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Heatwaves as an occupational hazard: The impact of heat and heatwaves on workers' health, safety and wellbeing and on social inequalities

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Introduction

Heat is a well-known occupational hazard, traditionally found in jobs in industries and in manufacturing which generate heat, in activities taking place outdoors under the radiation of the sun, such as agriculture and construction, and in those tasks implying exertion or the use of personal protective equipment. However, in the last decades, especially since the beginning of the 21st century, episodes of hot days are posing a new challenge to workers' health, safety and wellbeing.

At present it has become clear that very high summer temperatures and heatwaves are no longer rare events. Heatwaves are becoming more frequent, more intense and more extended. Defined broadly, heat events (or extreme heat events) refer to hot conditions, temperature and humidity that exceed the local climatological normal. Today these are a reality both in regions where summers are generally hot and in those where summers are typically cooler, even at high latitudes.

Weather-related heat exposure has become a sanitary concern given the wide repercussions it has for health. Both physiological and epidemiological research show that the impact of heat on human health goes far beyond acute heat conditions such as potentially fatal heat strokes. Heat exacerbates the problems associated with a wide variety of cardiovascular, respiratory and other acute illnesses and reproductive health. During heatwaves there is an increase in injury-related mortality in comparison with that experienced in communities' usual climates; a part of this is occupationally-related.

Such events add risks in particular to working people, especially when these are topped by pre-existing occupational heat stress factors, as the use of personal protective equipment, which can hinder the dissipation of body heat, exertion or other occupational hazards. As climate change is multiplying the number of hot days and their intensity, and adding to the period of summer, a greater variety of occupations are becoming potentially exposed to heat. Some jobs have become exposed as a result of the 'non stop' economy and the contemporary management of working time.

We argue here that weather-related heat stress should be considered an escalating occupational hazard that deserves full societal recognition in order to be considered as an emerging occupational risk requiring public action.

Moreover intervention is essential for the protection of workers in precarious positions, who are without workplace union representation or where this is only weak and those subject to the intensification of work and to the myriad of management practices and work arrangements adopted, in particular by SMEs, as a means of survival in highly competitive national and international markets.

EU member states are committed to confronting what is considered the biggest challenge currently facing humanity: the mitigation of and adaptation to climate change. Many actors are called on to stop 'business as usual' attitudes and to tackle the environmental challenge by adaptation. To cope with the occupational impact of high temperature events, policies must be grounded on an understanding that various socio-economic aspects, in particular inequality and unfair working conditions, interact with the new physical environment created by climate change.

Heat health is one of the main lines of action concerning climate change adaptation with strong evidence showing that protective interventions can radically reduce the impact of heat on mortality. As this fact is being recognised, urban authorities are being urged to change the surfaces of cities, the cladding of public and private buildings and the allocation of space to greener means of transportation and these lines of action are gaining support and resources.

Few, if any, lines of action by the authorities are, however, being directed to the protection of the working population during such events. This need is being only recently noticed by social actors and may well change in the next few years as a result of recent public policy statements and collective bargaining.

Today, preventive management in occupational health and safety (OHS), in terms of anticipating the impact of heat events, is still not an obligation even if evidence of the need has advanced in recent times.

This report is focused on how to interrupt inertia in order to accelerate workers' protection.

The first two chapters aim to show that ambient heat poses a serious hazard to human health and that the risk is multiplied for workers, both those regularly exposed to heat stress risks and those exposed only in the course of heat events. It shows that the impact of heat goes far beyond heat illnesses such as heat stroke since workers are exposed to other factors of heat stress and also because heat exacerbates other occupational hazards. Chapter 3 discusses why heatwaves need committed action at workplace level requiring specific policies in terms of OHS and social inequality, while Chapter 4 describes some of the limitations to the preventive management of heat event hazards. Chapter 5 identifies that, at last, climate change adaptation policies are taking a promising direction with regard to the need for specific policies aimed at the protection of the working population. Finally, Chapter 6 offers some conclusions as well as discussion pointers.

1. Heat: a pressing threat to health, safety and wellbeing; and to social cohesion

Labour market structures, work arrangements, labour regulation and other aspects of industrial relations condition work and employment conditions and, as such, are the social determinants behind workplace health. This is recognised by the World Health Organization (Benach *et al.* 2010).

Heat poses a threat to the human population. Recent literature points out that heat illnesses such as heat stroke only represent a small proportion of the cases of health impairment, illnesses and injuries that occur during hot periods. Many workers are exposed to very high risk levels associated with heat, even at temperatures lower than those eliciting public alerts, especially where tasks require physical exertion or the use of protective clothing, or PPE, that may hamper natural heat dissipation. In outdoor settings, solar radiation adds to the heat which may be generated by work activities, creating extreme heat conditions. In indoor workplaces in which appropriate preventive action is not taken, temperature can increase during heatwaves, adding heat stress on top of those ambient factors which stem from the production process such as heat or humidity emissions or other factors associated with the requirement for exertion. Both indoor and outdoor workers are also exposed to other occupational risk factors leading to dangerous combinations highlighted by the research (Morris *et al.* 2021; Casanueva *et al.* 2019; Al-Bouwarthan *et al.* 2019; Pattisson 2019).

1.1 Heat can cause fatal heat stroke and other short-term illnesses

Our bodies constantly generate heat so, to avoid our internal temperature rising, we need to transfer that part of it which we do not require to the environment. Human core body temperature must stay stable but variations in it, occurring within a limited range, do not impair our comfort, wellbeing and health (Hanna and Tait 2015). For the transfer of heat, our body enacts its normal heat-loss mechanisms: vasodilation and sweating (perspiration).[1]

Table 1 **Heat illness - the short-term effects of heat strain**

Disorders or illnesses	Signs, symptoms and mechanisms
Heat rash	Causes small papules (red spots) and itching, usually on areas such as the face, neck, upper chest, under the chest, groin and scrotum. It is associated with intense sweating, very common in hot and humid climates.
Heat oedema	Swelling of the lower extremities, generally in the ankles; appears at the start of the hot season.
Heat syncope or fainting	Manifests itself in a short spell of loss of consciousness or dizziness. Usually affects people who have been on their feet for long periods without moving or who have stood up suddenly from sitting or lying down, generally during the first days of exposure to heat.
Heat cramps	Painful muscle spasms which are usually experienced in the legs, arms or abdomen, generally at the end of an extended period of exercise. Can be related to dehydration, loss of electrolytes and muscular fatigue.
Heat exhaustion	Mild to moderate illness characterised by the inability to maintain heart rate, intense thirst, weakness, discomfort, anxiety, dizziness, fainting and headache. Core temperature may be normal, subnormal or slightly elevated (below 39 °C). The pulse is irregular, with postural hypotension and rapid, shallow breathing. There is no alteration of the mental state. Usually appears as a result of exposure to high levels of environmental heat or vigorous physical exercise, sometimes associated with dehydration and/or loss of electrolytes.
Heat stroke	Very serious illness: the body is unable to control its temperature; the temperature increases and can rapidly reach 40ºC and continue to rise. The main symptoms are heat, dryness and red skin, rapid pulse, intense headache, confusion and loss of consciousness. There may be nausea, hypotension and increased respiratory rate. The body suffers a generalised inflammatory response, which presents with very varied clinical symptoms, resulting in injuries to internal organs (liver, kidney, etc.) and tissues (intestines and muscles). At its most severe, which can occur rapidly, in addition to the above-mentioned injuries there is profound dysfunction of the central nervous system. When the process is not stopped (which requires hospitalisation) fatalities occur.

Source: Produced by the author on the basis of MacGregor *et al*. 2015, Mora *et al*. 2017 and Spanish Ministry of Health website

When normal thermoregulation encounters a problem, core temperature tends to rise and additional systemic and costly physiological mechanisms are triggered to avoid overheating (hyperthermia). These responses represent

1. Vasodilation is a cardiovascular adjustment that accelerates the movement of heat from the core to the periphery, easing its dispersion into the surroundings. Although this is a natural process, it places a load on the body that can lead to pathological processes. Sweating is also a normal process but maintaining high sweat rates, as is normal with high levels of workload or of heat stress, can lead to difficulties replacing it or to excessive water intake. Variations in the sweat rate are dependent upon exercise intensity and duration, age, gender, training, heat acclimatisation, thermal conditions, clothing and the individual sweat rate. If dehydration occurs, normal sweating encounters difficulties or becomes ineffective at maintaining thermal equilibrium. On hydration programmes, see Annex 1.

a huge challenge to health and our bodies become less able to carry out their normal physiological functions. Such processes are behind a range of heat-related illnesses (HRI) from heat exhaustion to heat stroke – the most severe form and a life-threatening condition implying multi-organ system injuries that can have fatal consequences if appropriate healthcare is not provided in time (Mora *et al.* 2017). Heat health disorders are not differentiated according to their source: the symptoms are the same if heat strain is the result of passive exposure to ambient heat or to metabolic heat, or has been caused by the hindering of mechanisms for the dissipation of body heat or by any combination of these factors (American Conference of Governmental Industrial Hygienists 2016; OSHA 2017).

1.2 Heat also has long-term impacts on health

Beside heat illnesses, representing the most immediate impact of heat stress, heat increases the risk of suffering a wide variety of cardiovascular, respiratory and other illnesses via multiple biological pathways (Mora 2017). Heat stress produces a rise in mortality from injuries among the general population (Parks *et al.* 2020). The mechanisms which have been identified as responsible for this increase are based on the physiological impact of heat and dehydration, affecting both behaviour and cognition (reduced attentiveness, etc.), but there may also be an impact from accumulated fatigue. Heat stroke only represents a small proportion of the excess mortality which occurs during heatwaves.

1.2.1 Heat has effects on the reproductive system: on male and female fertility; and on pregnancy and fœtal development

Heat has a proven impact on fertility, foetal health, pregnancy duration and lactation.

Regarding fertility, exposure to heat is linked to temporary infertility both in women and in men with the effects being more pronounced for the latter. It has been demonstrated that heat affects semen in qualitative and quantitative terms: density of sperm; motility; the percentage of spermatozoa with normal form; etc. (NIOSH 2016; Hamerezaee *et al.* 2018).

In terms of foetal health and pregnancy duration, epidemiological evidence highlights that ambient heat produces low birth weights, pre-term deliveries and developmental effects concerning the central nervous system (Cox *et al.* 2016; Linares *et al.* 2017). Hyperthermia during pregnancy can result in embryonic death, miscarriage, growth retardation or other developmental defects (Zhang *et al.* 2019). According to NIOSH (2016) even mild hyperthermia (raised internal temperature not exceeding 38°C) poses a risk, albeit a limited one, to pregnant women who perform heavy work or who are exposed to ambient heat; while severe hyperthermia (internal temperatures above 38ºC) during the first trimester can cause congenital defects, especially in the development of the central nervous system.

Animal experiments show that hyperthermia is a teratogenic agent (that is, it can affect foetal development, causing malformations in the foetus). The literature also shows other effects, such as the shortening of telomeres in cord blood and in the placenta of newborns, especially in mothers exposed in week 36 (Martens *et al.* 2019).

1.2.2 Heat increases the health impact of environmental pollution

There is extensive toxicological and pharmacological evidence showing that both the rate of absorption and the effect of certain drugs increase with heat. The risk posed by certain substances is heightened at high temperatures due to increased volatility and thus presence in the environment; in other cases, such as with organophosphates, higher temperatures lead to greater risks as a result of an increase in their rate of transformation into more toxic compounds.

In addition, exposure to heat is associated with an increase in the pulmonary and cutaneous absorption of xenobiotics (chemical substances that are foreign to a living organism) related to an increase in their concentration in biological fluids. Physiological changes resulting from the activation of thermoregulatory mechanisms in response to heat stress can also alter the functioning of organs related to the absorption and metabolism of certain chemicals; for example, by increasing the rate of respiration, inhaled toxicants are more easily introduced into the body, increasing their concentration in biological fluids (Truchon *et al.* 2014).

The symptoms of acute intoxication (respiratory, neurological, etc.) suffered by those exposed to pollutants can go unnoticed because they are sometimes confused with the response to heat stress itself, such as excessive sweating, dehydration, etc. Moreover exposure to certain pollutants can affect the mechanisms of thermoregulation, thus reducing people's ability to adapt to heat.

