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.

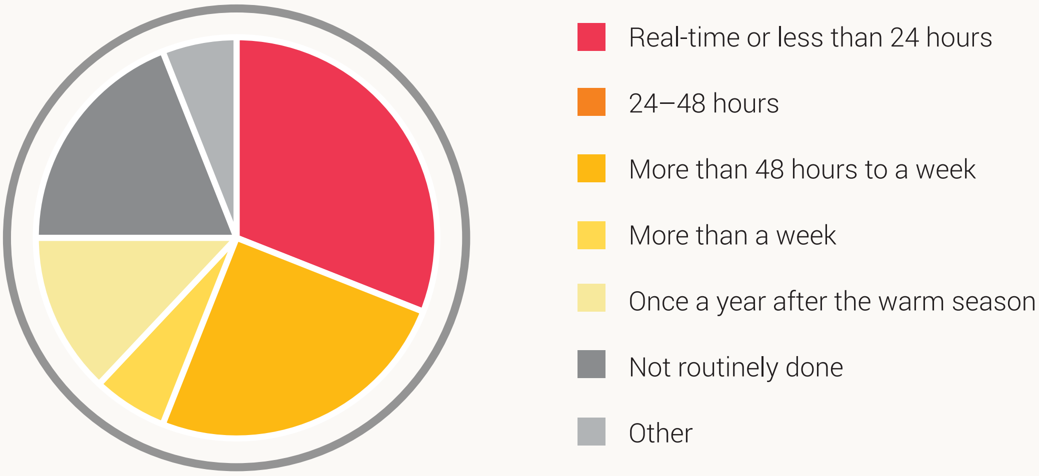
9.2 Current status of HHAP surveillance

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: • mortality – daily temperatures and deaths before, during and after heat-wave periods; mortality in different settings such as care homes • morbidity • health care utilization • non-health-related outcomes such as productivity and workforce absence • an assessment of the temperature–mortality function • 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.

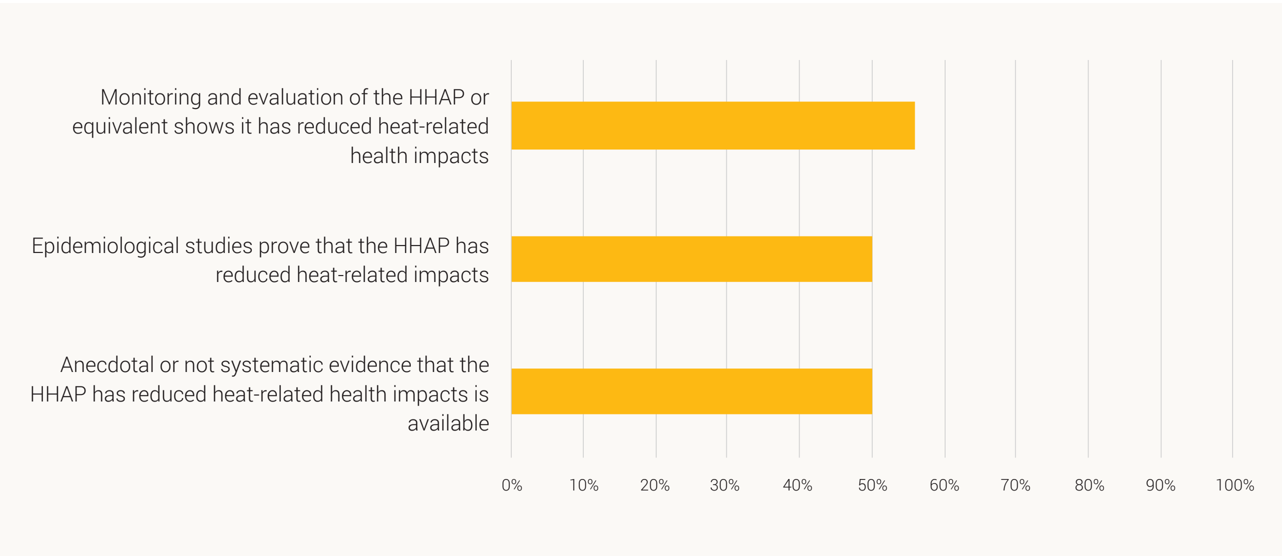
Moreover, to date very few HHAPs report or quantify coverage of information campaigns or training; this needs to be included in future assessments. Evaluations have often found a need to define roles and responsibilities more clearly and to address perceptions of stakeholders when updating HHAPs, as 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:

