SCORCH

Funded by
European Union
Civil Protection

# LITERATURE REVIEW

## DELIVERABLE 2.2

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| Grant agreement no. | 826565 |
| Project start date | 01/02/2019 |
| Duration of the project | 24 months |
| Deliverable number | 2.2 |
| Deliverable leader | Université catholique de Louvain |
| Dissemination level | Public |
| Status | Final |
| Submission date | 31/07/2019 |
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This project has received funding from the European Union's Directorate-General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) under grant agreement No 826565.

# Literature review

## Deliverable 2.2

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**Acknowledgement**

The authors would like to thank International Advisory Board members Sophie Lokietek, Jorgen Sparf and Werner Hagens for providing feedback and useful insights. We would also like to thank Max Xhauflair for contributing to the literature analysis.

## Preface

This report presents the work that has been performed by SCORCH partners to create a literature review as part of WP2.

# Table of contents


1. Introduction ..... 3

Background & objectives of SCORCH ..... 3

Why this literature review? ..... 3

2. Methodology ..... 4

2.1. Search strategy ..... 4

2.2. Selection criteria ..... 5

2.3. Characteristics of the selected articles ..... 6

2.4. Analysis ..... 7

2.5. Report ..... 14

3. Literature review ..... 15

3.1. Heatwave plans: implementation and risk dimensions ..... 15

3.2. Heat warning system ..... 17

3.3. Surveillance and evaluation ..... 19

3.4. Long-term planning ..... 21

3.5. Communication plan ..... 22

3.6. Care for vulnerable groups ..... 26

4. Key lessons from the literature review ..... 28

4.1. Research question 1 ..... 28

4.2. Research question 2 ..... 31

References ..... 32

Annexes ..... 36

Annex 1 – Overview of search results automated search ..... 36

Annex 2 – WHO core elements of heat-health action plans and sub-elements ..... 38

# 1. Introduction

## Background & objectives of SCORCH

Extreme temperatures, including heat and cold waves, are climatological hazards. Both in the EU as in EU-Neighbourhood countries, research has shown that heatwaves cause a rise in morbidity and mortality. Since heatwaves are not restricted to country borders, a cross-border approach is required to ensure collective preparedness and response to mitigate the impacts on communities and limit the financial and health costs.

The overall objective of SCORCH is to reduce the impact of heatwaves on vulnerable, urban populations through improved risk communication strategies based on existing EU plans and guidelines. In addition, we will measure risk perception and behaviour in communities in EU-neighbourhood countries through surveys and foster a cross-country culture of prevention and cooperation.

## Why this literature review?

To make maximum use of existing knowledge and strategies on heatwaves, the project started out by collecting existing heatwave plans of EU countries (D2.1). In this report, we go one step further and review literature that analyses heatwave plans of EU countries, Switzerland, Norway or EU candidate countries. The review is aimed at assessing the effectiveness of the heatwave plans, based on a desk study, and addresses two research questions:

1. How effective are the processes described in the national heatwave plans with regard to their implementation and risk management?
2. How effective are the national heatwave plans in changing behaviour and perceptions of the public and in particular vulnerable populations regarding heatwaves?

The first research question focuses on the professionals involved in the national plan and the extent to which they succeed in effective implementation. The second research question focuses on the perspective of the populations targeted by the plan, i.e. the general public and vulnerable populations, and the extent to which the plan succeeds in sensitising and mobilising populations and involved stakeholders.

The report outlines the methodology used for the systematic literature review, and describes the results of this effort.

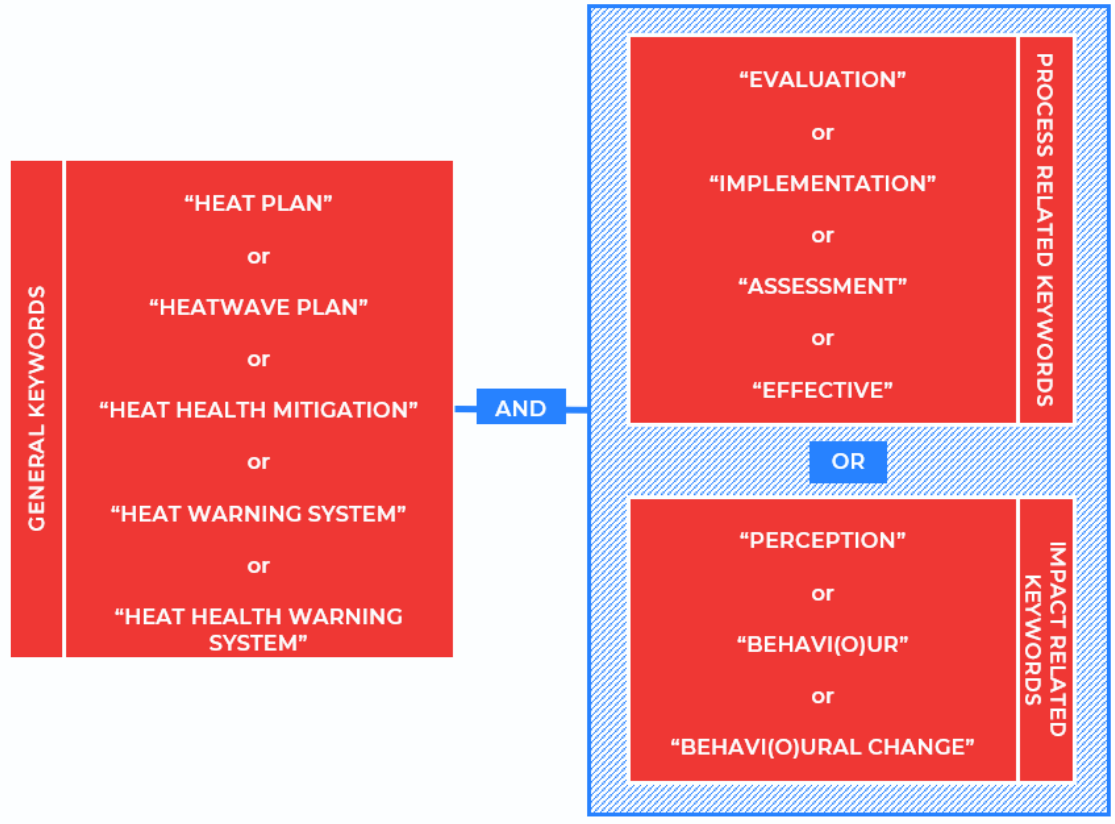
# 2. Methodology

We conducted a systematic literature review of peer-reviewed and published literature. We completed the PRISMA flowchart (figure 2), which is useful for conducting systematic reviews on evaluations if interventions (Moher et al. 2009). The review includes literature on the effectiveness of national heatwave plans. Similar to D2.1, we only include articles based on studies in EU countries, Switzerland or EU candidate countries. Following the two research questions, we look for 1) output that describes the effectiveness of processes described in the national heatwave plans; and 2) output that describes the impact of the national heatwave plans on behaviour and perceptions regarding heatwaves.

## 2.1. Search strategy

We applied a combined search strategy of automated search and manual search in reference lists of peer-reviewed articles. Three databases were searched: Science Direct, Pubmed and Scopus. The search terms were applied in combinations of general keywords and keywords that focus on either the process or the impact of the heatwave plans (figure 1). The results of this search are described in annex 1.

**Figure 1 – Applied search terms and their combinations**



## 2.2. Selection criteria

The following inclusion and exclusion criteria were applied:

Inclusion criteria:

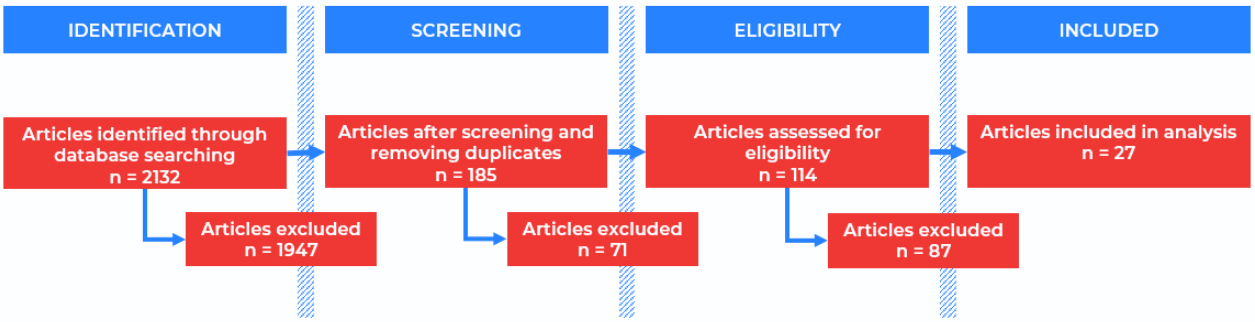
a) must include an analysis, reflection or evaluation of a national heatwave plan or a part of it, for one of the specified countries (EU country, Norway, Switzerland or EU candidate country);
b) must include output relating to the effectiveness of processes (e.g. shown by a decrease in mortality), and/or the effectiveness in realising changes in behaviour and/or perception (e.g. an increase in the implementation of protective behaviour) (i.e. the two research questions);
c) peer-reviewed papers and published national reports;
d) published after 2003, since the heatwave that year stimulated the development of national heatwave plans in Europe;
e) written in English, French or Dutch.

