Consideration of non-health-related outcomes (economic cost–benefit analysis) |
| Stakeholders considering the overall plan | Health care utilization |
| **For both outcomes:** a defined evaluation protocol, regular evaluations, objective methods, written evaluation reports | |

*Sources:* Matthies et al. (2008); WHO Regional Office for Europe (2011).

A Cochrane review was carried out to evaluate whether heat-related public health interventions reduce adverse health effects of heat-waves and high temperatures in the population (Michelozzi et al., 2014). It found only four studies: one experimental study suggesting that social and health care intervention at home was able to reduce hospital admissions among frail elderly people; two studies (one experimental and one non-experimental) suggesting that an information campaign seemed able to increase protective behaviour towards heat among elderly people living at home and to reduce heat-related mortality in the general population; and one study showing a reduction in mortality risk among patients hospitalized during heat-waves in wards with AC.

Public health decision-makers and health and social workers involved in HHAPs are key players and need to be adequately informed and aware of what to do. Process evaluation should include an assessment of how these stakeholders perceive their roles in HHAPs and how this influences practice. It should also consider whether the advice and interventions provided within the HHAP are feasible and realistic. Several countries carry out questionnaires, surveys, workshops or working groups at the end of the summer to evaluate HHAPs (Sheridan, 2007; Wolf et al., 2010; Van Loenhout, Rodriguez-Llanes & Guha-Sapir, 2016; de'Donato et al., 2018; Price et al., 2018). Information on the distribution of informative material and communication strategies is reviewed from various stakeholders at different levels – from core actors to the community level – as well as sharing of best practice experience and critical aspects. Evaluation of heat–health warning systems and stakeholder understanding and action is addressed in more detail in Chapter 3. It is important that these activities are carried out regularly and that user responses are taken into account to improve HHAPs the following summer. Price et al. (2018) described the framework for evaluating the HHAP in place in Montreal, Canada, covering implementation, practice and awareness among health care professionals and vulnerable subgroups.

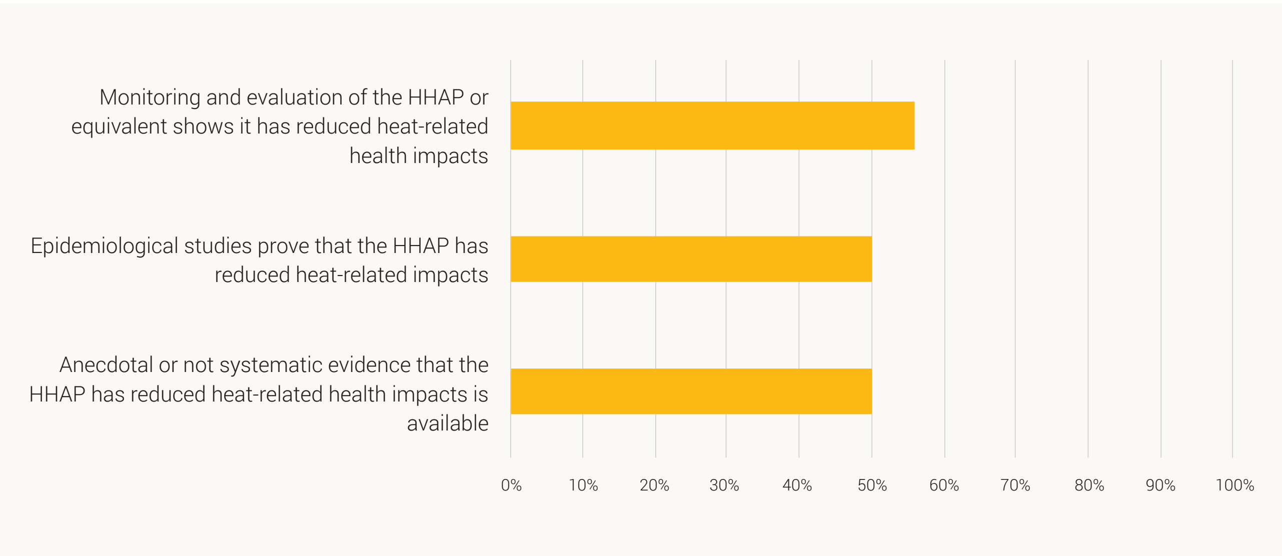
Moreover, to date very few HHAPs report or quantify coverage of information campaigns or training; this needs to be included in future assessments. Evaluations have often found a need to define roles and responsibilities more clearly and to address perceptions of stakeholders when updating HHAPs, as well as to improve interagency cooperation and communication throughout (Lowe, Ebi & Forsberg, 2011; Toloo et al., 2013a; Boeckmann & Rohn, 2014). Public Health England carried out an independent evaluation of the national HHAP (Williams et al., 2018). The results suggest that it has motivated local authorities to implement and operate a response system for hot temperatures but that heat-wave planning is still largely perceived as an exercise in emergency preparedness, focused on "warning and informing" through the alert system, rather than a strategic objective of long-term public health and environmental planning (Box 15). These formal evaluation processes can help improve understanding and formal uptake of the evaluation framework within HHAPs (Martinez et al., 2019).