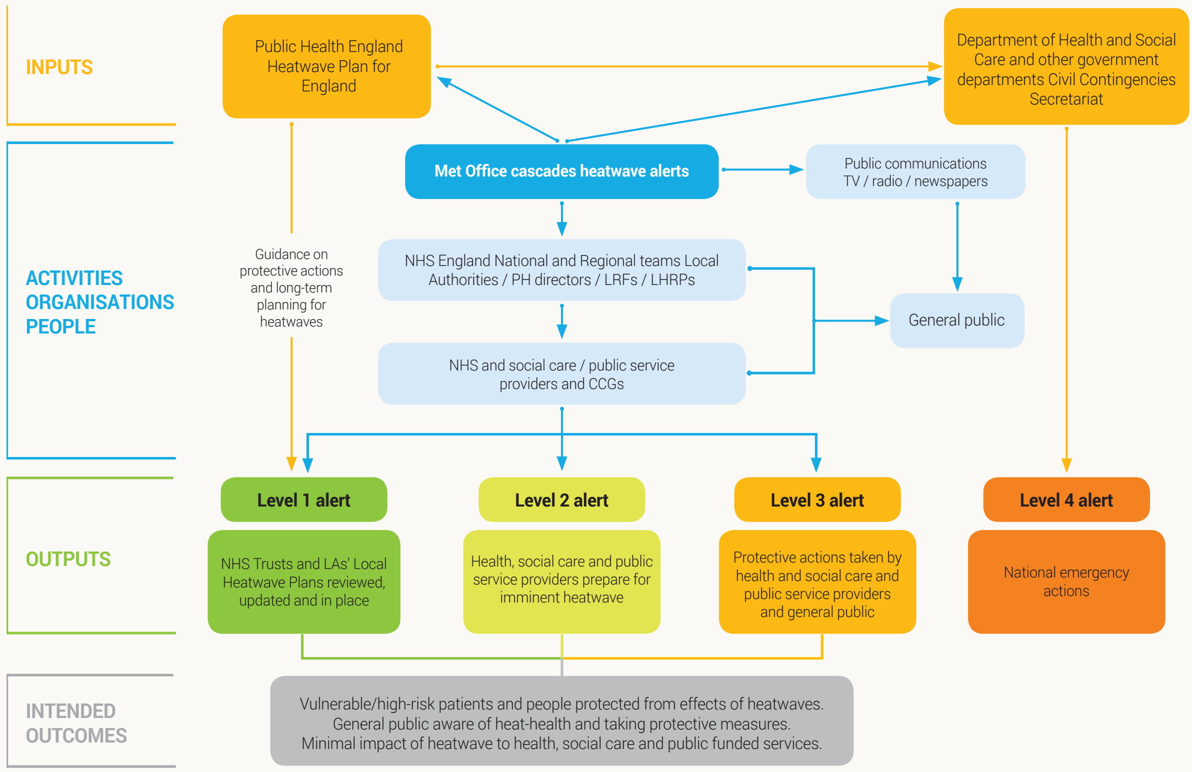
- detect any effect in terms of reducing morbidity and mortality (outcome evaluation);
- determine whether the plan informed local decisions on management of heat-related health risk and response (process evaluation);
- describe awareness of heat risks among the general population and health service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

References

Abrahamson V, Wolf J, Lorenzoni I, Fenn B, Kovats S, Wilkinson P et al. (2009). Perceptions of heatwave risks to health: interview-based study of older people in London and Norwich, UK. J Public Health (Oxf). 31(1):119–26. doi:10.1093/pubmed/fdn102.

Bassil KL, Cole DC (2010). Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: a structured review. Int J Environ Res Public Health. 7(3):991–1001. doi:10.3390/ijerph7030991.