Exclusion criteria:

a) articles that focus on countries other than those specified;
b) papers on heatwaves and their health impact without link to a national plan;
c) analyses, reflections or evaluations of regional and local heatwave plans;
d) reviews, comments, editorials, correspondences and letters are excluded.

The selection process occurred in three steps. We initially reduced the number of articles by withholding articles with relevant key words in the title and abstracts. After screening and the removal of duplicates, 185 articles were withheld. Next, the criteria were applied in two steps. First, we applied inclusion criteria a, c, d and e, as these were all criteria for which the screening could happen quickly. This resulted in 114 remaining articles. Then we applied inclusion criteria b. In total, 27 articles complied with all criteria. The PRISMA flowchart in figure 2 provides more details on this process.

**Figure 2 – PRISMA flowchart of study selection process**



## 2.3. Characteristics of the selected articles

Table 1 provides a description of the analysed articles.

Of the 27 articles included, 10 were studies conducted in the United Kingdom (Abeling 2015; Abrahamson et al. 2008; Abrahamson and Raine 2009; Boyson, Taylor, and Page 2014; Elliot et al. 2014; Lefevre et al. 2015; Smith et al. 2016; Tang and Rundblad 2015; Wolf, Adger, and Lorenzoni 2010), 4 in Belgium (Brasseur, Berger, and Lokietek 2014; Bustos Sierra and Aikainen 2017; Cox et al. 2010; Martinez et al. 2017), 3 in France (Fouillet et al. 2008; Léon et al. 2007; Pascal, Le Tertre, and Saoudi 2012), 2 in Germany (Bittner and Stößel 2012; Herrmann and Sauerborn 2018), 2 in Italy (de'Donato et al. 2018; Schifano et al. 2012), 2 in Belgium and the Netherlands (van Loenhout and Guha-Sapir 2016; van Loenhout, Rodriguez-Llanes, and Guha-Sapir 2016), 1 in the Netherlands (Kunst and Britstra 2013), 1 in Spain (Linares et al. 2015), 1 in Switzerland (Vicedo-Cabrera et al. 2016), and 1 in Portugal and Spain (Cuesta et al. 2017).

20 studies contribute to answering the first research question and 9 studies to the second research questions (2 studies contribute to both research questions). 17 studies use quantitative methods that mostly involve longitudinal data, 9 studies use qualitative methods such as interviews and focus groups, and 1 study uses a mixed-methods approach. The articles address the following topics:

**Articles relating to research question 1[1]:**

- risk knowledge and heatwave management (Abeling 2015)
- staff perceptions on plan and its feasibility (Abrahamson and Raine 2009; van Loenhout et al. 2016);
- effectiveness of dissemination and barriers to use (Boyson et al. 2014; Kunst and Britstra 2013);
- evaluation of warning parameters (Brasseur et al. 2014)
- mortality surveillance and influence of the plan (Bustos Sierra and Aikainen 2017; Cox et al. 2010; de'Donato et al. 2018; Fouillet et al. 2008; Linares et al. 2015; Martinez et al. 2017; Pascal et al. 2012; Schifano et al. 2012; Vicedo-Cabrera et al. 2016);
- syndromic surveillance and influence of plan (Elliot et al. 2014; Smith et al. 2016);
- identification of vulnerable people (de'Donato et al. 2018);
- care for vulnerable groups and implementation of protective measures (Abrahamson and Raine 2009; Bittner and Stößel 2012; de'Donato et al. 2018).

[1] RQ1: what is the effectiveness of processes described in the national heatwave plans?

**Articles relating to research question 2[2]:**

- staff perceptions on health impacts of heat and preventive measures (Bittner and Stößel 2012; Herrmann and Sauerborn 2018);
- risk perceptions and knowledge of protective behaviour in elderly or general public (Abrahamson et al. 2008; Bittner and Stößel 2012; Cuesta et al. 2017; van Loenhout and Guha-Sapir 2016; Wolf et al. 2010);
- protective behaviour and experienced health impact of heat (Khare et al. 2015)
- impact of communication on protective behaviour (Lefevre et al. 2015; Léon et al. 2007);
- interpretation of heat-health alerts (Tang and Rundblad 2015).

While there is some overlap between the two research questions, for the purpose of this literature review we delineate the questions according to the topics given here.

## 2.4. Analysis

The collected plans were imported and analysed inductively in NVivo, a software program for conducting qualitative analyses. The analysis of the literature builds on the analysis of the national plan in deliverable 2.1. Hence, a similar approach was used. We began with a descriptive analysis to identify key characteristics of each article. The main results of the descriptive analysis are summarised in Table 1. Next, we used axial coding (i.e. a qualitative research technique based on grounded theory used to make connections between data (Bryman and Burgess 1994)) to organise the content of the articles under the two research questions in thematic categories.

[2] RQ2: what is the impact of the national heatwave plans on behaviour and perceptions regarding heatwaves?

## Table 1 – Description of the included articles in alphabetical order

| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| (Abeling 2015) | UK | RQ 1 | 49 semi-structured expert interviews | Explores how disaster risk knowledge shapes local heatwave risk management by focusing on the implementation of the national heatwave plan through public sector organisations. Findings suggest that the national heatwave plan is an important source of disaster risk knowledge, and that organisational ownership of the national heatwave plan contributes to the perception of local actors that heatwave planning is a public issue. |
| (Abrahamson and Raine 2009) | UK | RQ 1 | Semi-structured interviews and focus groups with 109 health, social care and voluntary staff | Explores the perceptions of frontline statutory and voluntary sector staff on the feasibility of implementing the national heatwave plan for elderly people. Results show that few staff are aware of the plan and most do not perceive heatwaves to require prioritization within their routine summer workloads. Respondents point out that the heatwave plan does not assign ultimate responsibility to health or social services which causes confusion over who should take this role. |
| (Abrahamson et al. 2008) | UK | RQ 2 | Semi-structured interviews with 73 elderly people | Determines the knowledge and perceptions of elderly people with regard to heat-related health risks and protective behaviours. Results show that few elderly people consider themselves as risk, though they do recognise risks in others. Respondents thought that intervention was unnecessary, intrusive and unlikely to be effective. Findings suggest that the heatwave plan should consider giving greater emphasis to a population-based information strategy to increase awareness of vulnerability to heat and to ensure clarity about protective measures. |
| (Bittner and Stößel 2012) | DE | RQ 2 | Questionnaire-based interviews with 20 elderly people and 13 caretakers | Explores individual risk perceptions and adaptive measures of elderly people and their caretakers. Results show that elderly people consider themselves as less affected by heat than others. Most, however, do adopt preventive measures and receive warnings or some information related to heatwaves. Findings show that GPs hold a central role in the promotion of preventive action, but their outreach is limited. |
| (Boyson et al. 2014) | UK | RQ 1 | 5 semi-structured interviews with managers and 2 focus | Understands how effectively the national heatwave plan is disseminated within a hospital and identify barriers to its use. Results show that managers are aware of the plan but deem it a low priority. Frontline staff |

| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| | | | groups with in total 7 nurses and healthcare assistants from 1 hospital | is not aware of the plan but is familiar with the dangers of excess heat. Barriers include communication of information between managers and frontline staff, and inadequate building stock and equipment. |
| (Brasseur et al. 2014) | BE | RQ 1 | Evaluation of parameters | Assesses the heat and ozone surveillance after ten years of activity in order to verify the relevance of thresholds used in the plan. Findings include main parameters to be considered for the activation of the plan, and shows that mortality monitoring is a complementary parameter to changes in meteorological parameters. |
| (Bustos Sierra and Aikainen 2017) | BE | RQ 1 | Quantitative analysis relating meteorological and environmental circumstances to mortality data in 2004-2017 | Reports on the surveillance of monitoring mortality during the vigilance phase identified in the national heatwave plan. Results show that excess mortality was limited to the period of the 2017 heatwave in June. There was an unexpected excess mortality in the population of women aged 0-64. The report suggests that preventive measures in the national heatwave plan should focus on the population aged 0-64. |
| (Cox et al. 2010) | BE | RQ 1 | Quantitative analysis relating temperature, ozone levels and mortality data in 2006-2007 | Describes the automated system for early detection and quantification of the mortality impact of public health events, including heat and ozone peaks. With regard to heatwaves, the results show that weekly death counts are less appropriate compared to daily counts, analysis of excess mortality should not be restricted to official heatwaves and the lack of timely data can be a hampering factor for mortality surveillance. Overall, the identification of heat-related excess outside the official definition suggests reconsidering the heatwave scenario. |
| (Cuesta et al. 2017) | ES, PT | RQ 2 | Population survey, 260 respondents in each Madrid and Lisbon | Assesses the awareness and knowledge of the population regarding national heatwave plans. Results show that heatwave plans were not widely known, but practical concepts about vulnerable groups and protective measures were found. Some groups, e.g. foreigners, were less knowledgeable than others highlighting the importance of targeting these groups in communication plans. |
| (de'Donato et al. 2018) | IT | RQ 1 | Quantitative analysis to estimate association between temperature and mortality, survey | Evaluates the temporal change in the effect of heat on mortality after the introduction of the national heatwave plan. Findings show that heat still has an impact on mortality in Italian cities, though a reduction has been observed. The plan seems to have improved the awareness on the health |

| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| | | | sent to health and social services on heat preventive measures adopted in Italian cities | risks of heatwaves and the adaptive capacity of local populations. The ageing of the population increases the population at risk, which can explain why there is still a significant impact of heat on mortality. Active surveillance of vulnerable people by GPs has the greatest potential to be effective, though only suggestive evidence is available. |
| (Elliot et al. 2014) | UK | RQ 1 | Real-time syndromic surveillance of health-related data of 2013 | Presents the syndromic surveillance data used to monitor the impact of heat on morbidity, and demonstrate how these are an integral part of the national heatwave plan. Syndromic surveillance is a vital tool for monitoring public health and has the ability to influence public health action. Further, it provides the reassurance that public health impact is within expected limits. |
| (Fouillet et al. 2008) | FR | RQ 1 | Quantitative analysis relating temperature and mortality from 1975-2003 to estimated expected mortality in 2004-2006 | Evaluates the effectiveness of measures in the national heatwave plan by comparing the actual excess mortality to the expected excess mortality. Findings show that the excess mortality during the 2006 heatwave was lower than predicted, which may be interpreted as a decrease in the population's vulnerability to heat and an increased awareness of heat-related risks, preventive measures and the warning system. |
| (Herrmann and Sauerborn 2018) | DE | RQ 2 | Interviews with 24 GPs | Investigates GP's perceptions of heat health impacts to inform the development of effective prevention measures. Results show that GPs were generally aware of the health impacts of heat, focusing on cardiovascular morbidity and volume imbalances. GPs knowledge and awareness on health impacts and climate change needs to be strengthened. |
| (Khare et al. 2015) | UK | RQ 2 | Online population survey with 1497 respondents | Investigates behaviour during the 2013 heatwave, housing characteristics and experienced negative health outcomes due to heat. Results show a high awareness of actions to take during heatwaves, and identify sections of the population (e.g. elderly, low income earners) that might benefit from additional or more targeted information. |
| (Kunst and Britstra 2013) | NL | RQ 1 | Survey with 27 managers of long-term care institutions | Assesses the extent to which measures recommended in the national heatwave plan have been and could be implemented in long-term care institutions. Findings suggest that a national heatwave plan could be implemented with few problems. Most institutions had a heat protocol |

| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| | | | | and care managers are aware of preventive measures. Areas of improvement include cooling of buildings and staff training. |
| (Lefevre et al. 2015) | UK | RQ 2 | Online population survey with 701 respondents | Examines the relationship between heat protection behaviours during the 2003 heatwave and self-reports of having heard protection recommendations, attitude towards heat, seeing preventive measures as effective and trusting organisations making those recommendations. Results show that those who heard recommendations, also implement more protective behaviours, perceive those measures as effective, feel more positive about heat and will implement those measures in the future. |
| (Léon et al. 2007) | FR | RQ 2 | 2 population surveys with 1270 (in 2005) and 1240 (in 2006) respondents | Evaluates changes in heat protective behaviour and the effectiveness of the communication plan. Findings show that a majority of respondents has taken protective measures, and that this number increased from 2005 to 2006. Knowing the campaign is not linked to adopting protective measures. A majority has taken measures to support vulnerable people, which is linked to knowing the campaign. |
| (Linares et al. 2015) | ES | RQ 1 | Quantitative analysis relating temperature and mortality from 1991-2008 | Determines the impact of heat on mortality and compares results from before and after the implementation of the national heatwave plan. A decrease in mortality was observed, but the study cannot conclude that this is due to the implementation of the heatwave plan. |
| (van Loenhout and Guha-Sapir 2016) | BE, NL | RQ 2 | Population surveys with 120 (BE) and 133 (NL) respondents | Assesses the knowledge of the general population on vulnerable groups and protective measures. Results show that efforts at raising heat awareness must be strengthened and public health actions should effectively target vulnerable groups with lower education. |
| (van Loenhout et al. 2016) | BE, NL | RQ 1 | Interviews with 6 (NL) and 7 (BE) key stakeholders in the NL and BE heatwave plans | Assesses the perceptions of stakeholders within the plans in BE and NL on their responsibilities, the partnerships and the effectiveness of the local implementation of the national heatwave plans. Findings suggest that care organisations had a lack of familiarity with the national plan and deem heat a low priority. Stakeholders reported that responsibilities were not clearly described and that the national plan does not describe tasks on a local level. The study recommends to increase awareness on the health-impact of heat within care organisations and to emphasise the variety of vulnerable groups. |