In urban environments the impact of exposure to ambient heat is combined with environmental pollution. In anticyclonic conditions environmental pollution increases and becomes more persistent. Epidemiological evidence shows an increase in the human mortality rate during simultaneous exposure to heat and xenobiotics. Forecasts concerning the increased rate of climate change and the slow pace of the action being taken to reduce pollution in cities suggest that the significance of these exposures, in combination, will continue.

1.2.3 Growing evidence of heat exposure as a cause of chronic illness

The hypothesis of the central role taken by heat stress in the aetiology of a particular form of chronic kidney disease affecting young individuals, in central America and elsewhere, working in physically strenuous occupations (as sugar cane cutters, construction workers, miners and port workers) has gained strong scientific support. Recently a study has shown that kidney function decreases to abnormal levels over the course of a single sugar cane harvest in about 10 per cent of workers. This study also found that workers performing more demanding physical tasks are at the highest risk of worsening kidney function compared to other job categories (Kupferman *et al.* 2018; Ramirez 2019). Kidney health impairment is also related to dehydration during intense physical exercise increasing the destruction of muscle fibre (rhabdomyolysis).

Repeated exposure to heat and dehydration has long-term effects on health and interacts with other factors damaging health such as toxicants and ambient pollution. A powerful study discussed by the National Institute for Occupational Safety and Health (2016) is that by Wallace *et al.* (2007) comparing a cohort of US Army personnel hospitalised for heat illness with a cohort of people admitted for appendicitis. The study found that those people who were suffering from heat illness have a 40 per cent increased risk of all-cause mortality compared to patients admitted for appendicitis. Moreover it found that men who suffered heat illness have a high mortality rate from cardiovascular and ischaemic heart disease in comparison to those admitted for appendicitis.

1.2.4 Increased morbidity, use of health services and mortality rates

The link between heat exposure and the immediate adverse health outcomes of heat illnesses is well documented. However, as we have already noted, heatwaves have a greater impact on mortality than the reported number of deaths or cases certified as due to classical forms of heat illness. This increase is due not only to the impact of heat on health: heat also leads to an increased rate of all-cause accidents (Epstein and Yanovich 2019; Parks *et al.* 2020; Pitica *et al.* 2019).

1.2.5 Heat causes the impairment of human performance

General work productivity and the ability to work are reduced by heat strain, while thermal stability is the most favoured context for our bodies' biochemical and physiological processes.

Heat leads to a lack of comfort which may underlie behavioural and motor changes. During heat episodes, workers refer to dizziness, confusion and the loss of concentration; tasks involving tracking, monitoring and multiple tasks can be the ones most affected. In fact, the physiological impact of heat strain, together with dehydration and heat-related accumulated fatigue, lies in the impairment of our cognitive performance: working memory, attentiveness, information retention, information processing, response speed and processing speed (Mazloumi *et al.* 2014; Habibi *et al.* 2021). Those symptoms can warn about heat exhaustion and heat stroke.

Reduced labour productivity can also be seen in terms of the social impact of the loss of production. Higher temperatures lead to productivity losses which can be assessed in terms of lost working hours, decreased production output or reduced quality of products and services.

A reduction in human performance and work capacity leads to a reduction in hourly work output. As more daylight hours become too hot for work to be carried out, people who live in hot areas worldwide experience significantly reduced work capacity. The loss of labour productivity for each degree increase in Wet Bulb Globe Temperature (WBGT) beyond 24°C ranges from 0.8 per cent to 5 per cent (Kjellstrom and Maître 2019; Watts *et al.* 2019).

Loss of productivity can result from slowing down and taking longer rest breaks in order to reduce the heat generated by muscles. This is one of the recommended measures to address the problems caused in the workplace by heat, when other solutions are not available.

Workers with daily production targets or who are paid on the basis of output have to work longer work days or suffer reduced daily income. Lack of trade union representation in the workplace and/or authoritarian management and social vulnerability may lead workers to push themselves beyond safe thermal limits (Lucas *et al.* 2014).

1.2.6 Occupational heat exposure is deepening social inequalities

Adaptive behaviour such as avoiding or interrupting intense or prolonged exposure dramatically reduces the risk posed by the thermal environment. Any human culture has developed a set of coping strategies to reduce exposure to weather hazards and to avoid an impact on internal body temperature or, otherwise, to restore it to the correct range.

However, for workers, the ability to apply self-care behaviours at work, to avoid or interrupt exposure is conditioned by management practices, and those on a mix of socioeconomic and employment factors.

Workers' precariousness seems to be behind much of the most threatening conditions of exposure and the lack of protection of workers suffering heat strain. Staff turnover also increases risk. An analysis of cases of occupational heat-related illnesses in the US-OSHA data for 2015 shows that the majority (over 70 per cent) of heat-related fatalities occur during the first week on the job, with nearly one-half (45 per cent) occurring on the first day, or the return to duty after an absence of a week or more (Tustin *et al.* 2018). A lack of acclimatisation to high temperatures, especially when heatwaves occur at the start of the season, can explain part of this relationship.

But it is also true that precarious workers face higher-risk conditions because of lack of OHS management, especially in small companies or micro-entities that lack preparation for preventive or protection measures for heat and heat events. The most precarious workers, (those on temporary or no contracts, subcontractors, seasonal positions, in false self-employment, paid on the basis of piece rates, and immigrants – especially those who are undocumented (lacking work permits) and/or those who do not speak the local language, etc.) are at the highest risk due to overexertion, dehydration, cumulative exposure, and lack of information and neither training. In the worst cases, workers lack a scope to implement even the minimum self-care behaviours recommended by the authorities for the general public (taking more breaks, resting in areas away from heat and/or solar radiation, regulating the intensity and rate of physical effort, consuming sufficient fresh, cold water, etc.).

The likelihood of being exposed to occupational heat stress reflects pre-existing social inequalities and at the same time occupational heat exposures accentuates social inequalities. Heat is a frequent occupational hazard for workers in manual low-skilled occupations, featuring low income and tasks requiring physical exertion.

Occupational exposure threatens workers not only when heat impairment occurs but also when productivity is undermined. Furthermore the impact of heat stress on health deepens pre-existing social inequalities with the health impact of heat exposure affecting earnings and career trajectories.

As long as working conditions become more polarised, heat exposure expresses a social dividing line (Hoffman *et al.* 2020).

Extract from Nunfam *et al.* 2019:

> 'Social impacts include the consequence of socioeconomic and natural events (e.g. projects, policies and heat exposure) which affect the corporeal and mental wellbeing of a person, socioeconomic groups, work environment and society. Social impacts often result in significant changes to at least the health and safety, environment, rights, participation in decision-making, fears, culture, community or political organisation of people. Heat stress social impact is exemplified in morbidity, injuries, reduced productive capacity, loss of employment, decreased income and disruption of social lives and comfort. Social

> impacts due to heat stress reflect those that directly affect the physical, social and emotional wellbeing of people including health effects, poverty and income inequality.'

Extract from Kim and Lim 2017:

> 'This study investigated the size of the wage gap between the group of workers that risk heat-exposure and the group of workers that do not risk heat-exposure. It was also determined how much of this gap is caused by social discrimination [...]. A change in the thermal environment can create social discrimination variables, or there is the possibility of compensating differentials in the labour market. The no heat-exposure risk group has a high level of human capital and an advantageous position in the labour market. In contrast, the heat-exposure risk group has insufficient human capital and a relatively disadvantaged position in the labour market. The polarization of the labour market is highly likely to divide the working conditions for such risks.
>
> Climate change makes thermal extreme events like heatwaves more extreme and frequent, and it makes the future working conditions, in particular for occupations like outdoor workers, riskier with respect to the thermal environment. In many cases, these workers are likely to be at a disadvantaged position in the labour market. Especially in a polarized labour market, extreme heat-related events due to climate change can add to the social discrimination of heat-exposure risk groups. Even if wage premiums for heat-exposure risks exist, the compensation is not significant enough to overcome the unequal conditions that pre-exist in the labour market. In particular, in labour markets without perfect competition, such risks are most likely to become a burden for workers in disadvantaged positions.'

The impact of heat in agriculture combines with other outcomes of climate change for ecosystems such as droughts, forest burn, etc. Heat leads to reductions in yield, changes in land use, losses in gross domestic product, impoverishment and migration (National Institute for Occupational Safety and Health 2016: Kjellstrom *et al.* 2016; Schulte and Chun 2009; Kjellstrom and Maître, 2019; Flouris *et al.* 2018).

Regarding manufacturing, it has been shown that people who encounter difficulties in maintaining thermally comfortable ambient conditions (≤25°C) during heat waves, suffer reductions in productivity that may require a recovery time after an extreme weather event of more than one week (Ciuha *et al.* 2019).

Other sectors where work is carried out in indoor premises may find it easier to adjust ambient conditions by adaptation measures such as artificial air cooling, increased ventilation or adjusting clothing, etc. However economic considerations may restrict the options open to companies in some industries and regions.

Migrant workers, a great part of whom are employed in precarious, laborious and risky, manual, low-tech and unskilled jobs, summarised as ‘3D’ jobs (dangerous, dirty and demanding/degrading work), can also be at higher risk where they are suffering greater job insecurity, are undocumented and do not have skills in the local language (Messeri *et al.* 2019).

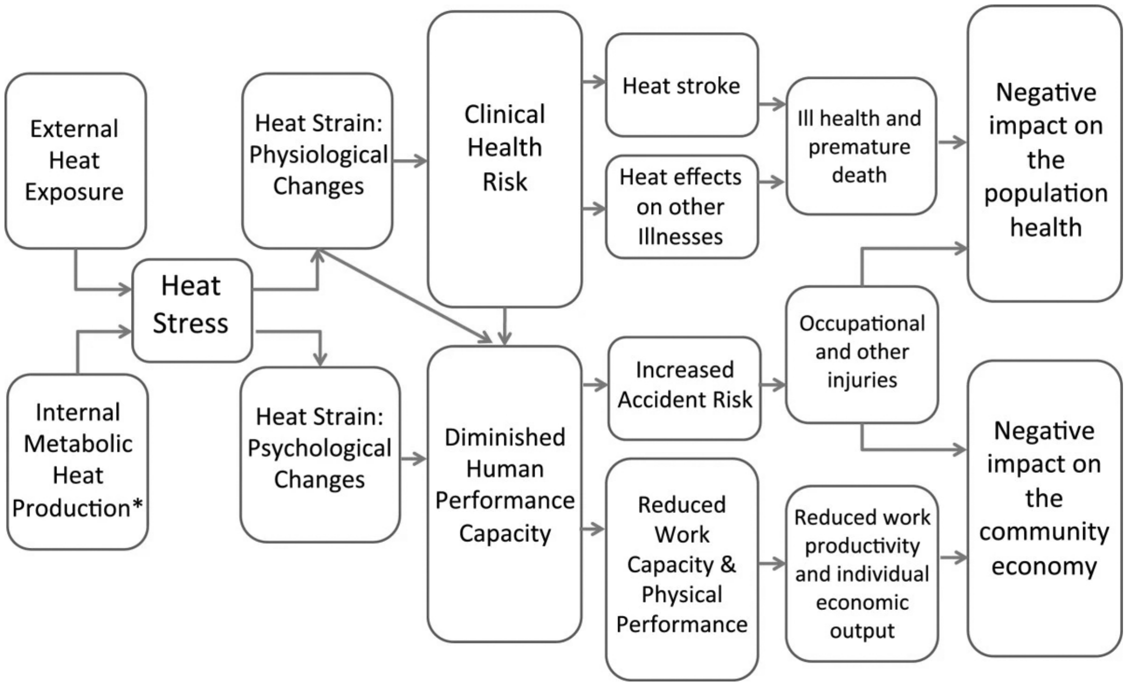
Low income workers exposed to heat stress at work tend also to be more exposed out of work: on the way to work, whether on foot or commuting in vehicles without air conditioning. Likewise low income workers are additionally more exposed in their homes where their buildings are poorly insulated thermally and lack air conditioning or where they suffer ‘energy poverty’ (an inability to afford electricity bills); while those situated in neglected urban areas are highly affected by the ‘heat island’ effect.

Heat stress is a social hazard that affects not only individuals but also, through impacts on performance and productivity, the local community and economy (Kjellstrom 2016).

