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

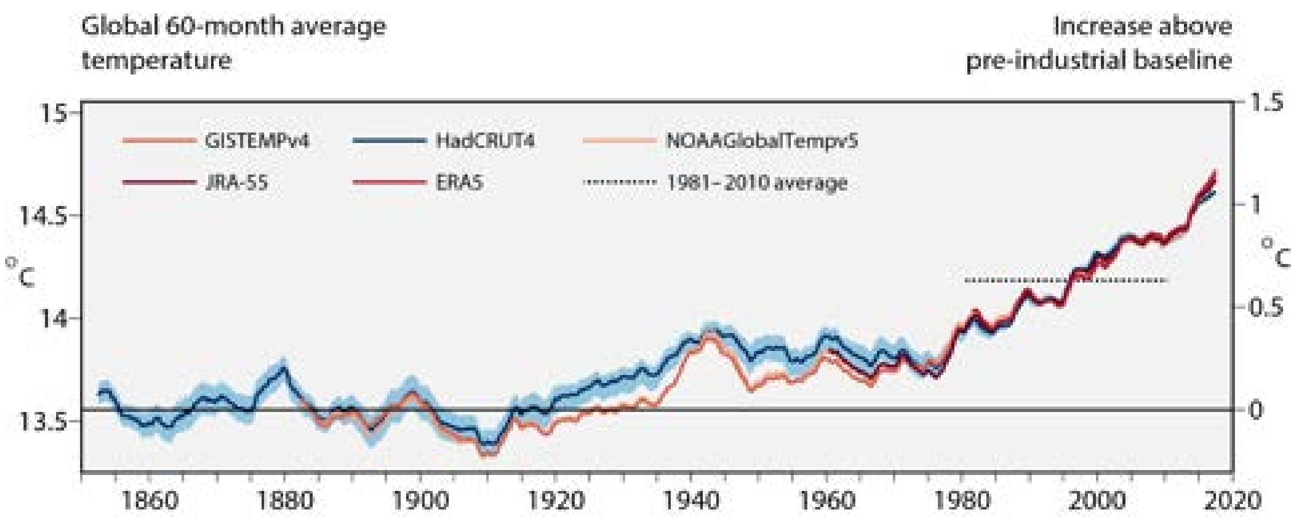
1.1.1 Observed trends in temperatures

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).

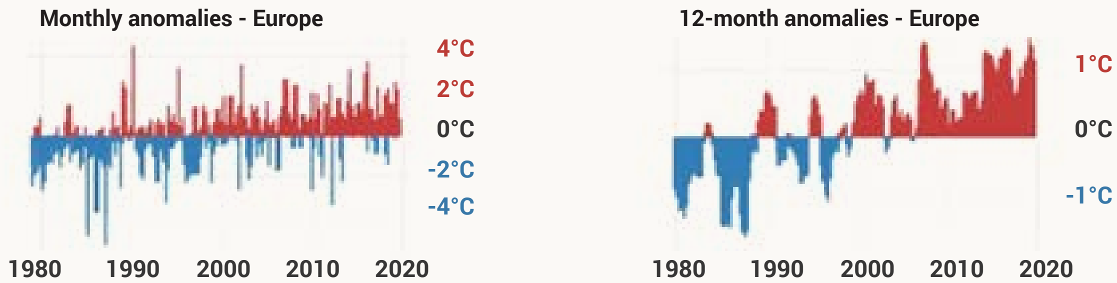
Box 1. Copernicus Climate Change Service and Climate Data Store

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



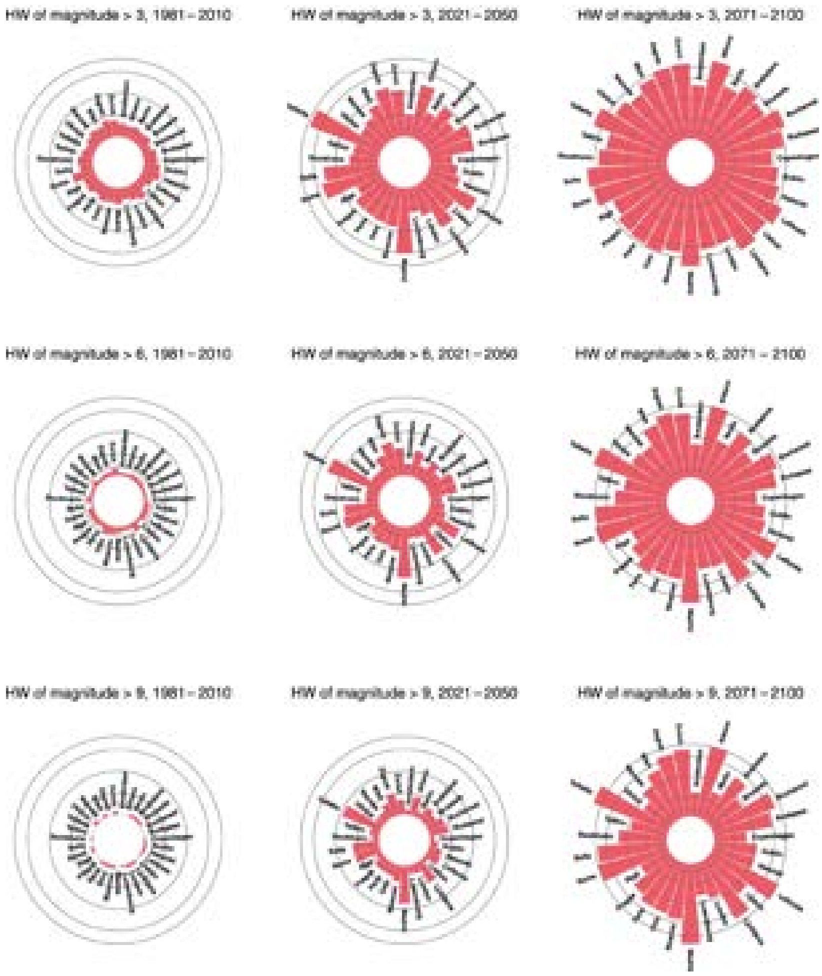
Source: ECMWF (2020b).

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. (Vienna) Muthers, Matzarakis & Koch (2010a): changes in heat vulnerability were observed from 1970 to 2007. (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. Kyselý & Plavcová (2012): declining trends in mortality impacts were observed from 1986 to 2009. 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. (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. Pascal, Le Tertre & Saoudi (2012): mortality was lower in the 2006 heat event than the 2003 heat event. 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. 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. 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). 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. 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. (Barcelona, Valencia) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010. Gasparrini et al. (2015): mortality risk associated with high temperatures was lower in 2006 than 1993. (Central Spain) Mirón et al. (2015): heat-related respiratory mortality did not decrease as circulatory cases declined from 1975–2008. (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. (Stockholm) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010. (Stockholm) Åström et al. (2013a): the relative risk of heat-related mortality remained stable from 1980–2009. (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. (London) de'Donato et al. (2015): a reduction in heat risk was seen from 1996 to 2010. (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. (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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