Although some efforts have been made in recent years to evaluate HHAPs, formal comprehensive assessments including evaluation of both processes and health outcomes are lacking, and publications relating to these even more so. In WHO's 2019 survey of heat–health action planning, nine of the 16 countries with national HHAPs (56%) reported that their own monitoring and evaluation of the plan showed that it had reduced heat-related health impacts, although only seven of those provided a supporting reference (Fig. 14). Similarly, while half of the respondents reported the existence of epidemiological studies showing effectiveness, only one provided the study itself. Somewhat surprisingly, only 50% reported anecdotal or not systematic evidence of the HHAP's effectiveness. The expert consensus is that anecdotal evidence abounds, but systematic evaluations are scarce. In future, these assessments should become a formal part of an HHAP to improve effectiveness and response at the local and national levels.

### 9.4.3 Outcome evaluation

Outcome evaluation entails assessment of measurable impacts in terms of health outcomes (mortality, hospital admissions, ambulance calls, GP visits and so on) and how these change over time in response to the introduction of an HHAP and different prevention and response measures. In recent years, some studies have been carried out using surveillance data to evaluate the effectiveness of HHAPs; other independent epidemiological studies have looked at temporal variations in the temperature–mortality relationship in response to climate change (temperature increases) or potential adaptation (reduction in effect estimates).

**Fig. 14. Evidence that the HHAP has contributed to reducing heat-related health impacts**



## Box 15. Methods for evaluation of the *Heatwave plan for England*

The United Kingdom's Department of Health and Social Care developed the *Heatwave plan for England* in 2004 and it has subsequently been updated several times in response to additional evidence (PHE, 2020). The Department also commissioned an independent evaluation of implementation and potential effects of the plan (Williams et al. 2020), to:

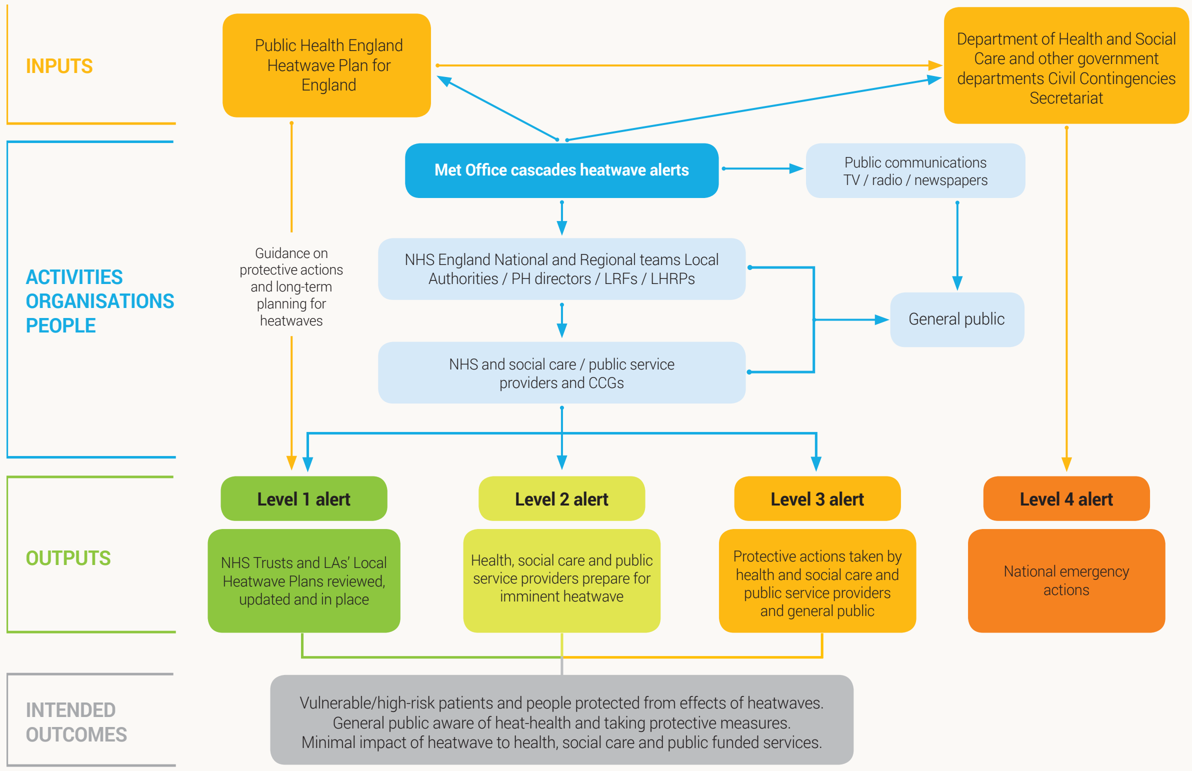
- detect any effect in terms of reducing morbidity and mortality (outcome evaluation);
- determine whether the plan informed local decisions on management of heat-related health risk and response (process evaluation);
- describe awareness of heat risks among the general population and health service staff and what actions were taken in response to alerts (process evaluation) (Fig. 15).