Recent research points to the social vulnerabilities that lie behind heat stress exposure at work:

- ‘Piece rate’ work and low pay disincentives taking breaks to rest, seek shade or drink water (Lam *et al.* 2013);
- Unstable work relations. A large part of heat stroke cases happen to workers that are on their first day of employment. This may have to do with a lack of acclimatisation to heat conditions but also with the limited scope that newcomers have to apply high-temperature adaptive behaviours (Narocki 2016);
- Company size. The exposure of personnel and the effects on their health and safety are often more serious in small companies compared to larger ones; this is partly due to weak preventive management (Xiang *et al.* 2014; Lundgren *et al.* 2013; Gubernot *et al.*2015) and, consequently, a lack of preparedness;
- Heat-related illnesses and/or traumatic injuries reinforce inequalities. In polarised labour markets those occupations that are most exposed to heat and solar radiation are occupied by more vulnerable groups in the workforce. Social discrimination against those groups most exposed to heat increases the factors of inequality in the labour market (Kim and Lim 2017);
- Low-paid workers also tend to face heat stress away from their work environment, notably in housing and transportation (Kjellstrom and Maître 2019).

Figure 1 **A schematic summary of the proposed links between occupational heat exposure and health and productivity**



* Internal metabolic heat production significantly increases with physical movement or work.
Source: Lucas *et al.* 2014

2. Ambient heat exacerbates other occupational heat stress risk factors and OHS hazards

Ambient heat frequently exacerbates other occupational factors that contribute to the direct impact of heat, creating working conditions that can end up with workers experiencing heat illnesses. However, workers' health, safety and wellbeing can be affected by heat in various other ways.

2.1 Heat exacerbates other factors which can result in heat illnesses

Occupational heat stress can result, besides the environmental factors, from increased metabolic heat or from clothing or PPE the characteristics of which limit or prevent cooling by perspiration. Alternatively, all these factors together may combine to create a heat load on workers resulting in an increase in heat storage in the body, leading to a physiological response by which the body attempts to increase heat loss to the environment (heat strain).[2]

Occupational heat stress results from three groups of factors:

1. **The environmental conditions of the working environment**
   - air temperature: the specific level of heat in a given place and time;
   - relative humidity: high ambient humidity obstructs the evaporation of sweat, our main cooling mechanism and which becomes almost the sole mechanism in conditions of intense heat and/or intensive physical activity;
   - radiant temperature: there is an exchange of heat between the body and the surrounding, surfaces and, in outdoors environments, the sun;
   - air movement: higher air speed helps to dissipate the heat produced by the body, facilitating the elimination of excess heat through sweat by heat convection. However, when air temperature is equal to or greater than skin temperature (starting at 35ºC), air speed does not help.

2. Heat strain is defined by ACGIH as the overall physiological response dedicated to dissipating excess heat from the body resulting from heat stress (ACGIH 2016).

2. **Physical activity performed**
   - metabolic heat resulting from physical work can pose an enormous challenge to normal thermoregulation; it can lead to heat illnesses even in 'normal' environmental conditions;
   - the level of heat produced during physical work or exercise results from its intensity, pace and duration as well as from factors such as the level of acclimatisation and fitness, or individual factors such as gender and age.

3. **Personal protective equipment (PPE) or heavy clothing**
   - clothing and PPE can be factors in heat stress as long as they complicate or even prevent the dissipation of body heat to the environment by sweating;
   - the higher the thermal resistance and the lower the water vapour permeability of the materials making up the PPE, the more those create a micro-environment around the skin. If air cannot circulate around the skin, perspiration is not effective in cooling the body. So, heat loss capacity via the skin surface is reduced.

It is important to emphasise here that the effect of different occupational heat stress factors is additive: a threat to the stability of the body's internal temperature can appear at relatively low temperatures if work is intensive enough; and at any temperature when using PPE or clothing which imposes limits on perspiration.

2.2 Individual sensitivity factors, acclimatisation and discomfort

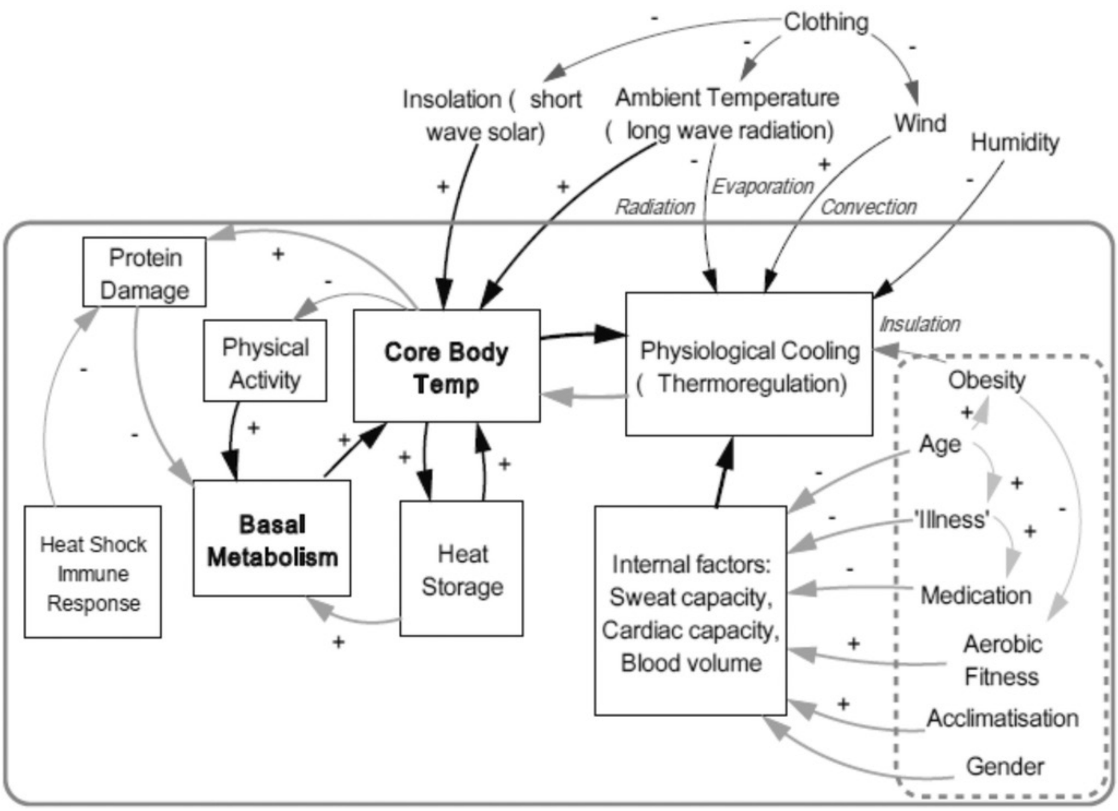
Some individual physical characteristics and biological states can make people particularly sensitive to heat stress. People can be differentiated by their tolerance to heat stress: each person has an upper limit above which the resulting heat strain will cause heat illness. Factors such as obesity and age also have an influence on the effectiveness of key thermoregulatory functions such as perspiration, the efficiency of the cardiac system and the adjustment of blood volume. Adults as young as 40 may demonstrate impairments in their ability to dissipate heat. Examples of people who are particularly sensitive to heat exposure are those who have previously suffered heat illness, those who have been diagnosed with a condition that may be worsened by exposure to high temperatures, people taking certain medication (such as hypertensives, diuretics, antispasmodics, sedatives, tranquilisers, antidepressants and amphetamines, etc.), those who experience certain mental or sensory disabilities, etc.

But tolerance may vary for the same person, where they are experiencing some short-term biological states such as a cold, a change in diet or in rest, pregnancy, etc. that can reduce heat tolerance. Pregnancy beyond 20 weeks increases the individual's basal metabolic rate, contributing to an additional physical and metabolic heat load, and heat generation in pregnant women increases progressively until the time of delivery (Hanna and Tait 2015). Women who are breastfeeding should also be considered particularly sensitive.

This variability explains why heat stress limits may not adequately protect all individuals during work in hot conditions and why heat strain has to be controlled (Lamarche *et al.* 2017; ACGIH 2016).

Figure 2 depicts human body heat flows showing the interrelationship between the physiological and the external factors that influence thermoregulation.

Figure 2 **Thermoregulation model**



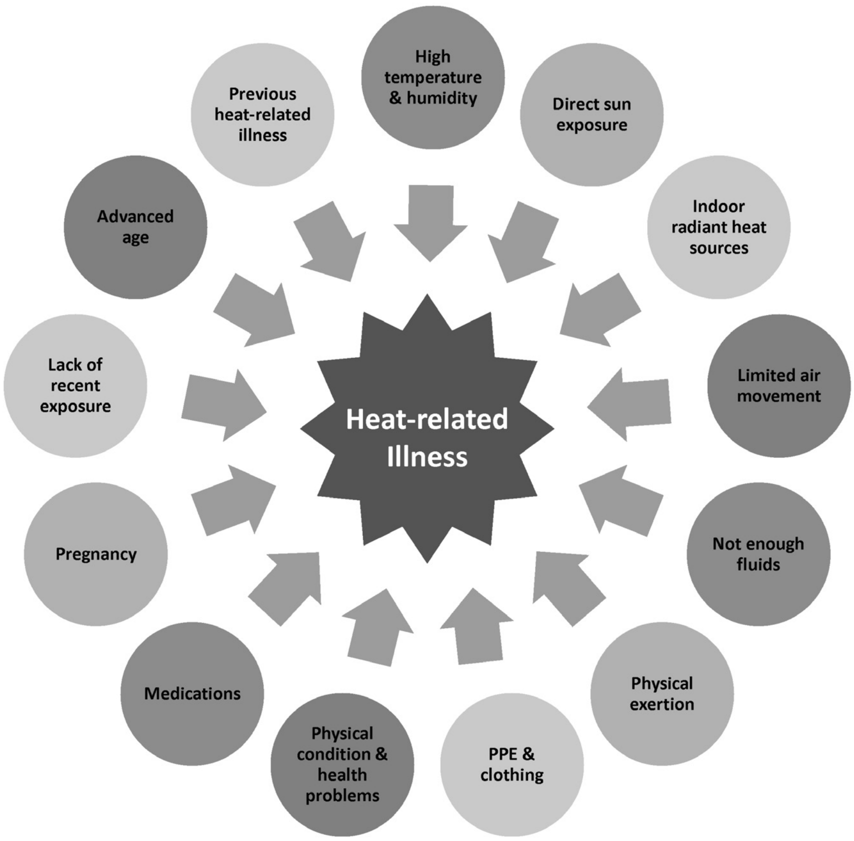
Source: Hanna and Tait 2015

Understanding that individual tolerance to heat is not uniform is crucial to a successful preventive effort. It is key to heat health protection and is relevant to a causal analysis of occupational heat illness cases, such as heat stroke or heat-related injuries; but this is not to say that those cases can commonly be attributed to the impairment of individual tolerance.

Variations in biological states or momentary conditions that can lead to a decrease in heat tolerance, dehydration, fatigue, etc., increasing the chance of heat illness, should be assumed. Consequently it has to be recognised that heat exposure can be a danger to anyone and that extreme exposure should be avoided (National Institute for Occupational Safety and Health 2016; McGregor and Vanos 2018). Moreover, one person in a group of workers experiencing a heat-related illness or injury should be considered an indicator of the inadequacy of preventive activities. A case should trigger a review of the prevention plan, including risk assessments, to check whether the plan remains effective and/or how the planned measures have been implemented, etc.

Individual tolerance and the personal sensitivities of occupationally-exposed people should ideally be assessed by occupational health surveillance programmes in order to enhance the protective effort. In addition, health monitoring should be in place to assess the effects of exposure and study the possible relationship with any health damage. Health surveillance can provide evidence about the efficacy of the preventive measures and activities carried out, both at individual and group levels, while the results ought to be considered when taking decisions about technical, procedural or organisational measures.

Figure 3 **Examples of risk factors in heat-related illness**



Source: NIOSH 2016

2.2.1 Acclimatisation

Gradual and repeated exposure to a high level of heat stress will, in most people, lead to a series of physiological adaptations that make the body more efficient in its response, improving tolerance levels. The process by which the body 'learns' to tolerate exposure to excessive heat is called 'acclimatisation'. With acclimatisation, sweating starts at a lower temperature and in greater volume but with a lower salt content, resulting in more efficient heat dissipation, less dehydration and less salt loss.[3]

Acclimatisation is always staggered: physiological adaptation to repeated heat exposure in conditions of a new, hotter environment requires the person to be physically active for several hours a day, at least for two weeks. Total acclimatisation (in the long-term) to a new thermal environment can take several years. Moreover physiological adaptation is usually quickly lost after several weeks of no exposure such as during sick leave, holidays or a period of unemployment.