Basu R (2002). Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. Epidemiol Rev. 24(2):190–202. doi:10.1093/epirev/mxf007.

Basu S, Meghani A, Siddiqi A (2017). Evaluating the health impact of large-scale public policy changes: classical and novel approaches. Annu Rev Public Health. 38(1):351–70. doi:10.1146/annurev-publhealth-031816-044208.

Benmarhnia T, Bailey Z, Kaiser D, Auger N, King N, Kaufman JS (2016). A difference-in-differences approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec). Environ Health Perspect. 124(11):1694–9. doi:10.1289/EHP203.

Bittner MI, Matthies EF, Dalbokova D, Menne B (2014). Are European countries prepared for the next big heat-wave? Eur J Public Health. 24(4):615–9. doi:10.1093/eurpub/ckt121.

Boeckmann M, Rohn I (2014). Is planned adaptation to heat reducing heat-related mortality and illness? A systematic review. BMC Public Health. 14(1):1112. doi:10.1186/1471-2458-14-1112.

Claessens YE, Taupin P, Kierzek G, Pourriat JL, Baud M, Ginsburg C et al. (2006). How emergency departments might alert for prehospital heat-related excess mortality? Crit Care. 10(6):1–9. doi:10.1186/cc5092.

Culqui DR, Díaz J, Simón F, Linares C (2013). [Impact of the effects of heat waves on mortality in the City of Madrid, Spain during the period 1990–2009]. Rev Esp Salud Publica. 87(3):277–282. doi:10.4321/S1135-57272013000300007.

de'Donato F, Leone M, Scortichini M, De Sario M, Katsouyanni K, Lanki T et al. (2015). Changes in the effect of heat on mortality in the last 20 years in nine European cities. Results from the PHASE project. Int J Environ Res Public Health. 12(12):15567–83. doi:10.3390/ijerph121215006.

de'Donato F, Scortichini M, De Sario M, de Martino A, Michelozzi P (2018). Temporal variation in the effect of heat and the role of the Italian heat prevention plan. Public Health. 161:154–62. doi:10.1016/j.puhe.2018.03.030.

Elliot AJ, Bone A, Morbey R, Hughes HE, Harcourt S, Smith S et al. (2014). Using real-time syndromic surveillance to assess the health impact of the 2013 heatwave in England. Environ Res. 135:31–6. doi:10.1016/j.envres.2014.08.031.

Elliot A, Hughes H, Morbey R, Loveridge P, Harcourt S, Smith S et al. (2015). A syndromic surveillance service supporting environmental public health incidents. Online J Public Health Inform. 7(1):e126. doi:10.5210/ojphi.v7i1.5792.

Fouillet A, Rey G, Laurent F, Pavillon G, Bellec S, Guihenneuc-Jouyaux C et al. (2006). Excess mortality related to the August 2003 heat wave in France. Int Arch Occup Environ Health. 80(1):16–24. doi:10.1007/s00420-006-0089-4.

Gasparrini A (2016). Modelling lagged associations in environmental time series data: a simulation study. Epidemiology. 27(6):835–42. doi:10.1097/EDE.0000000000000533.

Gasparrini A, Guo Y, Hashizume M, Kinney PL, Petkova EP, Lavigne E et al. (2015). Temporal variation in heat–mortality associations: a multicountry study. Environ Health Perspect. 123(11):1200–7. doi:10.1289/ehp.1409070.

Gasparrini A, Guo Y, Sera F, Vicedo-Cabrera AM Huber, V, Tong S et al. (2017). Projections of temperature-related excess mortality under climate change scenarios. Lancet Planet Health. 1(9):e360–7. doi:10.1016/S2542-5196(17)30156-0.

Green HK, Andrews N, Armstrong B, Bickler G, Pebody R (2016). Mortality during the 2013 heatwave in England – how did it compare to previous heatwaves? A retrospective observational study. Environ Res. 147:343–9. doi:10.1016/j.envres.2016.02.028.

Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, de Sousa Zanotti Stagliorio Coelho M et al. (2018). Quantifying excess deaths related to heatwaves under climate change scenarios: a multicountry time series modelling study. PLoS Med. 15(7):1–17. doi:10.1371/journal.pmed.1002629.

