3.2.10 CMTool

Introduction

Scope of prototype

Temperature-related illness and death is putting strain on public health systems; strengthening health systems and building capacity is crucial to providing climate-resilient healthcare and to protecting the health of millions of European Union citizens. Health service delivery needs to be assured at all times, particularly when challenged during times of crisis, such as during summer heat wave emergencies. Climate forecasts would allow for better short-to-medium-term resource management within health systems and would help authorities prepare and respond ahead of heat waves and cold spells. Heat–Health Action Plans (HHAP) and cold weather plans (CWP) depend on reliable early-warning systems to allow for long-term planning (e.g. energy use, urban design, health workforce management), as well as timely activation. This helps local authorities prepare and respond to emergency situations and thus reduce excess morbidity and mortality due to temperature extremes.

In this study, a climate-driven mortality model is developed to provide probabilistic predictions of exceeding emergency mortality thresholds for heat wave and cold spell scenarios. To evaluate the model, daily mortality data corresponding to 187 regions across 16 countries in Europe were obtained from 1998–2003. Data were aggregated to 54 larger regions in Europe, defined according to similarities in population structure and climate.

Scope of vulnerability analysis

This vulnerability analysis focuses on the impact of heat waves on the general public and the ability of the local health system to cope with such situations. For the purposes of this analysis, major decision-makers are defined as those responsible for implementation of the HHAP, i.e. ministries of health and senior public health professionals and administration.

System of concern

The majority of the heat–health action plans in Europe are organized at the national level and are usually developed by the national ministry of health in cooperation with national meteorological services and other state and non-state actors. Implementation is mostly at a regional or local level involving the local health infrastructure, such hospitals, pharmacies, other health centres and social services (Matthies and Menne 2009). Thus, the operational boundaries and physical boundaries are related to the respective administrative unit for which health service institutions are responsible. Success criteria are primarily safety of the general public and resilience of the health system, which has the goal to prevent morbidity and mortality, and to ensure continued functionality (business continuity) health system. Limiting factors may economic in nature (UniversityHospital_Barcelona 2014), or lack of technical capacity for implementation.

Critical situation

Heat can have negative health effects for individual persons when the thermoregulation system fails. Typical heat-related health problems include heat rash, heat œdema, heat syncope, heat cramps, heat exhaustion, and ultimately heat stroke and death (WHO 2008). Cardiovascular and respiratory diseases are commonly considered as underlying cause for death during heat waves; however, the link between deaths and heat exposure on hot days

is difficult to establish as heat exposure can exacerbate many existing medical conditions other than heat-stroke and hyperthermia and have compounding effects with medication. Consequently, mortality attributed to heat-related causes are commonly underestimated. Heat mortality is usually studied by measuring the short-term associations between numbers of daily mortality and temperature at the community level. The vulnerability of a population to heat is indicated by a heat threshold (temperature above which heat effects can be observed) and the heat slope (measure of effect size). Both parameters may vary significantly across populations depending on differing geography and climate, as well as demographic and socioeconomic characteristics (Hajat and Kosatky 2010). Vulnerable population members are often elderly, socially isolated, chronically or mentally ill, homeless, individuals with cognitive disorders or those taking medication that affects thermoregulation, cognition or have photosensitive side effects. The build environment can significantly increase the heat exposure of population groups, especially in urban centres (e.g. through the urban heat-island effect) (Lowe, Ebi et al. 2011).

Hazard: Studies referring to heat-mortality in Europe clearly indicate that mortality due to heat exposure is not related to annual mean temperatures. In regions with warmer summers, minimum mortality occurs at higher temperatures than in regions with colder summers. Thus, heat-mortality is a function of days with maximum temperatures above the regional minimum-mortality band. Interestingly, the number of days above the minimum-mortality band is not greater in the hotter countries, nor is the annual heat-related mortality significantly greater. Furthermore, the rise in daily mortality in relation to temperature increase shows no significant difference between regions. Upper limits of the minimum-mortality band range from 17.3°C (in northern Finland) and 22.3°C (in London) to 25.7°C (in Athens) (Keatinge, Donaldson et al. 2000). However, other studies state a higher mortality in cities in Mediterranean regions as they are exposed to higher heat-wave frequencies. But in general, the daily mortality increases significantly with an increase of the intensity and duration of heat waves all over Europe (WHO 2008).