That acclimatisation cannot be achieved suddenly is particularly relevant with respect to health protection at the beginning of a high temperature episode when workers are suddenly exposed to higher than average levels of heat stress. It is also enormously relevant to workers that are moving to significantly warmer and/or more humid environments than those to which they are accustomed for work purposes.

Even though the capacity to tolerate heat increases with acclimatisation, acclimatised people should not be considered invulnerable to the negative effects of exposure; no-one is free from the risk of heat. Even though some people are able to tolerate higher temperatures due to their individual traits (e.g. elite athletes), it is unacceptable from a preventive point of view for working conditions to impose an extreme heat load because, besides other reasons, individual response is not uniform from day to day.

2.2.2 Heat can create thermal discomfort, leading to several negative effects

Thermal comfort describes a situation in which a person has a neutral sensation regarding the thermal environment. Discomfort or unease due to heat occurs as the body meets difficulty dissipating its internal heat and as its normal thermoregulatory mechanisms become active (vasodilatation and sweating). Workers' thermal environmental complaints are sometimes defined as 'only' discomfort, but thermal discomfort is not a minor OHS issue

3. Acclimatisation entails an adjustment of the cardiovascular, endocrine and renal systems so that the body's response to a given heat load creates less heat strain. The heart works less: the maximum volume of blood expulsion from the heart increases, the maximum heart rate decreases, plasma volume expands and there is a higher rate of blood filtration.

as it has a clear impact on wellbeing, on concentration and perception, on working capacities[4] and performance. In this way, thermal discomfort can be a source of a range of workplace issues concerning safety, productivity and even personal relations.

Thermal discomfort can be caused by the same factors as heat stress but which are not severe enough to jeopardise the body's thermal balance. Discomfort is frequently regarded as a subjective issue. There is surely a subjective element of 'discomfort' as people's response to a given environmental situation is not uniform: some people (sometimes very few, or even just a single person) express discomfort in situations in which other people express satisfaction. In this way, some definitions of thermal comfort consider 'satisfaction with the thermal environment' as a 'state of mind'. However, it should be noted that: (1) the physiological response of people is not even because of the factors of sensitivity that vary among people and with time; and (2) not all the variability in terms of thermal comfort is due to individual physiological responses, since unnoticed factors related to the working environment could be in play. For instance the thermal environment to which different people are exposed within the same room is uneven as there are localised thermal factors such as air flow and radiant surfaces such as windows or warm floors; and it may also be that the requirement for exertion is different.

Another very common factor of variability in the level of satisfaction with the thermal environment is the use of clothing with different thermal properties; a 'classic' case in climate-controlled environments such as offices, which rarely manage to achieve comfort for all staff as people who are wearing summer clothes report low temperatures while people who are wearing heavier clothing (such as suits and ties) express comfort. A gender perspective shows that, in masculinised workplaces, the thermal environment fits the comfort requirement of this second group.[5]

2.3 Heat stress multiplies the risks posed by other OHS hazards

2.3.1 Increased risks posed by toxic occupational compounds

There are many occupations in which higher temperatures increase the impact of xenobiotics (see 1.2.2). A study on industrial settings carried out in Quebec

4. Working capacity refers to the ability of people to perform a certain job in a sustained manner over time without adversely affecting their wellbeing, health or safety, either during the period of exposure or in the medium or short-term after performing the task.
5. In indoor environments where heat is dealt with by means of air conditioning, it is necessary to avoid both discomfort due to cold and energy waste. In Spain, mandatory regulations to meet these two objectives are contained in the Regulations for Thermal Installations in Buildings [Real Decreto 178/2021, de 23 de marzo, por el que se modifica el Real Decreto 1027/2007, de 20 de julio, por el que se aprueba el Reglamento de Instalaciones Térmicas en los Edificios, known as RITE].

(Truchon *et al.* 2014) identified the twenty most affected occupations, all of which are concentrated in non-metallic mineral manufacturing, primary metal manufacturing and metal product manufacturing, construction (especially in jobs with exposure to the sun) and firefighting. Regarding substances, the workers most affected are those exposed to lead and its inorganic compounds (dust and fumes), certain pesticides (organophosphates and carbamates) and metal oxide fumes (zinc, aluminium, antimony, cadmium, copper, magnesium, manganese and tin).

Particularly affected by the combined exposure of heat and toxic compounds are workers in contact with pesticides, as in the agricultural sector, and those affected by urban pollution while performing work outdoors or indoors (Ferguson *et al.* 2019).

2.3.2 Reduction in the effectiveness and/or applicability of certain measures against other risks

Heat increases the risk of hazards such as those arising from chemicals, noise or biological agents, etc. even where these are being addressed by PPE. The use of PPE may also, as we have seen, represent a source of heat stress or multiply it. Furthermore workers, in the attempt to reduce this source of stress, tend to reduce usage or wear the PPE in inappropriate ways.

In addition to these behavioural aspects, heat stress reduces the effectiveness of measures based on respiratory protection. Facial perspiration reduces the contact of respiratory PPE with the skin, thus reducing its fit and allowing external non-filtered air to enter the breathing zone via the gaps which open up between the face and the respirator. The use of respiratory protection devices, in addition, makes it more difficult to drink which increases the risk of dehydration (NIOSH 2016; Ferguson *et al.* 2019).

Standard clothing also provides less protection: heavy perspiration can affect the integrity of fabrics, increasing the probability of environmental pollutants passing through and being deposited on the skin and then absorbed.

2.3.3 Increase in occupational injuries

As identified above (1.2), high environmental temperatures are associated with an increase in injury-related mortality, associated with all causes, among the general population. NIOSH (2016) cites studies finding that 'unsafe acts' and 'human errors' associated with accidents increase as temperatures rise above 28°C WBGT. A retrospective study by OSHA also points out that the accidents analysed occurred from this temperature level upwards and that occupational risk is particularly increased in the early days in a series of hot days, during the first heat episodes in the spring and for recently hired workers (Tustin 2018).

Research shows quite clearly that occupational injuries related to heat do not only happen in the form of heat stroke. Strong evidence demonstrates that high environmental temperatures are associated with an increased risk of overall occupational injuries, both during single hot days and during heatwaves (Martínez-Solanas *et al.* 2018; Fatima *et al.* 2021; Binazzi *et al.* 2019; Xiang *et al.* 2014; Spector *et al.* 2016).

A very recent study by Parks *et al.* (2020) indicates that heat leads to an additional 20 000 workplace injuries each year in California alone. On days when the temperature is 30-33ºC, the researchers found that the overall risk of workplace injuries, regardless of the official cause, is 5-7 per cent higher than on those days when temperatures are in the 15,6. When the temperature tops 38ºC, the overall risk of injuries is 10-15 per cent greater.

In order to advance in quantitative studies trying to assess the relationships between heat stress and occupational injuries, a shared definition of heat events and common metrics for exposure are needed. For example, a scrutiny of occupational injuries in northern Italy shows that the 'official' heatwave definition is associated with an increased risk of occupational injuries only for agricultural workers, whereas if the correlation takes as its point of reference 'high temperature' (35ºC) then the results indicate that risk is increased also for industrial workers (Riccò *et al.* 2019).

Regarding the exploitation of occupational injury statistics data, by itself, the usefulness is limited as the methodology seems to fit work-related injuries that health professionals would call 'heat illnesses', including heat syncope or heat stroke, but is not prepared in such a way that reflects the impact of the hot weather conditions behind accidents such as wounds, lacerations or amputations caused by vehicles or machinery, etc.[6]

2.3.4 Solar radiation, a source of heat and UV radiation

The occupational risk associated with working in hot and sunny environments is exposure to heat and solar ultraviolet (UV) radiation, both factors threatening the health and wellbeing of outdoor workers.

UV radiation is necessary and beneficial to human health but, in excess, it can cause various types of damage to the skin and the eyes. Regarding skin, UV radiation harms collagen, causing premature ageing and other forms of

6. The European Statistics on Accidents at Work (ESAW) methodology includes a code for type of injury (101 Heat and sunstroke, described as 'the effects of excessive natural heat and insolation (heatstrokes, sunstrokes) or man-made heat'). But it has difficulties in coding injuries in which heat is an intervening cause but which are not in themselves heat illnesses. For example, the coding of the material agent variable includes a code that is well fitted to reflect a physical agent as cold, but not heat. Only the parent code 'Physical phenomena and natural elements - not specified' (20.00) could be used as the list of subcodes does not include one for hot or hot and humid ambients (European Commission 2013; Narocki 2016).

damage; it can also cause mutations of DNA, thus significantly increasing the risk of skin cancer. Regarding eyes, the prolonged exposure of the human eye to solar radiation can cause pathological responses such as photokeratitis, photoconjunctivitis, cataracts and photoretinitis, in addition to reducing visual comfort and perceptiveness.

As an occupational hazard, it is most important to control exposure to solar radiation at source: the creation of shade should be the preferred intervention as it can give protection against UV radiation while reducing heat stress. Creams should not be considered a suitable means of occupational protection for various reasons. It should be noted, however, that shade can be insufficient for the protection of the eyes, requiring in many cases additional means such as sunglasses (see Annex 4).

2.3.5 Impact of the Covid-19 pandemic

It has been pointed out above that heat multiplies the health impact of other forms of occupational exposure in several ways. This applies also in respect of the Covid-19 pandemic which may augment the health risks from heat among workers as several of the risk factors for severe Covid-19 overlap with key heat sensitivity factors (WHO 2021).

For example the mandatory use of specific Covid-19 PPE for a wide range of occupations following the return to indoor workplaces may, where heat events occur, aggravate the heat response even in thermoneutral conditions, bringing heat discomfort or even heat stress issues to new occupations.

Another issue is that common recommendations for reducing heat stress while working with PPE can become impractical, infeasible or insufficient to meet the risk during the pandemic. For example in healthcare settings, requiring the simultaneous use of PPE such as gowns, eye protection, face masks or respirators, gloves, etc., interventions such as adjusting the work/rest schedule to incorporate additional or longer breaks, as well as ensuring additional hydration, can became difficult to implement among other reasons because clinics and hospitals are often understaffed and, during pandemics, staffing shortages can dramatically worsen. Another problem is having enough refreshment areas to allow for social distancing to occur during break times to minimise contact. A further example is that the usual recommendations for the use of fans and air conditioning to reduce heat stress and contamination exposure are questionable as only ventilation and properly-designed air conditioning can reduce the risk posed by high airborne concentrations of SARS-CoV-2 or other airborne contaminants (Leung 2021; Global Heat Health Information Network 2020).

Exposure to smoke or other particulate matter may introduce additional risks or even multiply the risk of SARS-CoV-2 infection. It may also aggravate the severity of respiratory diseases in exposed workers including wildfire firefighters: exposure may increase the risk of more severe Covid-19 illnesses such as cytokine release syndrome, hypotension and acute respiratory distress syndrome (Navarro *et al.* 2021).

Another difficulty that arises in relation to Covid-19 is how to train employers and workers to give the proper response to symptoms of heat stress and dehydration such as fever and/or shortness of breath as these can intersect with symptoms of Covid-19 (GOV.UK 2020). On the other hand, people that have experienced Covid-19 can have increased sensitivity to heat: those that have suffered acute kidney damage associated with this illness are more vulnerable to the effects of heat (Morabito *et al.* 2017).

The pandemic highlights a particular case in which the occupational impact of heatwaves is obvious but it is almost absent from occupational guidance. This can be observed in the call directed at the general population to avoid heat stress exposure during the pandemic without making any reference to exposure in a workplace context (see WHO Regional Office for Europe).

3. Heatwaves should be considered as an emerging OHS hazard

Heatwaves, considered rare phenomena in the past, are today a reality across the European continent and across the globe, creating adverse effects for human health, agriculture, natural ecosystems and infrastructure. From the beginning of the 21st century, heatwave episodes have been becoming more frequent, more intense and more long-lasting and are a reality in regions where summers are generally hot as well as in those where summers are cooler. For instance, in France at the end of June 2019 the previous record of 2003 was broken by almost 2ºC, while in July all-time temperature records were established in Belgium, Germany, France, Netherlands and the United Kingdom with temperatures above 40ºC in some of these (Vogel *et al.* 2020). Dramatic heat events are being registered even at high latitudes, as happened during the first month of the 2021 summer in Canada, in the west of the USA and in Siberia (WMO Climate Monitoring and Policy Division 2021).