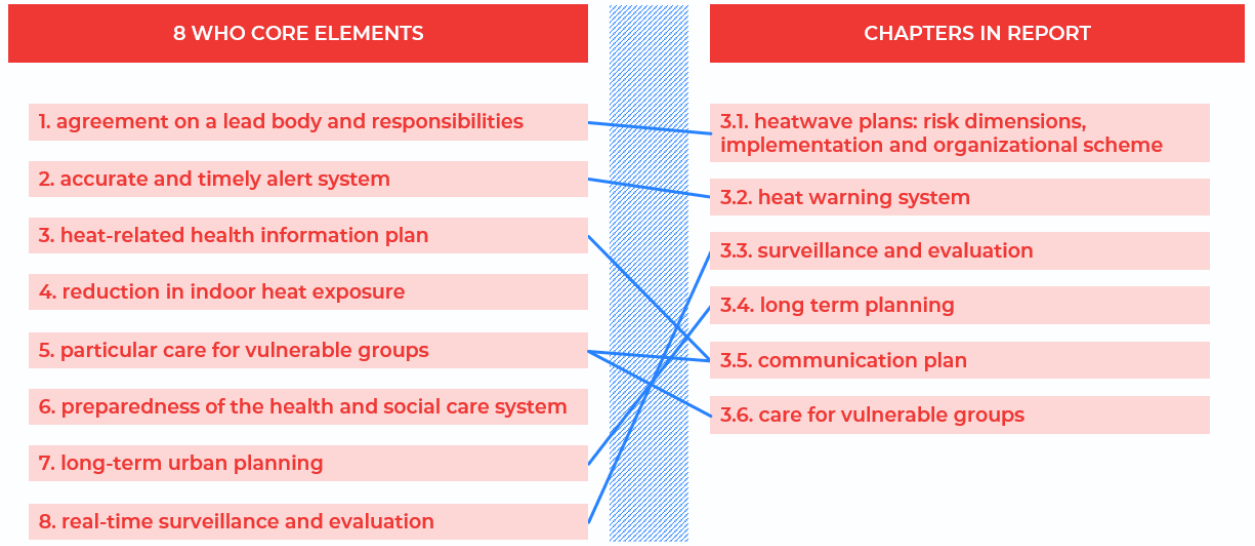
| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| (Martinez et al. 2017) | BE | RQ 1 | Quantitative analysis relating temperature, mortality and hospital admissions in 2009-2013 | Analyses the relation between temperature, mortality and hospital admissions and estimates projected mortality in the near and far future under changing climate and population. Results show mortality increases from a maximum daily temperature of 26°C, and no effect in case of hospital admissions due to cardiorespiratory causes. Mortality will increase in the near future under a no acclimatization scenario. This highlights the importance of a long-term perspective in the prevention of heat exposure and the calibration of existing prevention activities. |
| (Pascal et al. 2012) | FR | RQ 1 | Quantitative analysis relating temperature, air quality and mortality from 2000-2006 | Assesses the mortality impact of the 2006 heatwave and the influence of the heat prevention plan. Results show no additional effect of the heatwave in 2006, though there was excess mortality due to warm temperatures and air pollution. The absence of the heatwave effect may be explained by the prevention plan. |
| (Schifano et al. 2012) | IT | RQ 1 | Quantitative analysis relating temperature and elderly daily mortality in 1998-2002 and 2006-2010 | Estimates changes in the effect of temperature on elderly mortality before and after the 2003 heatwaves and introduction of heat prevention activities. The results show a change in the temperature-mortality relation attribuTable to temperature distributions and the introduction of preventive measures. The reduction in the effect of high temperature suggest that prevention programs can mitigate the impact. |
| (Smith et al. 2016) | UK | RQ 1 | Quantitative analysis of GP in hours, GP out of hours and emergency department syndromic surveillance systems | Examines the impact of the 2013 heatwave on primary care and emergency department visits using syndromic surveillance data. Results show that GP consultations and emergency department attendances for heat illnesses increased during the heatwave period. GP in hours consultations increased across all age groups but highest for children and people over 75. The study supports the monitoring of heat illnesses but suggests that monitoring heat illness in children would provide additional early warning and situation awareness. |
| (Tang and Rundblad 2015) | UK | RQ 2 | Focus groups with younger and older participants, from a Bangladeshi or white British background | Assess the role of age and ethnic and cultural background in the conceptualisation of the number and colour system used as part of the heat-health watch system. The results suggest potential cultural barriers to the intended interpretation of the colour and number sequences for certain groups. |

| Reference | Country | Research question addressed | Research methods & research participants | Summary of the article abstract |
|---|---|---|---|---|
| (Vicedo-Cabrera et al. 2016) | CH | RQ 1 | Quantitative analysis relating temperature and mortality in 2015 | Evaluates the impact of the heat in 2015. Results show excess mortality which was highest in July, in people aged 75+, and in specific regions. The results show that mitigation measures to prevent heat-related mortality in Switzerland have not become noticeably effective since 2005. |
| (Wolf et al. 2010) | UK | RQ 2 | Policy analysis and interviews with 15 elderly respondents | Examines evidence on whether heatwaves and cold spells are addressed differently by policy given that risks are mediated by similar perceptions that shape behavioural responses by vulnerable people. Results suggest that neither heat nor cold risks are perceived as personal risks. Policy related to heat relies on early warning and public information and does not reduce underlying vulnerability. Both types of policy ignore public perceptions of risks. |

## 2.5. Report

Similar to deliverable 2.1, the structure of this report is based on the eight core elements which have been identified by the WHO as important to the successful implementation of heat-health action plans (Bittner et al. 2013; WHO Regional Office for Europe 2008). The eight core elements are not equally covered by the collected literature, and some are not addressed by this review. Specifically, the literature selection does not include articles on elements 4 and 6, so we do not further include these elements in the report. Figure 3 describes the relations between these eight elements and the chapters in this report.

**Figure 3 – link between WHO core elements and chapters in report**




During the coding process, the analysis and writing of the report, we aimed to stay as close as possible to the content of the articles as written by their authors. This implies that we refrained from interpreting and assigning articles to certain themes that we think would fit, if this was not explicitly intended by the author. For example, Abeling (2015) discusses the transfer of responsibilities from Public Health England to local authorities from a risk knowledge perspective. Although this can be broadly framed as an implementation issue, they only discuss it from the perspective of risk knowledge and do not reflect on the broader implementation consequences.

# 3. Literature review

## 3.1. Heatwave plans: implementation and risk dimensions

### 3.1.1. Implementation

Since 2005, 30 Italian cities have developed a heat plan based on the national guidelines and an operational warning system. Between 2005 and 2008 the information campaign reached total coverage in Italy, information was disseminated in all cities each summer. Widely implemented measures include telephone hotlines and telemonitoring of registered elderly patients. Furthermore, heat-related courses for health professionals are part of the Italian Continuing Medical Education program (de'Donato et al. 2018).

With the implementation of the Dutch heatwave plan in 2007, health facilities for elderly residents were urged to reduce heat-mortality. After 3 years, Kunst and Britstra (2013) found that 16 out of 24 organisations that participated in their study had already implemented a heat protocol, and 3 more organisations were developing one. Protective measures focus mainly on infrastructure (e.g. insulation, cooling facilities) and on the level of the patients (e.g. fluid intake). These types of measures are also considered as more important than organisational-level adaptations, such as changing the daily schedule (Kunst and Britstra 2013).

### 3.1.2. Barriers to implementation

In order to implement a heatwave plan, it is important that stakeholders involved in the plan know and are able to effectively implement their role. Both Abrahamson and Raine (2009) and van Loenhout et al. (2016a) report that responsibilities and tasks assigned to stakeholders should be described more clearly, as to avoid confusion about who should take which role. A possible reason for such confusion is that the heatwave plans were developed without involvement of local stakeholders. Additionally, because the national heatwave plans do not describe roles and responsibilities on a local level, there is a lot of variation in the activities between municipalities (van Loenhout et al. 2016).

Further, there is a need for formal structures to improve communication and collaboration between stakeholders other than the formal (top-down) flow of the plan (Boyson et al. 2014). For instance, collaborations between health organisations are highly dependent on personal relations and could benefit from a formal structure (Abrahamson and Raine 2009; van Loenhout et al. 2016). Also two-way communication between managerial staff and nursing/home care assistance is lacking (Boyson et al. 2014).

Finally, the implementation of protective measures is not always feasible due to a lack of funding and time, inadequate contact with target groups, delays caused by the need for authorisation of extra visits, and difficulties in realising a behavioural change (Abrahamson and Raine 2009).

### 3.1.3. Risk management and risk dimensions

In the UK, the national heatwave plan is framed by the 2004 Civil Contingencies Act. The Act provides a legal mandate for category 1 responders[3] to plan and respond to emergencies such as heatwaves. This means that local authorities are required to develop risk assessments, complementary to and supported by the national and regional assessments. The national heatwave plan is a source of risk knowledge and provides guidance in developing local risk management plans (Abeling 2015; Cabinet Office of the UK Government 2013). For instance, Abeling (2015) finds that changes in local plans are closely tied to changes in the national heatwave plan. Additionally, also the responsibility of public health has been transferred from Public Health England to local authorities, for which they receive support and expert services from Public Health England (Abeling 2015; Public Health England 2014). This combined responsibility creates a demand at local authorities and local public health systems for risk knowledge, for which they currently depend on regional and national authorities (Abeling 2015).

In the UK, heat stress is predominantly framed as a public health problem, suggesting that actors from public health also must take organisational and policy ownership of the risk. This is true at both the national and local levels. However, heatwave vulnerability is more complex and also includes environmental, social and technical dimensions. These other dimensions are not always sufficiently considered in heatwave risk planning and require a long-term perspective. Consequentially, response-focused approaches are not sufficient to address heatwaves and risk strategies must also include preventive planning (Abeling 2015)

[3]This includes local authorities, emergency services, health protection agency and primary care trusts (Cabinet Office of the UK Government 2013)

.

## 3.2. Heat warning system

### 3.2.1. Effectiveness of the warning system

In Belgium the level 2 warning phase was activated 7 times between 2005 and 2013 (see also D2.1 for more information on the definition of the alert levels). Observations of maximum and minimum temperatures have always confirmed the forecasts of exceeding the thresholds. Only one heatwave (1-3 July 2010) could not be predicted, as the forecasts did not show that the maximum temperature threshold would be exceeded (Brasseur et al. 2014).