The methods used in the evaluation were both qualitative and quantitative to capture the full range of impacts and to look at barriers to implementation. Specific methods included:

- a time series analysis of daily mortality data linked to temperature for regions within England to analyse the temperature–mortality relationship and whether it has changed over time – specifically since the introduction of the *Heatwave plan for England*.
- an online survey of knowledge, attitudes and behaviour of the general population during heat-waves;
- a national survey of nursing staff in hospital, community and care home settings on their awareness of the plan and actions taken during heat–health alerts.

The evaluation was completed in 2019 and was published in 2020 (Williams et al., 2020).

**Fig. 15. Structure of the evaluation of the *Heatwave plan for England***




*Source:* PHE (2020).

NHS: National Health Service; TV: television; PH: Public Health; LRF: Local Resilience Forum; LHRP: Local Health Resilience Partnership; CCG: Clinical Commissioning Group; LA: Local Authority

As described in Chapter 1, the temporal variation in heat-related effects, especially in terms of mortality, has been analysed in 18 countries in the WHO European Region (Austria, Czechia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Kazakhstan, Latvia, the Netherlands, North Macedonia, the Republic of Moldova, Spain, Sweden, Switzerland and the United Kingdom) (see Table 1 in Chapter 1). Most studies estimated the impact of the 2003 heat-wave and compared it to previous periods or more recently extreme summers and heat-wave events.

Several countries have evaluated their HHAPs in terms of changes in heat-related impacts before and after the introduction the plan, mostly through time series studies, applying different methodological approaches to estimate the temperature–outcome curve and health impacts. Most studies have made an indirect assessment of HHAP effectiveness, under the assumption that if the underlying population remains unchanged, when considering the same temperature range or heat-wave definition, the only condition that has changed is population adaptation and response measures put in place by health and social services. Some studies have compared individual years with heat-wave episodes before and after the introduction of the HHAP (Fouillet et al., 2006; Green et al., 2016; Steul, Schade & Heudorf, 2018) but these only give insight into the health effects in the specific years studied. Several studies have compared periods before and after the introduction of HHAPs, thus comparing heat-related deaths in the two periods, giving more consistent estimates of the change in heat effects (Morabito et al., 2012; Schifano et al., 2012; Linares et al., 2015; de'Donato et al., 2018; Weinberger et al., 2018; Williams et al., 2018; Martínez-Solanas & Basagaña, 2019). Other studies have considered annual variations and time trends in heat-related mortality instead of period analyses (Culqui et al., 2013; Scortichini et al., 2018).

Nothing can be said about the causal effects of HHAPs and prevention measures on mortality, however. In non-randomized settings such as public health responses to heat and HHAPs, to evaluate public health policy effectiveness several quasi-experimental methods have been put forward that allow researchers to control for confounders and provide unbiased estimates in the context of HHAP evaluation (Basu, Meghani & Siddiqi, 2017). More recently, quasi-experimental approaches such as the difference-in-difference method have been used to address the causal effect of HHAPs in reducing health impacts (Benmarhnia et al., 2016; Heo et al., 2019). This method enables a policy effect to be distinguished from time trends in health outcomes. Specifically, in a study conducted in Montreal, Canada, the difference-in-difference approach was used to show that the HHAP contributed to reducing mortality on hot days, especially among vulnerable subgroups targeted by the plan (elderly people and low-education subgroups) (Benmarhnia et al., 2016). A similar approach, with a difference-in-difference model combined with propensity score weighting, was used to evaluate the heat plan of the Republic of Korea, showing a reduction in cardiorespiratory mortality among specific subgroups (Heo et al., 2019).