Heo S, Nori-Sarma A, Lee K, Benmarhnia T, Dominici F, Bell ML (2019). The use of a quasi-experimental study on the mortality effect of a heat wave warning system in Korea. Int J Environ Res Public Health. 16(12):2245. doi:10.3390/ijerph16122245.

Heudorf U, Schade M (2014). Heat waves and mortality in Frankfurt am Main, Germany, 2003–2013: what effect do heat–health action plans and the heat warning system have? Z Gerontol Geriatr. 47(6):475–82. doi:10.1007/s00391-014-0673-2.

Hughes HE, Morbey R, Hughes TC, Locker TE, Shannon T, Carmichael C et al. (2014). Using an emergency department syndromic surveillance system to investigate the impact of extreme cold weather events. Public Health. 128(7):628–35. doi:10.1016/j.puhe.2014.05.007.

Josseran L, Caillère N, Brun-Ney D, Rottner J, Filleul L, Brucker G et al. (2009). Syndromic surveillance and heat wave morbidity: a pilot study based on emergency departments in France. BMC Med Inform Decis Mak. 9:14. doi:10.1186/1472-6947-9-14.

Josseran L, Fouillet A, Caillère N, Brun-Ney D, Ilef D, Brucker Get al. (2010). Assessment of a syndromic surveillance system based on morbidity data: results from the Oscour® network during a heat wave. PLoS One. 5(8) :e11984. doi:10.1371/journal.pone.0011984.

Jung J, Uejio CK, Duclos C, Jordan M (2019). Using web data to improve surveillance for heat sensitive health outcomes. Environ Health. 18(1):59. doi:10.1186/s12940-019-0499-x.

Lee JY, Kim H, Gasparrini A, Armstrong B, Bell ML, Sera F et al. (2019). Predicted temperature-increase-induced global health burden and its regional variability. Environ Int. 131:105027. doi:10.1016/j.envint.2019.105027.

Leonardi GS, Hajat S, Kovats RS, Smith GE, Cooper D, Gerard E (2006). Syndromic surveillance use to detect the early effects of heat-waves: an analysis of NHS Direct data in England. Soz Praventivmed. 51(4):194–201. doi:10.1007/s00038-006-5039-0.

Li T, Ding F, Sun Q, Zhang Y, Kinney PL (2016). Heat stroke internet searches can be a new heatwave health warning surveillance indicator. Sci Rep. 6:37294. doi:10.1038/srep37294.

Linares C, Sánchez R, Mirón IJ, Díaz J (2015). Has there been a decrease in mortality due to heat waves in Spain? Findings from a multicity case study. J Integr Environ Sci. 12(2):153–63. doi:10.1080/1943815X.2015.1062032.

Lowe D, Ebi KL, Forsberg B (2011). Heatwave early warning systems and adaptation advice to reduce human health consequences of heatwaves. Int J Environ Res Public Health. 8(12):4623–48. doi:10.3390/ijerph8124623.

Martinez GS, Linares C, Ayuso A, Kendrovski V, Boeckmann M, Díaz J (2019). Heat–health action plans in Europe: challenges ahead and how to tackle them. Environ Res. 176:108548. doi:10.1016/j.envres.2019.108548.

Martínez-Solanas È, Basagaña X (2019). Temporal changes in temperature-related mortality in Spain and effect of the implementation of a heat health prevention plan. Environ Res. 169:102–13. doi:10.1016/j.envres.2018.11.006.

Matthies F, Bickler G, Cardeñosa N, Hales S, editors (2008). Heat–health action plans. Copenhagen: WHO Regional Office for Europe (https://www.euro.who.int/en/publications/abstracts/heathealth-action-plans).

Mazick A, Gergonne B , Nielsen J , Wuillaume F, Virtanen MJ, Fouillet A et al. (2012). Excess mortality among the elderly in 12 European countries, February and March 2012. Euro Surveill. 17(14):9–13. doi:10.2807/ese.17.14.20138-en.