### 3.2.2. Warning parameters

*Meteorological parameters*

Through an evaluation of the Belgian warning parameters, Brasseur et al. (2014) find that while they have demonstrated their relevance, certain improvements can be made. The analysis shows that while a heatwave is often the cause of high concentrations of ozone, this is not always true. When the wind is sufficiently intense, particularly during the night, ozone precursors are effectively dispersed. Contrarily, low wind speeds are associated with abundant ozone formation. Therefore, other meteorological factors besides maximum temperature should also be considered: air quality, duration of critical episodes, cumulative exposure to night-time temperatures above 16°C and average wind speed. In addition, although heat and ozone peaks usually occur between June and August, the excess mortality and temperature increases that often occur at the end of May suggest increased vigilance during this month (Brasseur et al. 2014).

Based on several other evaluations of the warning parameters (Bustos Sierra et al. 2016; Cox et al. 2010; Tersago and Mailier 2015), the Belgian warning system was adapted in May 2017. Specifically, the following changes were implemented (Bustos Sierra and Aikainen 2017):

- warning level 1 and warning level 2 were merged;
- the thresholds were simplified and no longer consider minimum temperature or ozone;
- thresholds now consider total mortality as a health parameter;
- the government knows about heat peaks 2 days in advance to prepare and implement preventive measures.

*Health parameters*

Most mortality monitoring systems (including the Belgian mortality monitoring instrument BE-MOMO, see also 3.3.1) focus on weekly mortality data. Cox et al. (2010) suggest that complementary information might be obtained from daily monitoring as weekly death counts are less appropriate for heat-related outbreaks that often imply a large excess during a limited number of days.

With regard to the target groups, preventive measures and (mortality and morbidity) monitoring should be expanded to include the age group 0-64 (Bustos Sierra and Aikainen 2017) and school-aged children (Smith et al. 2016) as unexpected health impacts in these groups have been found (Bustos Sierra and Aikainen 2017; Smith et al. 2016).

### 3.2.3. Interpretation of warnings

The UK warning system comprises 4 levels, and at each level a colour is assigned to prompt individuals to consider certain actions (see also D2.1. annex 2) (Tang and Rundblad 2015):

**Table 2 – alert levels and colours in UK warning system (taken from Tang and Rundblad (2015))**

| ALERT LEVEL | | COLOUR ASSIGNED |
|---|---|---|
| Level 1 | Heatwave and summer preparedness | Green |
| Level 2 | Alert and readiness | Yellow |
| Level 3 | Heatwave action | Amber |
| Level 4 | Emergency | Red |

Associations between colours, risk and alert level number is informed by cultural knowledge, specifically the use of numerical gradients and colours to calibrate intensity, the categorisation of colours in terms of temperature (red is hot, green is cool) and correspondences between colour and risk. This underlines the need to account for underlying conceptual processes involved in the interpretation of warning information, and how these can be influenced by environmental factors such as culture. Currently, the UK system still contains cultural and linguistic barriers for interpretation, to which older members of ethnic minorities are more vulnerable and less flexible than younger members (Tang and Rundblad 2015).

## 3.3. Surveillance and evaluation

### 3.3.1. Surveillance systems

The Belgian mortality monitoring instrument BE-MOMO monitors all deaths in Belgium (all causes combined) on a weekly base. Following the 2003 heatwave, the system was adjusted and environmental parameters (min. and max. temperatures, ozone concentrations and concentrations of airborne particles) were added (Brasseur et al. 2014; Bustos Sierra and Aikainen 2017; Cox et al. 2010). The BE-MOMO system allows to calculate excess mortality during heatwaves. Weekly data are gathered from week 20 to week 40 (Bustos Sierra and Aikainen 2017). The syndromic surveillance system in the UK is a multifaceted system that enables mortality and real-time morbidity reporting. It collects data from health care systems (e.g. GP[4] in service hours, GP out of service hours, emergency department) that monitor syndromic heatwave indicators in addition to other syndromic indicators on a daily base (Elliot et al. 2014; Smith et al. 2016). In the future, additional data sources may be added, such as ambulance dispatch data, counter prescribing data and social media data (Elliot et al. 2014).

Several authors (Brasseur et al. 2014; Cox et al. 2010; Elliot et al. 2014) find that mortality surveillance systems can be used complementary to meteorological monitoring to give an excess mortality alert in near real time. Moreover, the surveillance of mortality allows to monitor health risks, can support emergency services and can inform public health policy (Bustos Sierra and Aikainen 2017; Elliot et al. 2014). However, registration delays and the use of weekly data means that alerts and interventions can only be timely for slow, longer-term heat periods. For acute short heat periods a timely reaction might not be possible, unless the timeliness of declaration is improved and daily data are used (Cox et al. 2010).

With regard to the analysis of mortality data, comparing expected with real mortality provide insights in excess mortality, though this does not provide insights in the causes underlying mortality. Other variables besides heat, such as ozone and air pollution, can also be responsible (Linares et al. 2015). Linares et al. (2015) suggest to use a univariate ARIMA model of daily mortality registered to all causes except accidents and excluding external causes (because of the weak relationship with temperature), and with regional maximum daily temperature as the principal variable.

[4] GP is an acronym for general practitioner

### 3.3.2. Using surveillance to evaluate the impact of heat events on health systems

Smith et al. (2016) show that heat events burden UK health systems by causing an increase in GP consultations. This supports the need for public health advice and to ensure that GPs can identify and treat heat illnesses. Consistent with expecting health seeking behaviour, severely ill patients prefer visiting emergency departments and unscheduled GP services out of hours (Smith et al. 2016).

### 3.3.3. Using surveillance to evaluate effectiveness of heatwave plans

*The plan in general*

Analyses of mortality can provide insights into the effectiveness of heatwave plans and their components. The study of de'Donato et al. (2018) finds that the Italian heatwave plan has gradually reduced mortality in the period 2005-2016. The reduction in mortality in Italy occurred first for the effect of extreme temperatures and later, after several years of implementation of local programs and consolidation of actions, also for mild summer temperatures (de'Donato et al. 2018). For the period 2006-2010, Schifano et al. (2012) do not find the same reduction for milder temperatures, but report a larger heat effect on health in May, June and September. Possibly because the prevention activities are not activated in these months. The heatwave plan is suspected to have increased awareness on heat-health risks and to have improved the adaptive capacity of local populations. Further implementation of heatwave plans (e.g. by local authorities) can be promoted by describing the potential effectiveness of protective measures (de'Donato et al. 2018).

Also in France (for the period 2004-2006), the heatwave plan is found to have reduced mortality thanks to an increased risk awareness, preventive measures and the implementation of a warning system (Fouillet et al. 2008; Pascal et al. 2012). Nevertheless, there was a significant increase in mortality during this period, suggesting that efforts to promote short- and long-term prevention measures must be maintained and communication campaigns on risks and protective behaviour must be enhanced (Pascal et al. 2012). In addition, Pascal et al. (2012) report on the geographical heterogeneity of heatwaves and their impact. For example, a city with warm temperatures but lower compared to other cities can still have a high mortality burden when these temperatures are unusual for that city; and also the actions implemented may be different from those in other cities (Pascal et al. 2012).

In Belgium (Brasseur et al. 2014) and the UK (Elliot et al. 2014) mortality increases during heat events; but is found to be within the expected seasonal limits.

The Spanish (Linares et al. 2015) and Swiss (Vicedo-Cabrera et al. 2016) heatwave plans are not found to realise a decrease in mortality. Regarding the Spanish situation, an

important explanation of the results is the occurrence of heatwaves outside the implementation period of the heatwave plan. Furthermore, heatwaves in May – before activation of the plan – have a bigger impact on mortality: the population of vulnerable people declines with each successive heatwave, as mortality increases (Linares et al. 2015). The Swiss study find similar heat effects for the 2003 and 2015 heatwaves, indicating that public health campaigns and adaptation to heat, better health services, increases in air conditioning usage and improved insulation did not substantially help to reduce overall heat-related mortality. A possible explanation might be that only a few Swiss cantons have formally implemented heat-health warning systems (Vicedo-Cabrera et al. 2016).