More studies that explicitly looked at temporal variations in heat-related health effects after the introduction of HHAPs, using surveillance or official standardized health data, have been produced in Europe in recent years (Table 11). Most use mortality data as health outcomes and compare temperature–mortality effect estimates before and after the HHAP was introduced. Temporal changes are heterogeneous across European countries and geographical areas. Several studies found a greater reduction in relation to extreme conditions or on heat-wave days according to national warning systems, suggesting that response and adaptation efforts are concentrated on days when warnings are issued and emergency planning processes are put in place (Schifano et al., 2012; Linares et al., 2015; de'Donato et al., 2018; Williams et al., 2018; Martínez-Solanas & Basagaña, 2019). This aspect is important when updating warning systems and prevention plans – specifically communication and response measures activated when Level 1 or pre-warning conditions are forecast (Green et al., 2016; de'Donato et al., 2018).

**Table 11. European studies estimating changes in health outcomes in response to HHAPs**

| Author | Geographical setting | Period | Study findings |
|---|---|---|---|
| Heudorf & Schade (2014) | Frankfurt am Main, Germany | 2003 versus 2004–2013 | The intensity of heat-waves was not comparable to 2013; excess mortality was lower after the introduction of the HHAP. |
| Steul, Jung & Heudorf (2019) | Frankfurt am Main, Germany | 2003 versus 2004–2015 | Excess mortality was highest in 2003; heat-wave mortality was lower in 2006, 2010 and 2015. |
| Martínez-Solanas & Basagaña (2019) | Spain | 1993–2013 | Provinces with more actions implemented in their HHAP showed stronger reductions in heat-attributable deaths; the greatest reductions were among elderly people and those with cardiovascular disease. |
| Linares et al. (2015) | Spain | 1991–2003 versus 2004–2008 | Reductions in heat-attributable deaths were seen in some Spanish provinces. |
| Fouillet et al. (2008) | France | 2003 versus 2006 | Excess mortality was lower in 2006 than 2003. |
| Morabito et al. (2012) | Florence, Italy | 1999–2002 versus 2004–2007 | Reductions were seen only in elderly mortality. |
| Schifano et al. (2012) | Italy | 1998–2002 versus 2006–2010 | Mortality risk was lower after the HHAP was introduced. |
| de'Donato et al. (2018) | Italy | 1999–2002 versus 2005–2008, 2009–2012, 2013–2016 | Reductions in heat-attributable deaths (1900 fewer deaths) occurred in 2013–2016 compared to the years before the HHAP was introduced. |
| Ragettli et al. (2017) | Switzerland | 1995–2002 versus 2004–2013 | Following 2003, a reduction in the effect of high temperatures on mortality was found, although it is not statistically significant. |
| Green et al. (2016) | England, United Kingdom | 2003, 2006, 2010–2013 | Minor impacts on mortality occurred in 2013 compared to 2003 and 2006. |

Multicity studies conducted with common methodologies can provide important insights into changes in heat-related mortality, as well as enabling comparisons across European countries (Gasparrini et al., 2015). A study conducted in nine European cities analysing the years before and after 2003 showed a reduction in mortality due to heat in recent years in Mediterranean cities but not in cities in northern Europe (de'Donato et al., 2015). The authors suggest that the introduction of HHAPs may have played a role in improving adaptation and awareness among the local population.

Intermediate benefits such as behavioural changes at the individual or community levels are also important and provide useful insights into the effectiveness of measures in changing population perceptions of risk, knowledge and adaptation measures adopted. Community questionnaires have been undertaken on the perception of heat-waves, warning systems and prevention measures (Sheridan, 2007; White-Newsome et al., 2011; Nitschke et al., 2013; 2017; Vu, Rutherford & Phung, 2019). Studies suggest that although subgroups are aware of the risks, they do not perceive themselves as susceptible to heat-related illness; knowledge of what to do during heat-waves was also not common (Vu, Rutherford & Phung, 2019).

In the light of future climate change and the added burden on health (Gasparrini et al., 2017; Guo et al., 2018; Vicedo-Cabrera et al., 2018; Lee et al., 2019), efficient HHAPs become a priority to protect against the impact of more frequent and intense heat-waves years to come. A robust assessment of the risks and timely identification of concurrent or cascading risks from an intersectoral perspective are necessary in the context of climate change. Surveillance and evaluation become decisive factors in monitoring response and identifying potential changes in population vulnerability, allowing HHAPs to be adjusted and improved to protect local communities.