Michelozzi P, de'Donato FK, Bargagli AM, D'Ippoliti D, De Sario M, Marino C et al. (2010). Surveillance of summer mortality and preparedness to reduce the health impact of heat waves in Italy. Int J Environ Res Public Health. 7(5):2256–73. doi:10.3390/ijerph7052256

Michelozzi P, Bargagli AM, Vecchi S, De Sario M, Schifano P, Davoli M (2014). Interventions for reducing adverse health effects of high temperature and heatwaves. Cochrane Database Syst Rev. 4:CD011072. doi:10.1002/14651858.CD011072.

Morabito M, Profili F, Crisci A, Francesconi P, Gensini GF, Orlandini S (2012). Heat-related mortality in the Florentine area (Italy) before and after the exceptional 2003 heat wave in Europe: an improved public health response? Int J Biometeorol. 56(5):801–10. doi:10.1007/s00484-011-0481-y.

Morbey RA, Elliot AJ, Charlett A, Andrews N, Verlander NQ, Ibbotson S et al. (2015). Development and refinement of new statistical methods for enhanced syndromic surveillance during the 2012 Olympic and Paralympic Games. Health Informatics J. 21(2):159–69. doi:10.1177/1460458213517577.

Morgan A (2006). Evaluation of health promotion. In: Davies M, Macdowall W, editors. Health promotion theory. Maidenhead: Open University Press.

Nitschke M, Krackowizer A, Hansen AL, Bi P, Tucker GR (2017). Heat health messages: a randomized controlled trial of a preventative messages tool in the older population of south Australia. Int J Environ Res Public Health. 14(9):992. doi:10.3390/ijerph14090992.

Nitschke M, Hansen A, Bi P, Pisaniello D, Newbury J, Kitson A et al. (2013). Risk factors, health effects and behaviour in older people during extreme heat: a survey in South Australia. Int J Environ Res Public Health. 10(12):6721–33. doi:10.3390/ijerph10126721.

Pascal M, Laaidi K, Wagner V, Ung AB, Smaili S, Fouillet A et al. (2012). How to use near real-time health indicators to support decision-making during a heat wave: the example of the French heat wave warning system. PLoS Curr. 4:e4f83ebf72317d. doi:10.1371/4f83ebf72317d.

PHE (2020). Heatwave plan for England: protecting health and reducing harm from severe heat and heatwaves.

London: Public Health England (https://www.gov.uk/government/publications/heatwave-plan-for-england).

Price K, Benmarhnia T, Gaudet J, Kaiser D, Sadoine ML, Perron S et al. (2018). The Montreal heat response plan: evaluation of its implementation towards healthcare professionals and vulnerable populations. Can J Public Health. 109(1):108–16. doi:10.17269/s41997-018-0020-2.

Ragettli MS, Vicedo-Cabrera AM, Schindler C, Röösli M (2017). Exploring the association between heat and mortality in Switzerland between 1995 and 2013. Environ Res. 158:703–9. doi:10.1016/j.envres.2017.07.021.

Schifano P, Leone M, De Sario M, de'Donato F, Bargagli AM, D'Ippoliti D et al. (2012). Changes in the effects of heat on mortality among the elderly from 1998–2010: results from a multicenter time series study in Italy. Environ Health. 11(1):58. doi:10.1186/1476-069X-11-58.

Scortichini M, de'Donato F, De Sario M, Leone M, Åström C, Ballester F et al. (2018). The inter-annual variability of heat-related mortality in nine European cities (1990–2010). Environ Health. 17(1):66. doi:10.1186/S12940-018-0411-0.

Sheridan SC (2007). A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness, Int J Biometeorol. 52(1):3–15. doi:10.1007/s00484-006-0052-9.

Smith S, Elliot AJ, Hajat S, Bone A, Smith GE, Kovats S (2016). Estimating the burden of heat illness in England during the 2013 summer heatwave using syndromic surveillance. J Epidemiol Community Health. 70(5):459–65. doi:10.1136/jech-2015-206079.

Statens Serum Institut (2020). EuroMOMO [website]. Copenhagen: Statens Serum Institut (https://www.euromomo.eu/).