*Specific components*

With regard to specific components of heatwave plans, suggestions arise for determining the period of implementation and the definition of heatwaves. First, concerning the period of surveillance, results show that the effect of heatwaves is not limited to the period of the actual heatwave as effects are also observed after the heatwave has officially passed (Cox et al. 2010; Smith et al. 2016). Furthermore, heat effects on health are also found outside the traditional period June-September in which heatwave plans are implemented, suggesting that monitoring should already start earlier in May. Surveillance systems can help to determine the period in which the plan is best implemented (Brasseur et al. 2014; Linares et al. 2015).

Second, heatwave definitions and definitions of thresholds that take into account data from mortality and morbidity surveillance have an important advantage, since they consider population-linked factors and prevent activation of the plan when it is actually not required (Martinez et al. 2017; Vicedo-Cabrera et al. 2016).

## 3.4. Long-term planning

### 3.4.1. Infrastructure

Wolf et al. (2010) find no evidence of long-term adaptation measures to heat. While double-glazed windows and insulation are commonly used in the UK, air conditioning is not. In 2009, the UK heatwave plan did not include provision for actively supporting home improvements to help elderly people maintain a cool indoor environment, though this could help adaptation to heat. At that time, it did include encouragement of insulation, to increase urban green spaces and to establish links with other climate mitigation measures; but left open how these could be achieved (Wolf et al. 2010).

Between 2007 and 2010, care organisations in the Netherlands started to develop heatwave plans on an organisational level. Implemented measures focus on infrastructure and include indoor cooling facilities, outdoor sunshades on windows, rooftop insulation and heat-reflective window glass. Fans and air conditioning are not commonly used (Kunst and Britstra 2013).

### 3.4.2. Policy

Wolf et al. (2010) suggest that by connecting heatwave policy to e.g. cold policy or climate change policy an integrate approach can be created that considers vulnerability across seasons.

## 3.5. Communication plan

### 3.5.1. Information campaign

National heatwave plans lay out best-practice guidance for care and health professionals, and for local authorities during a heatwave. Communication plans can target health and social care professions, care home managers and staff, and the general public (Wolf et al. 2010).

Wolf et al. (2010) note that pamphlets for the general public outline vulnerable groups, symptoms of heat illness and protective behaviour during a heatwave. However, the pamphlet does not contain advice on how to prepare for heat before it occurs, nor provides aid with such preparation. These topics are only covered in publications that target professionals. Consequently, the public is not informed about the benefits of insulation, shading trees and fans at home before a heatwave occurs. In other words, the policy effort is less targeted towards alleviating vulnerability, which has implications for adaptation (Wolf et al. 2010).

Lefevre et al. (2015) report that over half of their respondents in the UK have heard information on protective measures through at least one channel, which was mostly on TV or through the Met Office. Especially people who have previously experienced negative health effects, seem more attentive to hear the recommendations. Also in France, the information campaign reaches a major part of the population (Léon et al. 2007).

### 3.5.2. Knowledge of protective measures and risk awareness

*General public*

Pascal et al. (2012) report that during the 2006 heatwave in France, a questionnaire revealed that 74% of the people had heard, read or seen prevention information; 63% had taken protective measures; and 73% had taken measures to protect their elderly relatives and friends. These findings suggest that the French heatwave plan has a broad reach and has changed awareness of heat-related risks in the general population (Pascal et al. 2012).

Two studies (Cuesta et al. 2017; van Loenhout and Guha-Sapir 2016) find that risk awareness of the general public must be strengthened in Belgium, the Netherlands, Portugal and Spain. Participants are not sufficiently aware of the plan, or able to adequately identify protective measures and symptoms of heat illness. Especially individuals from vulnerable groups (e.g. elderly), individuals with lower education or foreigners can benefit from a more targeted information (Cuesta et al. 2017; van Loenhout and Guha-Sapir 2016).

Lefevre et al. (2015) find that people who have heard recommendations regarding protective measures are more likely to implement these measures and perceive these as effective. But, (Léon et al. 2007) find no relation between recognising the information campaign and implementing protection measures. Moreover, research shows that knowledge about protective measures does not always result in implementation (Khare et al. 2015; Lefevre et al. 2015). In some cases, heat warnings may trigger positive memories about summers which are then used as cues to become unconcerned about risk protection (Lefevre et al. 2015). Furthermore, especially the elderly (61-75) are less likely to implement certain measures compared to younger people (18-25), while younger people are more likely to engage in risky behaviour during heatwaves (Khare et al. 2015). Similarly, men and low-income earners are less likely to take protection measures. Women are more likely to seek information on health risks, whereas high income earners face less barriers in adapting their behaviour (Khare et al. 2015; Lefevre et al. 2015).

### *Vulnerable groups*

Elderly people are found to generally not perceive themselves as vulnerable to heat, but point to other "older" people or people with certain medical conditions who may be effected (Abrahamson et al. 2008; Bittner and Stößel 2012; van Loenhout and Guha-Sapir 2016; Wolf et al. 2010). This group is reported to feel able to look after themselves, which is considered "common sense" and protective strategies focus mainly on reactive actions (e.g. buying appropriate food). These actions are efficient, but effective only in the short term and involve some exposure to heat since protective behaviour is only initiated after it is already hot. This implies that elderly people do not perceive a need for preparation and planned action (Wolf et al. 2010).

Wolf et al. (2010) suggest to address this gap in the information campaign by tailoring information to characteristics of vulnerability or to appeal to the wider public with information on specific vulnerability characteristics. In addition, people's risk perceptions must not be disregarded as this can hamper success in terms of behavioural adaptation. Instead, insights in psychological and sociological underpinnings of the elderly can help to encourage long-term adaptation (Wolf et al. 2010). This is supported by the findings of Abrahamson et al. (2008) and van Loenhout and Guha-Sapir (2016) who suggest that vulnerable groups can benefit from targeted information campaigns that use other media in addition to the traditional ones. Bittner and Stößel (2012) find that elderly people have received and prefer warnings from nursing services; television; newspapers and magazines and radio. GPs can be another potential information source.

### *Stakeholders involved in plan*

In order to implement a heatwave plan, it is important that stakeholders involved in the plan are aware of its existence, and of their role in it. Multiple studies (Abrahamson and Raine 2009; Boyson et al. 2014; van Loenhout et al. 2016) find that this awareness can be much improved in health and social services, especially among frontline staff (i.e. those in direct contact with patients).

The extent to which heat and the heatwave plan are considered a public health priority is another issue. Abrahamson and Raine (2009) and Boyson et al. (2014) find that in the UK, heatwaves are considered to not occur sufficiently frequent to justify the preparation required by the heatwave plan. The same argument is reported by van Loenhout et al. (2016). Reasons to increase the priority of heatwaves are, for instance, that protective measures can be cost-effective, the frequency and severity of heatwaves will increase in the future, there is a direct impact of heat on mortality, and heat has a higher importance compared to other public health issues.

Bittner and Stößel (2012) find that caretakers in nursing homes are aware of potential heat-risks and have previously applied preventive strategies. However, they also find the degree of information on heat warnings is insufficient, which can be dangerous for those dependent on caretakers.

GPs play an important role in the care for the elderly. Herrmann and Sauerborn (2018) find that GPs are able to identify medical and socioeconomic risk factors, but lack knowledge about the definition of heatwaves. In addition, they have little to no experience with elderly patients seeking their help for heat impacts or dying due to heat. GPs attributed this to the quality of care systems and to patients suffering from heat preferring to go to emergency departments, but it also shows they were insufficiently aware of the impact of heat on mortality. The authors remarked that the lack of awareness was unsurprising as GPs do not receive any training on climate change and health, despite this being part of the German adaptation strategy (Herrmann and Sauerborn 2018).

While Kunst and Britstra (2013) find that many care facilities have implemented an organisational heatwave plan following the national plan, dissemination of these plans and assessment of the importance of measures can be improved. In some cases, perceived effectiveness may depend on local conditions (e.g. type of building), but in other cases it stems from a lack of expertise (Kunst and Britstra 2013).

### 3.5.3. Knowledge of vulnerable groups

Elderly people identify vulnerable groups based on perceptions of medical conditions and of inabilities to implement protective measures (Bittner and Stößel 2012; Wolf et al. 2010). This suggests that the identification of vulnerable people is easier when there is a known underlying condition that is thought to impede well-being and independence.