## 9.5 Conclusions

Formal evaluation of HHAPs is a key aspect that needs more attention in the coming years, especially in the light of climate change, changes in vulnerable subgroups (an ageing European population and increases in chronic conditions) and potential additional risks. HHAPs should include an evaluation framework and invest in defining surveillance indicators capable of monitoring heat-related symptoms, both during and after extreme events.

The dual use of these surveillance tools – both informing health care systems and stakeholders of current impacts in order to modulate action during extreme events and evaluating the health impacts of action after heat-wave events – is vital for the effectiveness and progressive improvement of current HHAPs and the response measures introduced. To date, formal monitoring of impacts and evaluation has been limited, but needs to be promoted to identify barriers and opportunities to inform future development of HHAPs. Health surveillance systems already in place can be adapted to evaluating extreme heat events and HHAPs. Best practice evidence and sharing of experience is vital, both locally and at the European level, to improve HHAP implementation and effectiveness. Evaluation entails a multidisciplinary task force and collaborative action between various stakeholders to address the different aspects and components of the HHAP, user needs and caveats.

Suggestions of a reduction in heat-related impacts have been reported in recent years in several countries. Considering future changes in climate and in demographics anticipated across most of the WHO European Region, it is even more important to encourage continuous monitoring of health outcome indicators and formal evaluation of HHAPs to document health impacts and their potential changes over time.

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# Chapter 10. Conclusions

## Overall conclusion: the need to expand the number, coverage and reach of HHAPs

The evidence has become increasingly clear that trends in frequency and in relative and absolute intensity of heat-waves are accelerating throughout the WHO European Region. Projections for the Region under a changing climate indicate that heat-related exposures and impacts could increase substantially through the combined effects of climate change, urbanization and ageing, among other factors. Against this background, progress in the expansion of HHAP implementation and coverage has been slow, and many countries either do not have a functioning plan or their plan does not cover a significant proportion of the core elements of a HHAP.

Countries are at different stages of preparing, developing and implementing HHAPs, and no organized public health response to heat is available in several countries where heat has significant impacts on health. While the last decade saw a small increase in the number of national and subnational HHAPs, this growth occurred mainly in EU countries. These policies are urgently needed in other countries in the Region that are facing an increasing risk of high temperatures and heat-waves. Further, despite the nominal increase in plans among countries, information about their actual coverage and reach remains limited. Many plans lack organized monitoring and evaluation provisions, without which fundamental questions remain about their effectiveness.

With the 2017 Ostrava Declaration (WHO Regional Office for Europe, 2017), Member States committed to establishing national portfolios of action on environment and health. Such portfolios should comprise actions on climate change and health, including policies and measures relevant to managing heat–health, such as:

- strengthening natural risk reduction policies and early warning surveillance and preparedness systems for extreme weather events and climate-sensitive disease outbreaks; and
- developing information, tools and methodologies to support authorities and the public to increase their resilience against extreme weather and climate health risks.

## Individual conclusions for the elements in the report

Complementing this overarching conclusion, some specific conclusions for the areas covered in the report can also be derived.

### Good heat–health governance

Preparing for and responding to heat extremes, with consideration of climate change and fit-for-purpose governance arrangements, are areas of urgent priority for health policy and practice. Most current HHAPs are designed and operationalized in a static fashion, and do not integrate available information on climate change and on demographic and other variables and trends. Moreover, even though good heat–health governance elements and principles are outlined in international and national guidance, their translation into practice is highly context-dependent, with no generally agreed-upon best practice. The integration of HHAPs with other climate-sensitive early warnings, health adaptation and strengthening climate-resilient health systems, as well as other areas of governance, could result in synergies and efficiency gains.

WHO's 2019 survey of heat–health action planning revealed important insights regarding HHAP implementation and governance at the national/federal level.

- The number of countries with a functioning, comprehensive national HHAP has not increased since previous assessments in the published scientific literature.
- The WHO Regional Office for Europe's guidance on heat–health action planning (Matthies et al., 2008) has played a significant role in the design and revision of several HHAPs in the Region.
- The level of implementation of different core elements of HHAPs varies widely: warning systems are nearly universally fully implemented, while heat-protective long-term urban planning interventions are relatively uncommon.
- A clear shift towards web-based communication of warnings, heat–health risks and recommendations has been seen in the last decade.
- Many HHAPs lack adequate economic and human resources for implementation.
- While most HHAPs specify roles and responsibilities at the national level, these specifications are far less common at the subnational and local levels, including for non-state actors.
- HHAPs are relatively well integrated with national climate change policies, but less so with national health, disaster/emergency or environmental policies.