As the climate crisis is developing, forecasts indicate a tendency for extremely hot events to occur more often: the currently relatively low warming of average temperature compared to pre-industrial levels (1ºC) is behind the large jump in extreme heat events; and global warming has accelerated over the past five years. The most recent report from the United Nations Intergovernmental Panel on Climate Change (IPCC) warns that there is a risk that this increase in temperatures will rise to 1.5 degrees in the years to come (Kenny *et al.* 2020).

3.1 Diversification of scenarios of occupational exposure

Occupational heat stress exposure scenarios are diverse; exposure to dangerous heat stress conditions occurs in many different occupations, beyond those industries that typically generate or apply heat and those which are performed outdoors. As farmworkers and construction workers are known to suffer the highest incidence of fatal heat stroke, fatal cases in these sectors are more accurately notified as heat-related but, regarding less severe health impairments, heat stress-related injuries, etc., no statistical data is available even in these same sectors.

At present a diversification of exposure scenarios can be observed, resulting in a proliferation of ‘new’ occupations in which workers are exposed to ambient heat stress in combination with other heat stress factors:

- More activities are demanding the use of PPE against hazardous occupational exposure that is not properly controlled at source: chemical, biological and physical pollutants and safety risks such as cuts, bumps, splashes, etc. Some jobs require the simultaneous use of several of these items, as for example, wind turbine operation and maintenance, and asbestos removal specialists;

- The intensification of the pace of work associated with new strategies for labour management, payment systems, etc. is a reality even in semi-mechanised/automated activities (such as warehouses);

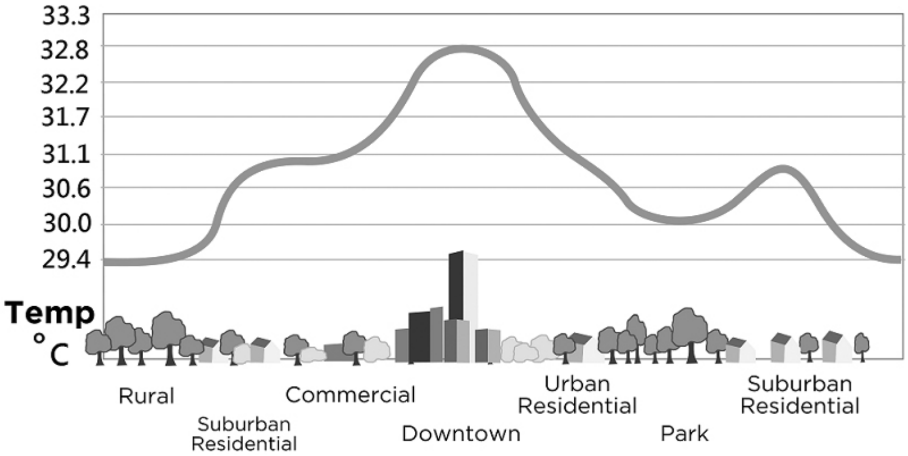
- An extension of the number of activities that are not brought to a halt in the middle of the day, even under extreme heat conditions. Here, a wide range of activities is being held to be 'uninterruptible' extending to the monitoring of regulated zones such as parking areas and airports; security activities including the police, the military and buildings surveillance; the supervision of technological systems; responses to emergencies including spills, leaks, fires, health emergencies, etc; the assembly and operation of temporary performance facilities including those related to sport and leisure, tourism, hospitality, etc.;

- Work done in non thermally-adapted buildings, machines and vehicles:
  - In urban settings, this refers to workplaces without due protection from external hot weather conditions. The lengthening of summers affects workplaces which, until recently, were not normally running during hot weather such as schools;
  - In vehicles or machines, drivers or operators of vehicles and machines which do not have air conditioning, such as wind turbine operation and maintenance personnel.

- Work affected by a hot local micro-climate. Varied micro-climates can be the result of direct sun radiation (the sunny vs. the shady side of construction sites or on the slopes of hillside locations) as well as of the presence of hot equipment including machines, motor vehicles, etc.;

- Within cities, certain areas can have temperatures which may vary by up to 10ºC at the same time depending on the urban landscape: the density of cement, asphalt, etc. compared to the presence of large parks and reflective surfaces, or the presence of large bodies of water such as rivers and ponds, result in urban micro-climate zones reflecting the 'urban heat island' effects, a city-specific phenomenon by which cities record higher temperatures than those in the surrounding region. This is because heat stored in building materials during the day cannot cool down sufficiently during the night. The 'heat island' effect has a specific impact during heatwaves and is especially noticeable in the evening and during the night: temperatures in the affected areas do not fall far enough to assure quality rest ('tropical nights'). Meanwhile, the heat emitted by air conditioning units additionally warms hot urban areas (Potera 2017).

Figure 4 **Urban heat island profile**



Source: Copernicus https://climate.copernicus.eu/demonstrating-heat-stress-european-cities

Examples of occupations in which workers can be simultaneously affected by ambient heat, showing a widening of the range of exposure and risk scenarios

Indoor workplaces

Where the problem of heat stress is usually identified:

- indoor jobs with processes that apply or generate heat (industries, laundries, kitchens, etc.), especially when the circulation of air from outside is used as the main means of reducing ambient heat;
- jobs which require very intensive physical exertion;
- jobs for which the use of heavy clothing or PPE is a requirement.

Where the risk of heat stress during heatwaves tends to have been dismissed (by being non-identified or evaluated): healthcare, educational, commercial and warehousing establishments, logistic centres, hospitality, manufacturing, etc.

Outdoors

- construction work, including road and railway construction and maintenance;
- agriculture in the open air and in greenhouses, livestock farming, forestry, arboriculture, gardening and landscaping;
- fishing;
- installation, operation and maintenance of lines and equipment (solar energy, wind power, gas, telephone systems, telecommunications, etc.);
- urban cleaning, waste collection and sorting, waste treatment;
- open-pit and underground mining;
- monitoring works; control of regulated parking zones or traffic;
- ground activities in airports;
- security and military activities;
- health emergencies, first aid and rescue operations;

– firefighting;
– loading and unloading;
– mail, parcel, food, etc. delivery, on foot or on bikes;
– tourism, leisure and free-time activities, outdoor restaurant service;
– set-up and operation of structures for entertainment and performances;
– in vehicles or machines without air conditioning;
– driving or operating tasks.

3.2 Increasing prevalence of occupational heat strain

Demonstrating the extent of occupational heat exposure seems to be a precondition for gaining public attention in respect of weather-related heat strain and, consequently, for appropriate and meaningful heat management.

At present, the authorities seem to rely on official statistics which are focused only on heat illnesses such as heat stroke although, as we have seen, this is linked to relatively few cases (see 2.3.3).

Another type of evidence could be the extent of experience of heat stress and heat comfort issues, but this is limited. The European Working Conditions Survey has a question asking about the permanent characteristics of the physical environment but not about heat stress or exposure during heat events. Its question says: 'Are you exposed to high temperatures?' with options referring to time percentages: at least one-quarter of the time; less than one-quarter of the time (Eurofound 2016).

Recent studies of the prevalence of heat strain are very important in attracting public attention to the issue of occupational exposure. These show that a large percentage of workers who work in occupational environments dominated by physically-demanding manual tasks, and especially in workplaces with high ambient temperatures, suffer heat strain and dehydration whether indoors or outdoors. For example, a systematic review and meta-analysis of 111 studies, encompassing more than 447 million workers from over 40 different occupations, estimated that 35 per cent of individuals who frequently work in conditions of heat stress experience the negative effects of occupational heat strain and dehydration. Meanwhile around 15 per cent of those who typically work under heat stress experience acute kidney injury or kidney disease (Flouris *et al.* 2018; Morris *et al.* 2021; Piil *et al.* 2018). A field study of heat strain among sugar cane workers in Guatemala reported daily average WBGT to be above 30 degrees during the majority of the study days. US-OSHA guidelines recommend that, if WBGT is greater than 30°C, workers performing very heavy labour should work no more than 15 minutes in every hour and should rest for the other 45 (Butler *et al.* 2021).

3.3 Vulnerability, occupational exposure and personal sensitivity

Heat health publications analysing the impact of heatwaves on the population identify the vulnerabilities and the populations that should be targeted by healthcare and welfare authorities. In many of these studies, workers are mentioned as one, among others, of the 'vulnerable' populations.

This public health definition of vulnerability does not, however, fit with the labour market realities. In this case, a distinction is required between occupational heat stress exposure derived from factors in working conditions and personal physiological sensitivity factors, and the factors of social vulnerability which arise from the wider institutional, social or labour context that create the conditions for exposure and which may impede self-care behaviour and collective action. With this in mind, a distinction is to be drawn between:

- Jobs potentially exposed to heatwaves such as outdoor work (construction, agriculture, livestock, tourism, mobility and traffic agents, cleaning and gardening services, baggage handlers, etc.); in indoor workplaces whose source of cooling and ventilation is external fresh air; or indoor workplaces which are co-located with internal heat sources (kitchens, industrial premises, etc.) especially where other heat stress factors may also coincide, such as exertion, clothing, etc. As long as the risks associated with heatwaves are recognised as an occupational hazard, heat stress factors can be tackled by applying appropriate preventive management while their heat health and other consequences can be avoided;
- Sensitivity to heat strain provoked by personal characteristics or biological states (at one point in time or permanently). Examples of personal characteristics that increase sensitivity to heat are repeated exposure to heat strain; having suffered previous heat illnesses; pregnancy and breastfeeding; health disorders that may be made worse by exposure to high temperatures or being on certain medications that decrease the body's ability to cope with heat; age; etc. (see 2.2);
- Vulnerable workers who are not sufficiently protected by employers' preventive management and who meet difficulties in applying adaptive behaviour regarding ambient heat in an institutional, social or labour context which facilitates the application of preventive management techniques.

4. OHS management of heat events

As heat events are no longer rare, recognising heatwaves as an occupational health and safety hazard is necessary in order to compel companies whose activities can potentially fall under the impact of hot weather events to prepare to manage heat-related hazards.

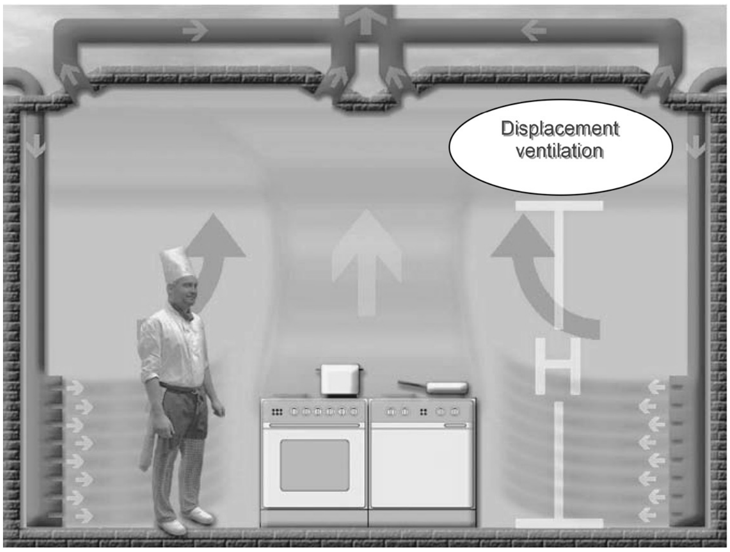
Risk factors should first be acted upon according to the preventive hierarchy of control set out in the Framework Directive which has two clearly distinguishable hierarchical levels: (1) to avoid the risks or eliminate the hazard; (2) to reduce the hazards and the risks. Preferred measures are those focused on avoiding or eliminating hazards but measures can also aim to reduce or minimise hazards or to separate hazards from workers. Specific measures are to be preferred in this order: technical; organisational; PPE measures; and, lastly, measures focused on improving safe behaviour.

Interventions at source are often weighed against their feasibility, effectiveness and cost, while measures are at present also weighed against the potential environmental impact. The cheapest alternatives appear to be those aimed at heat strain control and health protection, although all too often the costs are only analysed in the short term.