In Belgium and the Netherlands, the general public is not sufficiently able to identify vulnerable groups. Especially individuals from vulnerable groups (e.g. elderly) and with lower education can benefit from a more targeted information campaign (van Loenhout and Guha-Sapir 2016). In Portugal and Spain, the awareness is higher compared to Belgium and the Netherlands (Cuesta et al. 2017).

## 3.6. Care for vulnerable groups

### 3.6.1. Identification

In Italy, the identification of vulnerable individuals occurs through record linkage procedures that combined health information systems (hospital discharges, drug prescriptions) and administrative population registries (sociodemographic factors). Between 2005 and 2016, 20 cities implemented these procedures. 3 other cities use a procedure based on GP or social worker notifications from a questionnaire on health status, family support and living conditions (de'Donato et al. 2018).

### 3.6.2. Surveillance and care activities

Between 2005 and 2016, 22 Italian cities have implemented GP active surveillance, and 5 cities active surveillance by caregivers. Surveillance activities are determined by the alert level in place (level 2-3 warnings). Surveillance can occur through telephone calls and home visits, and activities include pharmacological treatments, homebased therapies; active health surveillance and access to nursing or residential homes when necessary (de'Donato et al. 2018).

While telemonitoring of registered elderly patients is common in Italy (de'Donato et al. 2018), Bittner and Stößel (2012) find that the participants in their study reject this idea because they believe themselves capable of assessing the situation.

### 3.6.3. Barriers to care for vulnerable groups

Several barriers exist for the identification, monitoring and care for vulnerable people, for which most heatwave plans include additional protective measures. In practice, the feasibility of these measures, however, is low. In order to identify vulnerable people, there is a need for up-to-date and personal knowledge of vulnerable people, effective communication between health organisations, flexible and digital databases, and a method to prioritise vulnerable people to not overwhelm care services (Abrahamson and Raine 2009).

Further, not all risk groups receive heat warnings or services because some vulnerable people are unknown to services, refuse services or do not meet criteria for support (Abrahamson and Raine 2009), or because local actors do not target all vulnerable groups (van Loenhout et al. 2016). Consequentially, the success in reaching risk groups varies. According to van Loenhout et al. (2016), some stakeholders feel that media information adequately reaches target groups, whereas others feel there is limited awareness among risk groups and that not all relevant stakeholders or risk groups are included.

Finally, the implementation of protective measures for vulnerable people is not always feasible due to a number of reasons (Abrahamson and Raine 2009; Bittner and Stößel 2012; Boyson et al. 2014; Kunst and Britstra 2013):

- perception that GPs are difficult to reach and are thus not valuable for short-term advice;
- lack of funding and time, inadequate phone contact with vulnerable people;
- delays caused by the need for authorisation of extra visits;
- lack of risk awareness and adaptation in elderly;
- need to respect the independence of patients; and
- conflict between heat protection measures and other guidelines.

# 4. Key lessons from the literature review

Based on the literature review above, we describe general key lessons and insights. Some key lessons might be specifically useful only for certain countries due to the organizational structure of the health care system, due to cultural differences or due to different responsibilities. These lessons have to be validated by the stakeholders in the different in each country before they are taken up as recommendations of change.

## 4.1. Research question 1

### Effectiveness of processes described in the national heatwave plans

#### Heatwave plans: risk dimensions, implementation and organisational scheme

- responsibilities for actors at different levels should be described more clearly (Abeling 2015; Abrahamson and Raine 2009; van Loenhout et al. 2016);
- for a more effective uptake and role division, stakeholders can be involved in the development of a heatwave plan (van Loenhout et al. 2016);
- highlight particular actions which are statutory can avoid confusion (Abeling 2015);
- a national heatwave plan can serve as a blueprint for plans at lower levels and can provide guidance in carrying out disaster risk management activities (Abeling 2015; van Loenhout et al. 2016), though national coordination might be beneficial as this can also result in heterogeneity in type and quality of local activities (de'Donato et al. 2018; van Loenhout et al. 2016);
- heatwave plans should equally consider health, environmental, social and technical aspects of heatwaves (Abeling 2015);
- heatwave plans must include both planning on the short- and on the long-term, i.e. responsive and preventive strategies (Abeling 2015);
- create effective formal structures to smoothen communication between actors at the same and different levels (Abrahamson and Raine 2009);
- support and ensure responsiveness of care, for instance by involving volunteers (family, neighbours and local community), funding of equipment (e.g. water bottles) and remote monitoring of vulnerable people (Abrahamson and Raine 2009).

## Heat warning system

- other meteorological factors besides maximum temperature should be considered for triggering warning systems, such as air quality, duration of heatwaves, cumulative exposure to night-time temperatures and average wind speed (Brasseur et al. 2014);
- a comprehensible communication system should consider possible cultural and linguistic barriers for correct interpretation (Tang and Rundblad 2015);
- preventive measures should also target the age group 0-64 as mortality increases are not only observed in the 65+ group (Bustos Sierra and Aikainen 2017);
- monitoring should also target children of school age (Smith et al. 2016).

## Surveillance and evaluation

- mortality surveillance can be used complementary to monitoring meteorological parameters to provide early warning (Brasseur et al. 2014; Cox et al. 2010; Elliot et al. 2014);
- mortality surveillance allows to monitor health risks, can support emergency services and can inform public health policy (Bustos Sierra and Aikainen 2017; Elliot et al. 2014);
- daily monitoring of mortality data is more appropriate to analyse the impact of heatwaves than weekly data (Cox et al. 2010);
- optimal timeliness (time between detection and reaction) can be obtained through a web-based process of death declaration (Cox et al. 2010);
- the effect of heatwave plans on mortality is gradual rather than direct (de'Donato et al. 2018);
- before and after studies of the effect of heatwave plans on mortality are an indirect but important measure to document the effect of preventive measures and changes over time (de'Donato et al. 2018);
- heatwave plans can be promoted by describing the potential effectiveness of measures (de'Donato et al. 2018);
- mortality surveillance should not be limited to official heatwaves as excess mortality also occurs outside of these (Cox et al. 2010);
- determination of the implementation period of the heatwave plan should be informed by mortality data (Brasseur et al. 2014; Linares et al. 2015);
- assessments of prevention plans based on mortality data must consider multiple years and best differentiate between the impact exclusively due to temperature and that attribuTable to other variables (Linares et al. 2015);

- heatwave plans can reduce mortality through an increased risk awareness, preventive measures and a warning system if implemented on a large scale (de'Donato et al. 2018; Fouillet et al. 2008; Pascal et al. 2012);
- differences in the local implementation of the national plan, in addition to familiarity of the local public with warm temperatures, cause geographical heterogeneity in the mortality impact of heat events (Pascal et al. 2012);
- mortality and morbidity data can be used to inform the definition of thresholds for triggering warning systems (Martinez et al. 2017; Vicedo-Cabrera et al. 2016).

### Long term planning

- vulnerability to extreme temperatures can be tackled across seasons for a more coherent policy (Wolf et al. 2010).

### Communication plan

- cross-country collaboration on raising awareness and exchanging strategies can be beneficial for policy (van Loenhout and Guha-Sapir 2016);
- heatwave plans tailored to specific stakeholders, such as care facilities, may help overcome the lack of clear responsibilities and ambiguity about how messages should be communicated to staff (Boyson et al. 2014);

### Care for vulnerable groups

- telemonitoring of vulnerable people can be effective, though people may object to being monitored (Bittner and Stößel 2012; de'Donato et al. 2018);
- identification of susceptible groups, modulation of measures by alert level and active surveillance by GPs can be core elements of caring for vulnerable groups (de'Donato et al. 2018);
- GPs can potentially play an important role in heat protection and advice, but need to be (perceived as) more accessible (Bittner and Stößel 2012);
- active surveillance of elderly may have the greatest potential to be effective and efficient for reaching elderly at-risk persons, but this has not yet been formally confirmed (de'Donato et al. 2018);
- implementation of protective measures for vulnerable groups must be ensured by providing sufficient funding and time, enabling physical or phone contact, limiting delays due to bureaucratic procedures and optimising behavioural change strategies (Abrahamson and Raine 2009; Bittner and Stößel 2012).