### Systematic monitoring and evaluation

Suggestions of a reduction in heat-related impacts have been reported in recent years in a number of countries, as well as clear indications of the role of HHAPs in such reductions. Formalized, generalized and systematic efforts of HHAP process and outcome monitoring and evaluation are crucial. They help to address user needs and to improve effectiveness by determining which elements are truly protective, and which may not be working and should be boosted or changed. Considering the future changes in climate and in demographics (an ageing European population and increases in chronic conditions) anticipated across most of the WHO European Region, as well as potential converging risks (such as the recent COVID-19 pandemic), it is especially important to encourage continuous and timely monitoring of health outcome indicators and systematic evaluation of HHAPs. This is crucial to document health impacts and their potential changes over time, as well as the definition of best practice measures. It is important that the evaluation process is formally defined, and that results are written up and disseminated to stakeholders involved in the HHAP. Evaluation entails multidisciplinary activity and collaborative action between different stakeholders to address the different components and processes of the HHAP, user needs and caveats.

Outcome evaluation can be more solidly based on health indicators, providing additional information on the causal pathways of the effectiveness of HHAPs. Evaluation frameworks should therefore invest in defining surveillance indicators capable of monitoring heat-related symptoms, both during and after extreme events. They should also endeavour to define and enhance integrated health surveillance systems, considering both mortality and morbidity outcomes associated with heat and ad hoc indicators (such as helpline or GP calls and social services notifications). The dual use of health surveillance indicators to inform health care systems and stakeholders of current impacts will assist with better targeted action. Evaluation of health impacts after a heat event is vital for ongoing improvement of current HHAPs and the response measures introduced.

## Communicating heat risk to specific audiences

Evidence from the last decade shows generally good awareness but low risk perception of heat by the general public, vulnerable groups and possibly health care providers. Psychological mechanisms and the familiarity and low-dread factor of heat may hinder the effectiveness of heat risk communications. A well developed heat-related information plan remains a central component of any effective HHAP, but can be more finely tailored to specific audiences.

It is crucial to gain better research-based understanding of the knowledge, attitudes and behaviour of high-risk groups and their carers when designing information and communication campaigns. Heat–health warnings and recommended actions should be understood across the system by different stakeholders and end users. Such improved understanding, adapted and customized to local settings and audiences, should both inform and drive heat-related health information plans.

### Including heat and health considerations in urban planning

At the city level, published evidence keeps confirming the protective effect of urban greening, to which a much wider range of interventions can be added to reduce hazardous heat exposure through modification of the urban landscape. Adequate intersectoral mechanisms for health authorities to promote these interventions are lacking, however. Entry points to include heat and health considerations in urban planning and management can make a lasting difference.

### Integrating data on factors affecting indoor and urban overheating

Prevention can be improved if it integrates data on factors affecting indoor and urban overheating and possible interventions to address them. Current preventive strategies do not make full use of the availability of fine grid information that can help predict hot spots of indoor overheating risks, in both residential and care settings.

### The role of AC

In terms of heat-protective technologies, AC remains the most prevalent, but concerns remain about its adverse environmental and economic impacts and about equitable access to it by vulnerable groups, with energy poverty a problem to be highlighted and acted upon. It is vital that those most vulnerable to heat can access the preventive benefits of AC, either as a product or as a service, while minimizing the societal and environmental drawbacks of the technology throughout its life-cycle. A wide range of effective passive cooling interventions can afford health protection from heat while minimizing energy consumption and greenhouse gas emissions.

### Greater focus on vulnerable population groups

The diversity within vulnerable groups should be acknowledged, and information campaigns and recommendations for vulnerable subgroups should be defined and updated regularly on the basis of new evidence and emerging risk factors.

The scope and definition of vulnerable groups is evolving, and public health response measures need to adapt accordingly. Subgroups most at risk change over time and evidence on vulnerable groups is more consistent both in terms of health impacts and potential biological mechanisms.

Key aspects to be promoted within HHAPs are the formal identification of vulnerable groups, the definition of specific public health response measures and active health and social care surveillance schemes; these should be enhanced during extreme events. Monitoring of the health status and impacts of heat among vulnerable groups should be undertaken to account for potential changes over time and ensure that prevention and response measures are tailored to their needs, thereby minimizing the health burden.

### Better planning and response measures in health and social care settings

With some exceptions, little progress has been made in planning for heat risks in health systems and care facilities, and it is often underreported. Greater effort needs to be made with sharing best practice planning and response measures in the health sector. Preparedness and planning within the health care system need to be promoted in HHAPs.