Decision-making processes: Measures to prevent or mitigate the impact of heat waves are usually determined by heat-health action plans which are developed by national authorities and implemented on the regional or local scale. Heat–health action plans can be evaluated based on inclusion of nine core elements (Matthies, Bickler et al. 2008, Bittner, Matthies et al. 2013):

- Agreement on a lead body and clear definition of actors' responsibilities
- Accurate and timely alert systems, heat–health watch-warning systems
- Health information plan
- Reduction in indoor heat exposure
- Particular care for vulnerable groups
- Preparedness of the health/social care system
- Long-term urban planning
- Real-time surveillance
- Monitoring and evaluation

The elements 2, 6 and 7 of an ideal HHAP would benefit from early-warning systems providing information on upcoming and ongoing heat waves on different scales (weather [2], seasonal climate [6] and climate change [7]) on the local level. On the scale of weather

forecasts, heat–health warning systems (HHWS) are used to initiate acute public health interventions. HHWSs vary widely in structure, implementing partner agencies, and the specific interventions deployed. Temperature ‘thresholds’ for action (e.g. magnitude, duration, temperature-humidity index) are strongly related to the local population’s adaptation to the local climate. An effective HHWS requires (Kovats and Ebi 2006):

- Reliable meteorological forecasts.
- Robust understanding of cause–effect relationships and evidence-based identification of high-risk meteorological conditions.
- Effective response measures implemented within the window of the warning lead-time.
- Involvement of appropriate institutions with sufficient capacity, resources and knowledge.

HHWSs in Europe basically address emergency services helping to outline plans to recruit, increase or recall staff to respond to emergency situations. Additionally, they can target particularly vulnerable population groups to initiate individual protection measures. Such warnings may be tailored due to the individual needs of specific population groups and are disseminated using multiple, and user specific, methods. Almost all HHWSs in Europe are active at least between May and September and provide heat wave warnings with lead-times between 1 and 5 days, often graded in different levels of warning (Lowe, Ebi et al. 2011).

Heat wave alerts mainly address the initial trigger conditions (highest alert level), which comprises the initial days of a heat wave. Thus, prolonged heat waves or high frequencies of heat waves which cause the greatest increase in mortality, as well as accumulated effects due to continuous heat exposure are little considered in HHWS’s (Kovats and Ebi 2006, Lowe, Ebi et al. 2011).

Decision-making processes which might benefit from longer-term climate forecasts to prepare for prolonged or higher frequency heat waves may address the necessary resource allocation and capacities of health services for longer-term emergency situations, and are loosely considered in HHAPs (Matthies, Bickler et al. 2008, Lowe, Ebi et al. 2011). Thus, the development of longer-term climate forecast tools are justified by such decision-making processes (Koppe and Jendritzky 2005, WHO 2008). However, despite the fact that mortality significantly increases with intensity and duration of heat waves, a similar relationship of heat wave characteristics and hospital admissions is not consistent within Europe. Many studies from Europe indicate a rather low or inconsistent correlation of temperature on hospital admissions compared to incidence of mortality (Kovats, Hajat et al. 2004, WHO 2008). The impact of heat waves on hospitals is widely discussed and analysed especially after summer 2003. Most aspects are related to the basic hospital infrastructure and design which appeared to be limited by technical failure of machines or insufficient cooling configurations (WHO 2008, Carmichael, Bickler et al. 2013). These issues would be addressed by long-term planning activities which might go beyond the seasonal time scale of decision-making. The importance of mid-term forecasts (weeks ahead) is also indicated by health service decision-makers who are generally interested in such climate information to be prepared for exceptional high hospital admissions. However, climate (e.g. heat waves) is only one of many factors influencing hospital capacity utilization, thus no specific decision-making structures exist at which such climate information would find direct impact. Statements on

general lead times to prepare for exceptional utilization are around 4 weeks (UniversityHospital_Barcelona 2014).

The critical situation arises when local temperatures rise to extreme values referring to local climate conditions and persist for too long so that local medical coping capacities will be exhausted.