Steul K, Jung HG, Heudorf U (2019). [Heat-related morbidity: real-time surveillance via rescue service operations data from the interdisciplinary care capacity proof system (IVENA)]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz. 62(5):589–98. doi:10.1007/s00103-019-02938-6.

Steul K, Schade M, Heudorf U (2018). Mortality during heatwaves 2003–2015 in Frankfurt-Main – the 2003 heatwave and its implications. Int J Hyg Environ Health. 221(1):81–6. doi:10.1016/j.ijheh.2017.10.005.

Tobías A, Armstrong B, Zuza I, Gasparrini A, Linares C, Diaz J (2012). Mortality on extreme heat days using official thresholds in Spain: a multi-city time series analysis. BMC Public Health. 12:133. doi:10.1186/1471-2458-12-133.

Toloo G, FitzGerald G, Aitken P, Verrall K, Tong S (2013a). Evaluating the effectiveness of heat warning systems: systematic review of epidemiological evidence. Int J Public Health. 58(5):667–81. doi:10.1007/s00038-013-0465-2.

Toloo GS, Fitzgerald G, Aitken P, Verrall K, Tong S (2013b). Are heat warning systems effective? Environ Health. 12:27. doi:10.1186/1476-069X-12-27.

Toutant S, Gosselin P, Bélanger D, Bustinza R, Rivest S (2011). An open source web application for the surveillance and prevention of the impacts on public health of extreme meteorological events: the SUPREME system. Int J Health Geogr. 10(1):39. doi:10.1186/1476-072X-10-39.

Van Loenhout JAF, Rodriguez-Llanes JM, Guha-Sapir D (2016). Stakeholders' perception on national heatwave plans and their local implementation in Belgium and the Netherlands. Int J Environ Res Public Health. 13(11):1120. doi:10.3390/ijerph13111120.

Vestergaard LS, Nielsen J, Krause TG, Espenhain L, Tersago K, Bustos Sierra N et al. (2017). Excess all-cause and influenza-attributable mortality in Europe, December 2016 to February 2017. Euro Surveill. 22(14):30506. doi:10.2807/1560-7917.ES.2017.22.14.30506.

Vicedo-Cabrera AM, Guo Y, Sera F, Huber V, Schleussner CF, Mitchell D et al. (2018). Temperature-related mortality impacts under and beyond Paris Agreement climate change scenarios. Clim Change. 150(3–4):391–402. doi:10.1007/s10584-018-2274-3.

Vu A, Rutherford S, Phung D (2019). Heat health prevention measures and adaptation in older populations – a systematic review. Int J Environ Res Public Health. 16(22):4370. doi:10.3390/ijerph16224370.

Weinberger KR, Zanobetti A, Schwartz J, Wellenius GA (2018). Effectiveness of national weather service heat alerts in preventing mortality in 20 US cities. Environ Int. 116:30–8. doi:10.1016/j.envint.2018.03.028.

White-Newsome JL, Sánchez BN, Parker EA, Dvonch JT, Zhang Z, O'Neill MS (2011). Assessing heat-adaptive behaviors among older, urban-dwelling adults. Maturitas. 70(1):85–91. doi:10.1016/j.maturitas.2011.06.015.

WHO Regional Office for Europe (2011). Public health advice on preventing health effects of heat: new and updated information for different audiences. Copenhagen: WHO Regional Office for Europe (https://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/publications/2011/public-health-advice-on-preventing-health-effects-of-heat.-new-and-updated-information-for-different-audiences).

Williams L, Erens B, Ettelt S, Hajat S, Manacorda T, Mays N (2019). Evaluation of the Heatwave plan for England. London: Policy Innovation and Evaluation Research Unit (https://piru.ac.uk/projects/current-projects/heatwave-plan-evaluation.html).

WMO, WHO (2015). Heatwaves and health: guidance on warning-system development. Geneva: World Meteorological Organization (https://www.who.int/globalchange/publications/heatwaves-health-guidance/en/).

Wolf J, Adger WN, Lorenzoni I, Abrahamson V, Raine R (2010). Social capital, individual responses to heat waves and climate change adaptation: an empirical study of two UK cities. Global Environ Chang. 20(1):44–52. doi:10.1016/j.gloenvcha.2009.09.004.