Structural measures addressing overheating and adaptive solutions undertaken in hospitals, residential care homes and other settings should be enhanced. Heat preparedness and response need to be managed in the context of increasing demands for sustainability and decarbonization in the health sector.

## Evidence and research gaps

Several gaps in knowledge continue to hinder prevention efforts throughout the Region. The following subsections address several across the topics presented in this report.

### Evidence lacking on good governance

Limited evidence is available on what constitutes good governance of the public health prevention of heat, although national data point at directions for improvement. The indication that some HHAPs may not have enough human and financial resources to be able to deliver on their mandate merits further investigation.

The opportunities for better reach and efficiency gains attainable through further engagement of subnational authorities and non-state actors (possibly including the private sector) are also topics for additional research. In addition, the possible benefits and synergies of integration of HHAPs into national health, environmental, disaster risk reduction and climate change policies are questions to be explored in greater detail.

### Heat–health prevention hindered by significant gaps in knowledge

A critical concern relates to the coverage of data and epidemiological studies on the health impacts of heat and their prevention. Although studies on heat and health have a wider geographical coverage now than they did a decade ago, several countries in the WHO European Region are still unrepresented, with no evidence of heat–health impacts. Furthermore, findings are still very much focused on urban areas, with sparse evidence related to suburban and rural areas.

The gradient in coverage has a clear geographical, economic and institutional capacity component, with western European, EU and high-income countries much better represented in heat–health research output than eastern European, Balkan, central Asian, Caucasian and low- or middle-income ones. Without basic epidemiological estimations on the relationship between temperature and health, the drive to implement HHAPs is limited. It is also possible that such studies are available nationally but have not been processed for publishing in indexed scientific journals, either national or international. In that case, targeted support and capacity-building could help release and distribute that knowledge.

### Data needed on the results of the transition to web-based and mobile platforms

The benefits and drawbacks of the fast and clear transition to web-based and mobile platforms for heat–health communications in the last decade need to be assessed. While this transition has seemingly obvious benefits in terms of timing and reach, it also entails risks of exclusion of vulnerable groups less familiar with newer information technologies.

Additional research could clarify the extent of the risk that potential exclusion adds to an increasingly clear systematic underestimation of the health risks of heat by the general public, and most importantly by vulnerable individuals and possibly health practitioners.

### More evidence needed to interpret observed trends accurately

Suggestions of a reduction in heat-related impacts have been reported in recent years in several countries. This is an important signal to implement and encourage the surveillance of health impacts and evaluation of HHAPs. Moreover, vulnerability factors may change over time and these need to be quantified and monitored in order to adapt health recommendations, response measures and actions.

### Research needed on protection in health and nursing care facilities

In recent years increased awareness of the vulnerability of people in residential care has led to improvements in care in these settings. More research is needed, however, to understand how hospitals, care-related buildings and facilities are at risk of overheating and the solutions to address overheating. Likewise, further research is needed on the varied impacts of heat-waves in health care settings among workers, patients and residents, as well as effective responses and barriers to implementation.

More effort is also required to understand how the health care system can improve preparedness and planning for heat. Since these heat risks are increasingly expected to be managed in the context of demands for greenhouse gas emission reductions in the health sector, operational research is needed on how to attain health system decarbonization while ensuring health system function performance across the board. Greater effort needs to be put into sharing best practice planning and emergency response measures in the health sector. Evaluation of measures and actions carried out in health care settings is a highly relevant element of any HHAP evaluation schemes.

### Epidemiological evidence required on the benefits of urban heat interventions

A significant proportion of the evidence on exposure reduction and health benefits from urban heat interventions is based on modelling rather than epidemiological evidence. With the relative exception of urban greening, the reported effects of several built environment interventions are not based on individual-level measurements. While there is no reason to doubt the overall protective nature of the interventions, models may fail to capture the complexity of urban interactions, thereby limiting their usefulness in practice for public policy design. In addition, it is not yet clear how far realistic urban management interventions can reduce temperatures in the places where dangerous heat exposures tend to occur.

Further, urban planning interventions remain largely disconnected from HHAPs, pointing to a lack of tools and incentives for intersectoral action to integrate health protection considerations into mainstream urban planning and management.

Additional questions extend to aspects of the cost–effectiveness of various types of interventions versus their public perception and political desirability. In practice, the health benefits of proposed urban interventions are rarely considered and/or evaluated. Better understanding is needed of which interventions provide better "health value for money"; this can come only from more and better operational research.