For example in indoor work areas some form of climate control (air conditioning, electric fans, shading, dehumidification, etc.) should first be considered. A good example is given in EU-OSHA E-fact 27 – Hot environments in hotels, restaurants and catering, showing how a variety of engineering controls, including general ventilation, air treatment, cooling and conditioning, can be useful in reducing not only heat stress but also pollution:

> ‘The most effective and preferred means to cut excessive heat and cooking fumes containing dangerous substances in professional kitchens is displacement ventilation. In a displacement ventilation system, air is introduced to the space at or near the floor level at a low velocity and at a temperature only slightly below the desired room temperature. The cooler air displaces the warmer air, creating a zone of fresh cool air at working level. Heat and contaminants produced by kitchen activities rise to the ceiling where they are pumped out.’ (See image below.)

Figure 5 **Hot environments in hotels, restaurants and catering**



Source: EU-OSHA, E-fact 27

When ‘at source’ solutions are insufficient or when they are not applicable at a certain workstation, or when the hazard stems from PPE, there is a need for measures aimed at health protection in terms of heat strain control. Measures for the reduction of the work rate and heat load can include automation and increases in staff numbers to enable sufficient rest periods, allowing workers to cool down (NIOSH 2016; NIOSH 2020; WHO 2021).

Despite these interventions, if it is still foreseeable that heat events could have an impact on working conditions, a heat weather action plan should be devised including a set of work practice measures to be implemented whenever required. Such a plan has to be prepared in anticipation and integrated into the company’s prevention plan (see an example in Annex 3).

In the preparation of this plan, all the presumed negative impacts in the conditions which apply in the worst foreseeable heat environment, should be thought out in advance in order to determine the needs against which preventive action needs to be taken: discomfort; cognitive impairment; reduction in productivity; health illnesses; interaction with other OHS risks such as injuries, chemicals; etc. The need for acclimatisation and the other personal factors that could make some individuals particularly sensitive to heat risks should also be identified.

Such measures should be prepared for any task and position. A qualitative job hazard analysis of any job or task that could possibly experience the impact of hot weather should be carried out, with a special focus on the presence of other heat stress factors such as exertion, PPE, sun radiation, the characteristics of people doing the job, etc.

Predefined grades of thermal heat risk should be set and adequate measures should be devised for any workplace or task, graduated to respond to different levels of ambient heat.

Identification, risk assessment, the subsequent at-source interventions and work arrangements and hot weather adaptive measures should be drawn up before the beginning of hot weather. In particular, the heat plan should be in place before the traditional 'hot months' and continue into the early autumn.

Workers' representatives should be consulted in due time before the design stage of the prevention programme, including an agreement on when to activate the different levels of alert, the measures and interventions required, the monitoring of the implementation and the verification of outcomes. Workers should also be consulted on the specific measures affecting them. The plan should be revised, periodically or as needed.

4.1 Ambient follow-up on heat alerts

Heat alerts that are part of national heat health action plans (see 5.1) and available information provided by tools for environmental assessment based on meteorological data are to be taken into account by companies.[7] But environmental conditions have also to be followed-up at premises in order to identify local and micro-local variations in ambient conditions in different parts of the premises due to incidental radiation by the sun and wind speed and direction. Conditions can vary also during the day, during a single shift. And because workers have the right to know the level of risk at any moment.

Regarding the method for the follow-up, given the sheer variety available, it is clear that the one adopted should be agreed with workers' representatives. The most suitable methods are indices which assess the impact of heat on human health. Using only ambient air temperature (as measured with a thermometer) is not acceptable because the impact of heat on human health is mediated by other variables such as relative humidity and wind speed: the skin's ability to cool via the evaporation of perspiration increases at low levels of humidity; higher air speed improves comfort only at temperatures below 35ºC).

Regarding when and how often during the working day to take measurements, US-OSHA states that:

> 'NIOSH recommends, in the 2016 Criteria for a Recommended Standard, taking environmental heat measurements at least hourly, during the

7. To facilitate the follow-up of the impact of heat and humidity conditions on work, the Heat Shield (Horizon 2020) and Climatechip projects provide assessments based on meteorological data. North American authorities provide the Heat Index Calculator and the Heat Index phone app (USA), as well as the Humidex index (Canada), while the former has produced an alert system that provides 'personalised heat alerts and rest/hydration advice'.

hottest portion of each work shift, during the hottest months of the year, and when a heat wave occurs or is predicted.’ (OSHA n.d; OSHA 2017)

4.2 Prevention of heat strain and heat illnesses

Occupational heat strain is a fully preventable condition. According to NIOSH, when facing the risk of heat strain, a heat-related illness prevention programme should be mandatory. Such programmes are the basis for interventions that are commonly applied in respect of athletes, military personnel or firefighters to improve exercise performance, decrease heat stress and enhance post-exercise recovery but can be transferred to other challenging occupations (Bongers *et al.* 2021; Morris *et al.* 2020; Foster *et al.* 2020).

The critical elements of such a programme, beside an agreed method for alert setting and communications are: (1) setting acclimatisation protocols; (2) monitoring heat strain: selected physiological parameters can be monitored (by means of devices, by peers, etc), provided the need to collect data on workers is balanced with the rights of workers to privacy and where transparency in the methods of collecting and using such data is assured to workers and their representatives; (3) providing information and training; and (4) delivering first aid and emergency programmes (OSHA 2017; National Institute for Occupational Safety and Health 2016; Flouris *et al.* 2018).

5. Adaptation policies – still required to protect against occupational exposure

5.1 The need for special policies to protect workers in the face of heatwaves

After 70 000 deaths were recognised in 12 European countries during the heatwave of summer 2003, heat and extreme heat episodes were recognised as a health policy issue. Since 2008 the World Health Organization has promoted the need for authorities to pay attention to this growing public health problem. In consequence most EU member states have developed national heat health action plans (NHHAP). These plans address the protection of the health of the population by (1) establishing an information system for the monitoring of the illness and mortality burden posed by heat and for the identification of vulnerabilities; (2) heat–health warning systems, including determination of action threshold, activation of warnings and risk communication and (3) enacting pre-planned measures by local authorities designed for the protection of the population identified as vulnerable; (McGregor *et al.* 2015; Vanderplanken *et al.* 2021).

Even if research shows some limitations of such plans, it seems that achievements have been made in terms of weakening the correlation between heatwaves and mortality, although different definitions of heatwaves may affect a comparison of the figures. Mortality results are the basis for pointing out that adaptation policies do indeed protect health: the intensity and duration of climatic phenomena and the level of acclimatisation achieved by individuals are not the determining factors with regard to the severity of the impact of heat on health (Díaz *et al.* 2018; Barreca *et al.* 2016).

However, few member states have developed specific plans for the protection of the working population in the face of heat events. According to one study, only Germany and the Netherlands (and, outside the EU, Switzerland) specifically target workers and engage trade unions in their heat events plans (Casanueva *et al.* 2019).[8]

8. The Spanish National Heat Events Plan includes only a brief mention of occupational exposure and workers in the context of a shortlist of populations having risk factors for contracting heat illness (‘environmental, occupational or social’). This is a plan for health authorities and local social services and does not include any specific measure to reduce occupational exposure or to secure protection in the workplace. Several ministries and agencies are a part of it but not the Ministry of Labour (Narocki 2016). Consequently the National heat health plan lacks a specific occupational line.

The result is that some of the assumptions of public heat health adaptation policies do not fit the needs of workers' protection. Furthermore they can even function in contravention of proper protection measures where they:

- Ignore the employer's duty to provide preventive risk management: the adaptation of working conditions to foreseeable weather conditions is clearly among the occupational hazards which must be addressed (it could be stated more explicitly, but this can easily be concluded from EU directives);
- Ignore the constraints on taking self-care measures which originate within the employment relationship. This lacuna is especially damaging to the most socially vulnerable segments of the workforce such as low-paid workers, most of whom also suffer heat exposure away from the workplace;
- Ignore that most workers who suffer fatal heat illnesses during heat events are occupied in low-skilled and low-paid positions. Jobs involving physical work in hot environments are mostly done by vulnerable workers – mainly, immigrants on precarious contracts, piece rate pay, etc. employed by companies where culturally-shared modes of self-care in the face of heat are marginalised and where basic human strategies to cope with heat are thereby inhibited, even though these are the substance of reminders to vulnerable populations;
- Ignore the OHS hierarchy of control of the Framework Directive, by prioritising change in workers' individual behaviour. To address occupational hazards properly, employers must control the working conditions that lead to heat stress with at-source measures, adapting work organisation to avoid or reduce workers' exposure, implementing health protection measures (such as heat strain controls), developing first aid and emergency procedures and providing training, health monitoring, etc. as required according to risk assessments.

5.1.1 A specific monitoring system is needed in respect of the heat health burden on workers

Existing epidemiological monitoring systems have yet to ascertain the burden of climate change-related illness on working people (Casanueva *et al.* 2019; Kendrovski *et al.* 2018). These are required in order to provide public health arguments and advice in terms of intersectoral governance as well as for the development of sectoral policies.

At present the precise impact of heat on workers' health remains largely undetected. Neither occupational injuries and illness statistics nor the specific information system for the monitoring of the population during heatwaves have the capability to capture the specific burden that heatwave events place on workers. Furthermore, as we have seen, occupational injury notification systems are not well-suited to capture the impact of heat; there are even difficulties in Spain in registering cases of occupational heat stroke and the public health monitoring system for heat illnesses and fatalities is simply not able to capture the occupational links of cases of heat stroke (Narocki 2016). However, one part of the burden of weather conditions can be captured by analysing increases in occupational injuries arising from all causes (as explained in 2.3.1).

5.1.2 Specific occupational alert systems?

There is currently no single internationally common, shared definition of what constitutes a heatwave (Piticar *et al.* 2019). Broadly speaking, heatwaves can be defined as weather conditions that are hotter and/or more humid than is typical for a certain location and season. All the definitions coincide, however, in that the phenomenon consists of abnormally high minimum and/or maximum temperatures in relation to the time and area under consideration. Heatwaves are defined based on a high percentile base and not on absolute air temperature thresholds since the latter method would not ensure that local climatology and acclimatisation have been assessed.

Most definitions include additional requisites and so not all hot weather episodes in a given country are considered 'official' heatwaves, omitting a good proportion of those days that are too hot for work (Riccò *et al.* 2019). The official definition of heatwaves in Spain, for example, includes the predicted duration of the event and the number of localities affected; it states that:

> 'A "heatwave" is an episode of at least three consecutive days in which at least 10 per cent of weather stations record peaks above the 95 percentile of their daily maximum temperature series for the months of July and August in the period 1971-2000.'

If the definition of a heatwave has as its main indicator the mortality burden,[9] its threshold values are obviously not set to protect against discomfort, nor against reduced performance, lower productivity, injuries, minor heat illnesses or the long-term health impairment caused by the added burden of heat on other forms of occupational exposure.

Any heat health early warning specifically designed for occupational purposes has to consider micro-location conditions; especially humidity and sun radiation. For heat stress assessment in workplaces, data from existing weather stations is very valuable but has to be complemented with important variables involved in the heat exchange between the body and environment, such as 1) local heat sources; 2) special work and protective clothing; and 3) physical work intensity (Gao *et al.* 2018).

9. Other negative outcomes of heat events, apart from hospitalisations and mortality, are not considered so the information system is not able to capture them. Official occupational injuries data is also not sensitive enough so the impact of heat remains invisible. Consequently, in terms of strengthening the focus on the specific impact on workers, there is a need to generate more precise or specific data.

Authorities wishing to strengthen the protection of more exposed and vulnerable workers, and to send an early signal for the activation of companies' own plans, must set specific occupational thresholds and a communication system to mobilise preventive and protective efforts by local authorities that can additionally contribute to occupational risk assessment with the mapping of local heat spots and by applying remedial measures.

5.2 OHS still omitted from climate change adaptation policies

The International Labour Organization (ILO) has called on governments and other organisations to respond to the occupational health and safety ramifications of climate change (Kenny *et al.* 2020; McGregor *et al.* 2015; ILO 2015).[10] A recent document states:

> 'Climate change is a current and future environmental OHS hazard. According to this publication, the little political or public attention that the impacts of climate change on OHS have received [...] may be because increasing heat stress levels at work are mostly invisible compared to chemical exposures or air pollution.
>
> This invisible threat, however, is just as dangerous and over certain thresholds can become lethal. Climate hazards also have the potential to interact, including in ways we cannot yet anticipate' (ILO 2019).