Buffer system characteristics

The impact of temperature on health conditions is very immediate; the critical threshold is related to the physical condition of the individual and their adaptation to local climate conditions. Thus, no buffer effect can be attributed to the direct climate cause–effect relationship. However, with respect to the second critical situation, a potential exhaustion of health system capacity, the attribute of concern changes: here, health service provision is the attribute of concern. This might be stressed by the total number of people requiring health care. With respect to heat waves, it is the total number of people within a specific affected system of concern (e.g. in a municipality) affected by heat to such an extent that they require primary health care, a service provision that is critical to a functioning health system. Thus, the constitution of the local population (i.e. proportion of a population that is vulnerable) defines the criticality of a heat wave (i.e. its intensity) and can therefore be considered as buffer system (Hajat and Kosatky 2010). However, the correlation of heat waves and hospital admissions is inconsistent (see Kovats, Hajat et al. 2004), and the temporal scale of this buffer effect is still dependent on the weather conditions since emergency health care provision is immediately implemented, irrespective of the number of people are affected.

From the perspective of the health system, an increase in demand for primary health care induced by a heat wave is only one of many factors stressing the system. The extent of the heat wave impact on the health system is strongly related to its basic capacity (resilience) to handle variabilities in demand (e.g. hospital admissions) and can additionally be stressed or challenged due to limitations of the basic infrastructure or the occurrence of multiple stressors at once. The health system can therefore be considered as buffer system: the critical duration and intensity of a heat wave and its subsequent consequences for health service demand is dependent on the resilience of the health system. The temporal scope of this buffer system may go beyond the scale of weather events.

Critical climate conditions and climate information

Critical climate conditions

High temperatures become critical for health and life when they become extreme in relation to average local climate conditions; the extremity is the dominant factor. This is very location-specific and may be compounded by local conditions, such as like surface and air circulation conditions, humidity and pollution. The effect of heat waves on health, and especially mortality, increases significantly with duration and intensity. The frequency of heat waves is also important, whereas the first heat spell within a season appears most dangerous. Subsequent heat waves occurring after a short time interval do have less effect than those which occur after three or more days (WHO 2008).

Critical climate conditions are continuous extremely high temperatures (compared to local climate).

Climate information

For the prediction of heat waves the information on the number of consecutive days with extreme temperatures are of special interest. The frequency of heat waves is of lower importance. Short-term medical service requires lead-times of 1-3 days. Mid-term preparation of the health system to distinct heat waves requires lead-times of around one month (UniversityHospital_Barcelona 2014).

Vulnerability attributes

Criticality of decision-making processes: Extreme temperatures and their impact on health are seasonal events, which are largely expected to happen every year. The negative impact role of these climate-induced conditions play would therefore define them as a hazard. The challenge of the decision-makers is to prepare health systems for periods of exceptional demand with respect to resources (e.g. medication), staff (e.g. doctors, nurses and other health professionals) and capacities (e.g. beds available, operations time, and equipment). To provide appropriate supply capacity during the acute phase of the emergency is the major goal of health services, and the preparing to prevent ultimate exhaustion of resources and potential failure of the health system.

However, studies and reports on the impact of heat waves on the health service system as well as HHAP primarily aim for the optimization of short-term warning, prevention and medical provision (at the weather timescale) as well as for the long-term adaptation of health service facilities to a warmer climate and the associated risk of the increasing frequency of heat waves (up to decadal timescales and longer). Decisions related to seasonal time scales of heat/cold events which imply mid-term resource and staff management are considered as important but appear as being less critical than short-term and long-term issues.

The impending exhaustion of health system capacities is of general criticality and not exclusively related to weather phenomena. Heat waves may cause a temporal high demand in medical services stressing health system capacities likewise other non-climate related factors which may be concurrently relevant. However, climate is considered as important, but not a crucial factor to assess and plan health service management issues (UniversityHospital_Barcelona 2014).

Usability of S2D climate information: Climate information with respect to prolonged heat waves has a great potential for respective decision-making processes regarding capacity management of health-services. However, no specific demands regarding critical period length can yet be articulated and also lead times are oriented at established (non-climate related) decision-making processes. Irrespective of very vague boundary conditions for climate services required for decision-makers, the characteristics of critical climate conditions is quiet clear. Consecutive days of exceptional heat are increasingly critical the longer the duration of such periods. Thus, distribution of extreme temperature is obviously a dominant factor. An estimated temporal scale according to the little information available would be that of 1 to maximum 5 months (length of the hot season) with high temporal resolution which provides the opportunity to identify heat spells of a couple of days.