### Remaining questions on links between the built environment, heat exposure and health

Much knowledge has been gained in the last decade about heat in indoor environments and on heat–health interventions at the building scale and below, but much of it has been obtained in controlled environments or through models. Real-life, empirical evidence on the role these interventions may play in thermal comfort, heat stress reduction and health protection for vulnerable groups is scarce. This lack of evidence extends to what "thermal comfort" means for vulnerable groups, with reviews reporting widely varying estimates, even in relatively comparable groups.

These knowledge gaps highlight a broader problem of research on heat and health – namely, the difficulty and costs involved in studies below the population level, and particularly those involving vulnerable subjects. While various technological options are becoming available in terms of personal cooling, AC has become the main technology for protection from overheating. Given its drawbacks, there is a clear case for research on both personal cooling devices and strategies to ensure the protective benefits of AC for vulnerable groups, for whom access to effective cooling is tantamount to a potentially life-saving medical device. More applied research is also needed into the regulatory, financial, procedural, knowledge and other types of barrier that may inhibit effective action on preventing indoor overheating as a public health risk.

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# Afterword: updating the 2008 WHO guidance on HHAPs

The accumulation of evidence related to the health impacts of heat and their prevention – as well as the physical, social and environmental modifiers of those relationships in the last decade – is significant enough to warrant a fresh look at how HHAPs should be designed and implemented. This evidence comes from a diversity of sources, including peer-reviewed scientific studies, monitoring and evaluation of existing HHAPs, national and international technical documents, and reports from regional task forces and working groups. Moreover, given the accelerated production of directly relevant knowledge, subsequent revisions or updates of the WHO guidance should probably happen within shorter time frames. As climate change, urbanization, ageing and technological progress modify the links between heat and health, so health authorities and organizations should address public health prevention proactively, rather than reactively.

Any revisions to proposed HHAPs design, development, implementation and core elements should actively integrate the notion of a changing climate and dynamic societies. Such integration would affect, for example, the structure of stakeholders in HHAP governance (which should actively include actors involved in overall adaptation). The thresholds within heat–health warning systems should become dynamic in nature. Climate change and heat response communications should become further intertwined. Interventions to reduce heat exposure should be considered with a long-term perspective, as should the planning of care for vulnerable groups. The preparedness of social and care systems for heat should be fully integrated into overall health systems resilience, and the long-term modifications of the built environment should become a priority for intersectoral action for health. Overall, HHAPs should no longer be standalone systems, but should rather be integrated with broader policies such as sustainable and green development plans, "One health" initiatives and COVID-19 recovery strategies.

The list of proposed core elements and their sub-elements could also be revisited in the light of the updated evidence and the accumulated experience of functioning HHAPs. The scope of the core elements themselves could in some cases be significantly broadened. For example, from the basic prerequisite of designation of a lead agency, a broader governance structure could now be proposed, based on experience of existing HHAPs, involving local and subnational authorities and non-state actors. Heat–health warning systems could now rely not only on national mechanisms but also on established supranational networks. Heat–health information systems, now almost universally reliant on web-based technologies, could be informed by empirical behavioural insights and Big Data, providing greater reach and effectiveness. The greatly increased availability of information, along with the advent of Big Data, provides unprecedented possibilities, both for targeting of life-saving public health prevention information and to complement traditional epidemiological surveillance, while protecting privacy and personal data.

The structure of the core elements themselves may be susceptible to revision. For example, given the body of scientific evidence generated on heat-reducing modifications of the built environment during the last decade, this may merit its own core element status within revised WHO guidance on HHAPs. Moreover, the reduction of indoor heat exposure based on building-scale physical modifications could be merged with broader-scale urban planning and advocated jointly, while the behavioural elements could be integrated into expanded guidance for heat–health information plans.

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The climate is warming quickly and dangerously in the WHO European Region, which is experiencing accelerated rates of temperature increase and an unprecedented frequency and intensity of heat-waves. Projections indicate that without adequate efforts for heat–health adaptation to climate change, heat-related exposures and the associated health impacts could increase substantially. Such projections, combined with long-term trends of ageing and urbanization, strongly warrant adoption of a long-term perspective to manage the health effects of temperature in the context of a changing climate.

This report collates and summarizes the most relevant evidence published since 2008, when the WHO Regional Office for Europe published guidance on heat–health action planning. It focuses on Member States in the WHO European Region and brings together the results of an in-depth review based on recent research and lessons learned from implementation in practice. The publication is primarily intended for practitioners, to support their own processes of establishing or revising national heat–health action plan elements or procedures.

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