## 4.2. Research question 2

### Impact of the national heatwave plans on behaviour and perceptions

#### Communication plan

- the awareness of vulnerable groups (Abrahamson et al. 2008; van Loenhout and Guha-Sapir 2016; Wolf et al. 2010), of the family of vulnerable individuals (Boyson et al. 2014), and the general public (van Loenhout and Guha-Sapir 2016) should be improved with regard to vulnerable groups, risks and protective measures;
- vulnerable groups, foreigners and individuals with low education can benefit from targeted information campaigns on heat risks and protective behaviour (Abrahamson et al. 2008; Cuesta et al. 2017; van Loenhout and Guha-Sapir 2016; Wolf et al. 2010);
- insights in perceptions (of vulnerable groups) of heat and risks and their psychological and sociological underpinnings can help to encourage long-term adaptation (Lefevre et al. 2015; Wolf et al. 2010);
- heat warnings must avoid evoking positive feelings about heat (Lefevre et al. 2015);
- improve the awareness among health professionals about the definition of a heatwave, the heatwave plan and their role in it, as well as information about heat risks and protective measures (Abrahamson and Raine 2009; Bittner and Stößel 2012; Boyson et al. 2014; Herrmann and Sauerborn 2018; van Loenhout et al. 2016);
- improve the risk awareness and prioritisation of heat among health services (Abrahamson and Raine 2009; Boyson et al. 2014; van Loenhout et al. 2016);
- people find it easier to identify vulnerable individuals when the latter have a known underlying condition that prevents them to implement protective behaviour (Wolf et al. 2010);
- insights in barriers to change behaviours that are linked to socioeconomic and demographic characteristics can help to encourage long-term adaptation (Khare et al. 2015);
- improving awareness alone is not enough, as knowledge of protective measures and risks does not necessarily lead to behavioural change (Khare et al. 2015).

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# Annexes

## Annex 1 – Overview of search results automated search

| Search term | Science direct | | | Pubmed | | | Scopus | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hits | Included* | Excluded | Hits | Included* | Excluded | Hits | Included* | Excluded |
| "Heat plan" and evaluation | 83 | 1 | 82 | 52 | 13 | 39 | 3 | 2 | 1 |
| "Heat plan" and implementation | 105 | 4 | 101 | 36 | 15 | 21 | 1 | 1 | 0 |
| "Heat plan" and assessment | 48 | 1 | 47 | 49 | 9 | 40 | 1 | 1 | 0 |
| "Heat plan" and effective | 43 | 2 | 41 | 47 | 8 | 39 | 0 | 0 | - |
| "Heat plan" and perception | 9 | 1 | 8 | 9 | 1 | 8 | 0 | 0 | - |
| "Heat plan" and behaviour | 27 | 0 | 27 | 37 | 6 | 31 | 1 | 1 | 0 |
| "Heat plan" and "behaviour change" | 25 | 0 | 25 | 4 | 2 | 2 | 0 | 0 | 0 |
| Heatwave and evaluation | 16 | 2 | 14 | 3 | 3 | 0 | 1 | 1 | 0 |
| Heatwave and implementation | 22 | 3 | 19 | 5 | 5 | 0 | 4 | 2 | 2 |
| Heatwave and assessment | 26 | 3 | 23 | 1 | 1 | 0 | 3 | 1 | 2 |
| Heatwave and effective | 19 | 2 | 17 | 4 | 3 | 1 | 4 | 3 | 1 |
| Heatwave and perception | 9 | 2 | 7 | 1 | 1 | 0 | 3 | 3 | 0 |
| Heatwave and behaviour | 19 | 0 | 19 | 5 | 3 | 2 | 3 | 3 | 0 |
| Heatwave and "behaviour change" | 19 | 1 | 18 | 2 | 2 | 0 | 1 | 1 | 0 |
| "Heat health mitigation" and evaluation | 80 | 1 | 79 | 10 | 1 | 9 | 0 | 0 | - |
| "Heat health mitigation" and implementation | 76 | 0 | 76 | 10 | 1 | 9 | 0 | 0 | - |
| "Heat health mitigation" and assessment | 85 | 4 | 81 | 44 | 1 | 43 | 0 | 0 | - |
| "Heat health mitigation" and effective | 76 | 1 | 75 | 25 | 1 | 24 | 0 | 0 | - |
| "Heat health mitigation" and perception | 41 | 1 | 40 | 11 | 1 | 10 | 0 | 0 | - |
| "Heat health mitigation" and behaviour | 65 | 1 | 64 | 7 | 1 | 6 | 0 | 0 | - |
| "Heat health mitigation" and "behaviour change" | 64 | 1 | 63 | 3 | 1 | 2 | 0 | 0 | - |
| "Heat warning system" and evaluation | 56 | 1 | 55 | 17 | 6 | 11 | 5 | 1 | 4 |
| "Heat warning system" and implementation | 50 | 2 | 48 | 13 | 5 | 8 | 7 | 1 | 6 |
| "Heat warning system" and assessment | 49 | 0 | 49 | 28 | 5 | 23 | 7 | 1 | 6 |
| "Heat warning system" and effective | 42 | 2 | 40 | 16 | 3 | 13 | 7 | 1 | 6 |
| "Heat warning system" and perception | 17 | 1 | 16 | 4 | 1 | 3 | 2 | 0 | 2 |

| Search term | Science direct | | | Pubmed | | | Scopus | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hits | Included* | Excluded | Hits | Included* | Excluded | Hits | Included* | Excluded |
| "Heat warning system" and behaviour | 34 | 0 | 34 | 10 | 2 | 8 | 3 | 0 | 3 |
| "Heat warning system" and "behaviour change" | 34 | 0 | 34 | 1 | 0 | 1 | 25 | 0 | 25 |
| "Heat health warning system" and evaluation | 45 | 0 | 45 | 14 | 5 | 9 | 3 | 0 | 3 |
| "Heat health warning system" and implementation | 41 | 1 | 40 | 11 | 6 | 5 | 3 | 0 | 3 |
| "Heat health warning system" and assessment | 42 | 1 | 41 | 23 | 4 | 19 | 10 | 0 | 10 |
| "Heat health warning system" and effective | 36 | 0 | 36 | 14 | 3 | 11 | 5 | 0 | 5 |
| "Heat health warning system" and perception | 20 | 0 | 20 | 2 | 1 | 1 | 4 | 0 | 4 |
| "Heat health warning system" and behaviour | 33 | 0 | 33 | 7 | 3 | 4 | 6 | 0 | 6 |
| "Heat health warning system" and "behaviour change" | 33 | 0 | 33 | 1 | 0 | 1 | 5 | 0 | 5 |
| **Total** | **148**<br>**9** | **39** | **1450** | **403**<br>**526** | **123** | | **94**<br>**117** | **23** | |

*included here means included in the selection process, not necessarily in the final selection on which the review is based

## Annex 2 – WHO core elements of heat-health action plans and sub-elements

Taken from (Bittner et al. 2013)

| Core element | Subelements |
|---|---|
| 1. Agreement on a lead body and clear definition of actors' responsibilities | Clearly defined lead body<br>Involvement of >1 other agencies<br>Regular meetings and/or reviews<br>Inclusion in national disaster preparedness<br>Cross-border cooperations |
| 2. Accurate and timely alert systems | Threshold definition scientifically sound<br>Regionally adapted definitions<br>Warning is issued well in advance<br>Different alert levels for different levels of action<br>Alert is communicated following a clear plan |
| 3. Health information plan | Clearly defined actors/recipients/contents<br>Effective dissemination of information (>1 channel)<br>Quality of advice<br>Public & professionals addressed<br>Appropriate timing of information campaign |
| 4. Reduction in indoor heat exposure | Giving advice<br>Providing cool rooms/spaces<br>Provision or use of mobile coolers<br>Planning or support for increased albedo or shading<br>Planning or support for better insulation |
| 5. Particular care for vulnerable groups | Identification of relevant groups (>1)<br>Activation of a telephone service<br>Specific measures (buddies, neighbours…)<br>Regular re-assessment of vulnerable population groups<br>Information and training for caregivers |
| 6. Preparedness of the health/social care system | Increase of capacity of health services<br>Heat reduction in healthcare facilities<br>Special precautions in nursing homes<br>Special resources for patients/public<br>Improving health-care networks |
| 7. Long-term urban planning | Increased green & blue spaces<br>Changes in building design (albedo, insulation, passive cooling)<br>Changes in land-use decisions<br>Energy consumption reduction<br>Individual and public transport policies |
| 8. Real-time surveillance | Less than 48-h interval<br>Involving data from >1 region/city<br>Involving data from >1 health effect<br>Use for adjustment of measures<br>Use for evaluation of effectiveness |