According to the ILO, this important area of heat health governance should be strengthened through further integration with other policy areas related to climate change adaptation, with instruments spanning research to the establishment of specific standards for occupational safety during heatwaves, industry-specific standards and the enforcement of regulatory compliance (WHO 2021).

At present, however, there is still no specific mandate on employers to put in place a planned adaptive and preventive response for addressing heat events in workplaces where working conditions can be affected by the hazards which result from hot weather. The regulations and policies of the European Union on occupational health and safety demand systematic approaches to the management of risk at company level. Via the duty of care (Article 5 of the EU Framework Directive (89/391/EEC), employers are expected to identify, evaluate and manage OHS risks in a participative way, engaging with workers and benefiting from their experiences in doing so (Walters and

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10. It is worth this emphasising that this document is focused primarily on the impact of climate change on productivity and on poverty, referring especially to outdoor work in countries and sectors already affected by low productivity.

Wadsworth 2020). Employers' obligations in relation to weather events are founded, in most EU countries, only on this general duty – a weak basis to secure protective management, especially in terms of securing the protection of workers not covered by the requirements of Directive 89/654/EEC setting out minimum workplace health and safety requirements.

A recent report by the United Nations Environment Programme (UNEP) highlights that late scientific recognition has delayed policy responses, recalling that the issue of heat at work was mentioned for the first time only in the Intergovernmental Panel on Climate Change fourth assessment report 2005-2007, although it received much greater attention in the fifth assessment, 2013-15 (Kjellstrom *et al.* 2016). This publication considers that attention from trade unions has been poor:

> 'Trade union materials on occupational health usually refer to heat as a hazard, but the link to climate change impact has not been pursued.'

In its policy recommendations it states:

> 'The most relevant international organizations have yet to establish any major programmes to address the major challenges of rising heat in the workplace. In November 2015, however, the ILO Governing Body adopted the "Guidelines for a just transition towards environmentally sustainable economies and societies for all", which includes occupational safety and health and social protection policies within the context of climate change. These guidelines recognize the need for enterprises, workplaces and communities to adapt to climate change to avoid loss of assets and livelihoods and involuntary migration. Under the Occupational Safety and Health (OSH) item, these guidelines call on the social partners to conduct assessments of increased or new OSH risks resulting from climate change; improve, adapt or develop and create awareness of OSH standards for technologies and work processes related to the transition; and review policies concerning the protection of workers. The Social Protection Policies item mentions the promotion of innovative social protection mechanisms that contribute to offsetting the impacts of climate change and tripartite mechanisms to identify and understand the challenges posed by climate change. [...] There are also a range of options that can be explored to further develop research and advocacy initiatives, review labour standards, and implement practical preventive measures in the workplace in the context of climate change adaptation. Swift efforts by all countries to live up to the UN Paris Agreement objective of well below 2 degrees of warming with efforts to limit temperatures to not more than 1.5 degrees will also constitute the most significant preventative measure against the tremendous escalation of workplace heat risks this century.' (Kjellstrom *et al.* 2016)

Considering that summer temperatures are rising, and that heatwave events are being reported with higher frequency and intensity, as well as the forecast impact on health and productivity by the Intergovernmental Panel on Climate

Change, public policies to protect the working population are urgently required (Al-Bouwarthan *et al.* 2019; Pattisson 2019).

5.3 Recent EU institutional policies are addressing the threats of extreme heat

Beside mitigation, recent European Commission institutional policies are addressing the threats of extreme heat posed by climate change with the adoption of urgent adaptation measures. Adaptation at different action levels and by actors is a way of reducing the impact of heat on human health, agriculture, natural ecosystems, infrastructure, etc. The new EU Strategy on Adaptation to Climate Change (2021), building on the European Green Deal, promotes and reinforces ambitious action among the member states for adaptation to climate change. In this document, the Commission points out that progress in adaptation planning remains slow and that implementation and monitoring are even slower. Moreover it points out that the focus on awareness raising, institutional organisation or policy development has to be shifted to developing and rolling out solutions to help reduce climate risk and increase climate protection.

The adaptation of working conditions to avoid hazardous heat exposure fits with the EU's objectives of socially sustainable development and of the health and workability of workers. The recent launch of the Commission's Occupational Safety and Health Strategic Framework 2021-27 aims to update protection standards for workers and to tackle traditional and new work-related risks. This strategy, grounded in the tenth principle of the European Pillar of Social Rights, states that actions for a healthy, safe and well-adapted work environment are based on workers' rights to a high level of protection of their health and safety at work. It is also grounded in the eighth principle on social dialogue and the involvement of workers. The new strategy correspondingly takes a tripartite approach involving EU institutions, member states, social partners and other stakeholders, focusing as one of its three key priorities on increasing the level of preparedness to respond to current and future health crises. Ensuring healthy and safe work environments addresses two of the employment, social and economic challenges that are identified in the European Pillar of Social Rights and its associated Action Plan, adopted in 2021, which aims to protect workers while upholding productivity and to allow for sustainable economic recovery.

The Commission's recent proposal for a first European climate law commits the EU and the member states to continuous progress in boosting adaptive capacity, strengthening prevention, preparedness and resilience, and reducing vulnerability to climate change as well as securing a just transition.

The European Trade Union Confederation Resolution 'A new EU adaptation to climate change strategy for the world of work' (ETUC 2020) calls on the EU to address the social dimension of climate change and the effects that climate change will have on people, workers and communities, mentioning among other aspects the OHS implications of heat. The ETUC points out, from a survey of its member unions, that many trade unions have not been associated with an integrated national consultation process on climate and energy plans (ETUC 2019).

Another recent input to this arena is being made by standardisation initiatives in respect of organisations' adaptation to climate change risks by risk assessment in this area. This encompasses the OHS-related risks (ISO 14090:2019 Adaptation to climate change — Principles, requirements and guidelines; and ISO 14091:2021 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment). According to the ISO's own explanations, these standards are designed to be adopted by different types of organisations and regardless of size, type and nature. The standards outline heat vulnerability concepts as well as guidelines for assessing the risks related to the potential impacts of climate change as a basis for climate change adaptation planning, implementation and monitoring and evaluation; and can be used in assessing both present and future climate change risks. Workers representatives in companies adopting those schemes will have to remain watchful in order to preserve their right to participate in risk assessment and to monitor the effectiveness of the risk management approach according to its results (Frick 2019).

5.4 Protection of the most exposed workers should be an element of just transition

During the last few years, heat health policies have become part of the objectives of climate change adaptation policies. As the impact of heat and heat events on the comfort, health and security of workers and their productivity becomes evident, mitigation and adaptation policies are beginning to develop a specific approach to give an answer on the protection of the working population against such impacts.[11]

However, even if just transition did encompass thermal protection for all workers, there would still be a need for measures aimed at the reduction in the social divide raised by occupational heat exposure.

Justified concerns about growing energy consumption related to the extension of the use of air conditioning units only indicates the need for a diversification of OHS interventions.

11. According to a survey by the ETUC among its member trade unions, only 59 per cent of respondents indicated they had been associated with an integrated national consultation process on climate and energy plans despite the presence of an explicit obligation in this respect. See (ETUC 2019).

The introduction of new mechanisation and robotic technologies can be an opportunity to reduce incidences of occupational heat stress as long as these do not lead to an intensification of work.

Authorities should be responsible for closely supervising the heat plans of industries and activities in which severe exposure takes place as well as in those sectors which employ the most vulnerable occupational groups. This could be done by an obligation to submit an action plan to the appropriate authorities.

Communications efforts to mainstreaming the OHS impact of heatwaves

Messages to the public should remind that external environmental conditions (humidity, solar radiation, wind) are only part of the factors that can lead to occupational heat stress and the interplay between heat stress and other risk factors.
It also should be remembered that, beside occupational exposure, workers are also affected by heat events outside the workplace.

Communications efforts must be made to reach employers and the most exposed and vulnerable workers; those that, within the employment relationship, find it difficult to apply the basic set of self-care behaviours necessary to face heat, as recommended to the wider population (such as avoiding exertion and being outdoors during the hottest hours of the day, wearing light clothes, etc.).

6. Overview and some conclusions

Occupational heat has long been known as an OHS hazard but heatwaves are posing new threats to European workers' health, safety and wellbeing that remain to be fully recognised and tackled. Even if climate change mitigation measures are adopted, the challenge posed by heat events is expected to rise.

Climate projections over the next decades show a continuous and accelerated warming across Europe together with longer, more intense and more frequent heatwaves posing an increasingly severe threat. Southern European workers are the ones currently most affected by heat, but heat events are dangerous for workers even in those parts of the continent where the summers are mostly cool, including at high latitudes.

Data on occupational exposure to environmental heat is scarce, but there is enough evidence to claim that, during heat events, many workers suffer exposure to heat stress that exceeds critical levels, especially among those doing physical work, working under solar radiation or who are affected by other occupational heat stress factors such as using PPE. If so, many workers are under heat strain.

A growing body of evidence shows that heat strain exposure has both short-term as well as long-term health impairment effects, worsened when in combination with other areas of exposure such as in terms of chemical and safety hazards. These impacts are largely ignored in official statistics.

There is strong evidence of reductions in labour productivity during heat events derived from the impairment of working capacities. The economic impact of an increase in injury rates sustained during heat events, as well as other heat health impairments, needs to be added on top.

Evidence shows that adaptation measures are efficient.

Adaptation to heat, to prevent major consequences for workers' health and to preserve productivity, could seem to be an arena of convergent interest which paves the way to a situation in which the threats might be addressed. Companies in which this risk can appear, or worsen, as the result of weather events ought to prepare heatwave programmes with the participation of workers, allowing them to continue production at the same time as delivering the full protection of workers' health.

That convergence is difficult to identify, however, in companies in which workers are subject to the most extreme heat conditions or without effective representation. There are additionally large numbers of workers whose protection requires direct public action and enforcement.

At present, preparation for heat events – preventive management – is not mandatory. Heat exposure at work reflects social inequalities and, by harming health, also causes a deepening of social divides.

To give an answer to the present and future challenges posed by heatwaves, such events must be recognised as both an OHS issue and a productivity one. At present, heat is a well-recognised public health issue, addressed in the public policy plans which have been developed in most European countries since 2004. These are focused on segments of the population considered to be vulnerable, such as the elderly. However, most do not have a specific line on the protection of workers beyond making recommendations for behavioural adaptation. In most EU states, unions are excluded from adaptation dialogue. Employers' duties of prevention, the particularities of labour relationships that constrain self-care behaviour in many occupational settings and the specific social vulnerabilities of some segments of the working population are ignored.

In order to alleviate the impact on health, communities and individuals, the authorities should go far beyond the current public health-inspired programmes that call on workers to avoid life-threatening exposure and to follow the rules of self-care behaviour.

The preventive occupational risk management of heat events should be a requirement for any occupational situation in which heat stress factors have previously been present or which can appear in the context of weather-related heat events. The preparation of a preventive and protective response by employers is crucial for OHS. Preventive action should be organised in advance even if the expected level of risk seems low or affecting no more than workers 'comfort'. Companies should initially act on the basis of workplaces' physical characteristics and then by adaptation activities to address heat events, with measures designed to give full protection to workers' wellbeing, health and safety under any weather circumstances.

Companies' heat plans should tackle all heat events that can be relevant to workers' OHS, not only those events that, in each separate country, are officially defined as 'heatwave' events in respect of the health of the broader population and other purposes.

Moreover, thermal discomfort should not be regarded as a minor OHS issue. The conditions in which heat stress factors do not reach such a level as would immediately, via heat illnesses, jeopardise human health must still be addressed at work as they can impair wellbeing, performance and productivity while, in some jobs, they may also constitute a safety risk factor. Risk assessments should consider any impact of heat events, not only for office workers. Thermal discomfort caused solely by external heat must first be controlled by measures tackling the ambient factors: temperature; humidity; radiant heat; and air movement. If these measures are insufficient, considering other heat stress factors, other adjustments should also be carried out, starting with tasks and work organisation.

The very identification of the prospect that a heat event could strike at OHS conditions, in any job, should lead to a set of preventive interventions being anticipated even if heat stress levels are not expected to be met.

In addressing a heat event, there should be no need to engage in a full assessment to signal the need to act in response to weather events that arise suddenly; while a measurement made at a 'representative' moment of the year cannot be used to negate weather-related reality.

As a part of climate change adaptation, it is widely recognised that there is a need for policies protecting the population from heat events. Both the EU and its member states have acknowledged and taken a lead in tackling rising average temperatures, heatwaves and extreme heat events via adaptation measures. Recent years have seen calls for the adoption of adaptation policies to reduce the most salient impacts of climate change. Urban authorities have a particular role so they are called on to take action to prevent or minimise the damage that hot weather events cause for urban populations.

Climate resilience and risk management measures should consider the social dimensions of climate adaptation strategies based on vulnerability assessments. These should allow the identification of diverse vulnerability profiles, going beyond demographic and physiological definitions to include economic, social, geographic, cultural, institutional, governance and local environmental factors, foreseeing the impact of stressful extreme and non-extreme events on exposed populations in addition to the vulnerability of infrastructure. Local action schemes here are complemented with heat health actions, including heat monitoring and warnings, alongside calls on the population to apply behavioural recommendations.

Even though the need to monitor the impact of climate change on workers' health, by itself and in terms of the policies adopted to face it, is recognised and even though there is an awareness of the impact of heat events, real attempts to tackle OHS conditions in practice are still lacking.

At present, it seems that no EU country has adapted its health monitoring or notification systems for occupational diseases and injuries so as to capture the full impact of heat on the working population's health, safety, wellbeing and productivity. In this context, most authorities, employers, labour inspectors and safety officers, and too many workers, still tend to view heatwaves as exceptional situations outside the scope of OHS.

Specific policies, laws and programmes are needed for the protection of workers, envisaged from the perspective of the most diverse exposure scenarios. At present, wide swathes of workers suffer inaction on the part of employers while authorities tend to continue to turn a blind eye regarding extreme exposure during heatwaves. This is the case even with regard to jobs that are known to be extremely dangerous, i.e. where hot weather exposure combines with other factors in heat stress, such as among agricultural and construction workers, delivery riders, etc.

Widening the arena of social dialogue and collective bargaining on working conditions to address heatwave-related hazards, especially in terms of exposure to threats such as high temperature, natural UV radiation and the other health and safety dangers brought by climate change, can be a means of pursuing both productivity gains and the protection of workers' health and safety. By bargaining on these new issues, the demands of the different social actors can be met. Dealing with the OHS risk associated with climate change can also create the opportunity to answer other rapid technological and societal changes (Kjellstrom and Maître 2019; ETUC 2020).

Up to now, public heat health plans have been prepared with the contribution of neither union nor employer organisations (Casanueva *et al.* 2019). Preventing the impact of heat events on OHS still needs to be mainstreamed in line with climate change adaptation policies. Policies to foster companies' preparedness to prevent occupational exposure and its impacts (reduced human performance and work capacity; the rise in occupational injuries; heat illnesses such as heat exhaustion or heat stroke; long-term diseases and health impairments; societal impoverishment; etc.) remain to be developed (Morris *et al.* 2021).

Specific occupational policies to address the effects of heatwave on the working population, with precise action points developed in collaboration with trade unions, are needed both from the EU and its member states. These should include:

1. Setting heat stress hazard obligations for employers:

– The obligation to prepare an action plan, with the participation of workers and their representatives, which encompasses any conceivable locally-determined level of heat, regarding any work situation and position, as well as workspaces and tasks which may be affected by environmental heat conditions and encompassing those excluded from the Workplace Directive;
– All hot weather-related impacts and risks should be identified in terms of the risks to health, safety, comfort and wellbeing, not only heat-related illnesses such as heat stroke. All contributory heat stress factors, such as exertion, PPE or special clothing requirements, solar radiation, humidity, etc., should be controlled;

- Sectoral guides for minimum technical and work organisation adaptations should be set, to be improved upon by collective bargaining. Preventive measures should follow the hierarchy of control. Examples of minimum mandatory provision against occupational heat stress exposure should be stipulated such as shade for any work setting; cool places of refreshment situated near the task location for breaks and for first aid; acclimatisation programmes; rest times and minimum breaks according to risk assessment and people's needs; a water consumption programme covering the variety of aspects that can lie behind dehydration, beyond the supply of fresh water by the employer; the provision of cooling devices and or showers; information and training; and effective first aid and emergency preparations;
- Heat strain control measures should be planned where severe conditions are foreseen, taking account of the protection of privacy and other human rights issues;
- The structural barriers which exist to the improvement of OHS and working conditions, such as piecework payment systems, need to be removed in respect of any position under heat stress as these incentivise long hours without breaks which can be deadly in a heatwave (see CLEO Institute 2021).

2. Setting heat stress hazard obligations for authorities:

- Adoption of a public heatwave warning system specifically intended to protect the working population, complementary to the warning systems which are already in place for the protection of the health of the general population and able to reach all actors capable of having an impact on the working environment;
- Setting occupational heat health services provision based on clinical care and health surveillance, to reduce exposure to and control the negative impacts of heat events. This should provide information for a heat stress prevention strategy focused on the most vulnerable segments of the working population taking into account age, sex, immigration status, sector, occupation, etc.;
- Intervention programmes should be directed to the protection of workers with regard to the most exposed economic activities, i.e. those activities and sectors where the most vulnerable workers are employed, as these combine exposure to several hazards and are workplaces which are frequently lacking in worker or trade union representation. Sectoral standards for adaptation to heat can be a good way to tackle the impact of heat events on workers' health and safety;
- Delivering protection of the residences and means of transportation of the most vulnerable workers by directing resources for climate change adaptation and just transition policies;
- Efforts should be directed to improve the ability of official occupational health and safety statistics and population heat-health monitoring systems to capture the link between cases and occupations. In the meantime, authorities have to support research efforts trying to show the impact of heat on workers.

Local and sectoral union representatives have to be able to give support, including technical support, to the efforts by workers and their representatives to promote better heatwave risk management, consolidating and building at local and workplace level on the adaptation criteria set by authorities and by collective bargaining.

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Annexes

Annex 1

On hydration programmes

Maintaining hydration levels is critical when working under thermal stress caused by heat. Dehydration is a condition in which the body does not contain the amount of fluid it requires; it can result from excessive sweating (excessive loss of fluid), from insufficient consumption of liquids to compensate for losses via sweating, or from both causes.

In occupational settings, especially in elementary occupations outdoors, work organisation demands, precariousness, workplace layout and other constraints are often obstacles to proper water consumption. An action plan for facing heat events in situations where it can lead to heat stress should include a workplace water consumption programme, covering a variety of aspects that go beyond the supply of water.

By means of a programme for paced fluid replacement (programmed drinking), as opposed to relying on the thirst sensation, people at risk of dehydration at work are encouraged to drink systematically to replace fluid lost through sweat. Such programmes are required because, under heat stress conditions, the voluntary replacement of water lost via sweat is often incomplete. Thirst is not an adequate guide to the requirement for fluid replacement and the lack of replacement may be for neither physiological nor psychological reasons: an inadequate or delayed thirst response has been observed regularly in occupational settings with poor access to water, lack of self pacing, insufficient quality or palatability of water, lack of or inadequate training and even a long distance to toilets. So a programme to encourage frequent water consumption at work (for example, every 15-20 minutes) has to review a range of working conditions.

Employers must ensure that there is a sufficient supply of easily accessible drinking water (and other healthy fluids) near the site of work, at a temperature below 15°C. Workers should be encouraged to drink from cups and/or bottles, rather than directly from fountains so as to allow a better self-assessment of the amount consumed. Easy access to toilets is essential: these should be situated near the place of work so that people, especially women, do not worry about drinking 'too much' and having to leave the work station for too long.

There is, however, a limit to the water supply 'solution'. Heavy liquid consumption (> 1.0 liter per hour; compare to recommendations for total daily fluid intake for the populations of around 2-3 liters per day) places a strain on the body; too much fluid intake can be dangerous as there is a limit to the amount of water the body can process on an hourly basis while remaining healthy. Working in conditions that require the drinking of a large quantity of water a day, as in jobs with a high level of physical activity, performed in a hot environment for a prolonged period of time (i.e. for two hours or more), can lead to hyponatraemia (a fall in sodium levels or sodium imbalance in the blood), a condition that can result in rapid cerebral inflammation leading to coma or death.[12]

Drinks with carbohydrates and electrolytes, or dry preparations to add to the water, may be provided to ensure the replacement of electrolytes lost through perspiration. Such drinks, however, do not guarantee protection against hyponatraemia as this condition can be caused by excessive water retention (as the body becomes unable to process so much water) and not just the loss of sodium.

Perspiration produces sweat, a clear liquid, via glands in the skin, primarily in the armpits, on the soles of the feet and on the palms of the hands, at a rate of up to two litres per hour. The production of large volumes of sweat imposes additional stress on the cardiovascular system.

To fulfil its thermoregulatory function, sweat must be able to evaporate. With high ambient humidity, with clothing or PPE with properties that obstruct the evaporation of sweat or when the person is dehydrated, this cooling mechanism becomes difficult or is halted.

Dehydration can be mild, moderate or severe, depending on the proportion of body fluid lost and/or not replenished. Moderate dehydration critically increases the impact of heat stress by causing the person to sweat insufficiently, meaning that the body overheats and cardiac function is affected. As the magnitude of the water deficit increases, especially when an individual exerts themselves in hot conditions, there is a gradual rise in core temperature which can reach 0.25°C for each percentage point of body weight lost.

Clinical symptoms of dehydration include increased heart rate, increased body temperature, decreased urine volume and a change in colour, restlessness, lack of energy, irritability, sleepiness, reduced work performance and circulatory shock. A hydration deficit of just 1 per cent or less of body weight raises body temperature during exertion and reduces work capacity and heat tolerance; with a 2 per cent loss, tolerance of heat stress begins to fall while heart rate, body temperature (and thus the risk of injury) increase, and skill and work capacity decrease; a 5 per cent loss makes work more difficult and creates a very dangerous situation: the heart rate increases and the effectiveness of sweating as a thermoregulatory mechanism is reduced which can lead to fainting and heat-related illnesses; a reduction of 15-20 per cent results in death.

12. In accordance with ISO 7933, the sweat rate should be limited to 1.0 litre/hour for non-acclimatised subjects and up to 1.25 litres/hour for acclimatised ones. See (2016) Occupational Hygiene Training Association Thermal Environment Student Manual, at: http://www.ohlearning.com/Files/Student/JB38_v2-0_20Mar16_W502_Student_Manual1.pdf

Methods of health monitoring to assess hydration status include plasma/serum osmolality, urinary specific gravity (USG), urine osmolality (Uosm), body mass control (to prevent a loss exceeding 1 per cent across a shift) and urine volume and colour. This last method is often recommended as a means to the self-monitoring of hydration status as a result of its practicality, but its effectiveness is still to be demonstrated (Kostelnik *et al.* 2021).

Annex 2

ETUC Resolution on the need for EU action to protect workers from high temperatures

Adopted at the Executive Committee Meeting of 18-19 December 2018

Background

When the workplace gets too hot it is more than just an issue of comfort. When the temperature goes too high, as was the case during the summer of 2018, then it can become a real health and safety issue.

Given the fact that average temperatures are likely to increase over the coming years as a result of global warming this is a problem that is likely to increase. It is also a problem that is usually relatively easy to resolve, demonstrating the value of trade union-led health and safety campaigns.

High temperatures: what is at stake?

When workers get too hot, they risk dizziness, fainting and heat cramps. In very hot conditions the body's blood temperature rises. If blood temperature rises above 39°C, there is a risk of heat stroke or collapse. There is increasing evidence that occupational heat stress is linked to kidney disease among outdoor workers. Even at lower temperatures heat leads to a loss of concentration and increased tiredness, which means that workers are more likely to put themselves and others at risk. High temperatures mean there is an increase in the likelihood of accidents due to reduced concentration and slippery, sweaty palms as well as an increase of discomfort from some personal protective gear which can result in reduced protection through inappropriate usage or non-usage.

Heat can also aggravate other medical conditions and illnesses such as high blood pressure or heart disease due to increased load on the heart as well as interacting with, or increasing the effect of, other workplace hazards. Pregnant women are at particular risk from high temperatures and specific arrangements need to be put in place to ensure that they are protected.

Ordinarily people work best at a temperature between 16°C and 24°C, although this can vary depending on the kind of work being done. Strenuous work is better performed at a lower temperature than office work.

The need for action at EU level

Workers in Europe should never have to work in temperatures that place their health at risk. As the world's leading trading bloc, the EU should lead the way in working conditions by ensuring workplaces with safe temperatures. In an era of climate change in which difficult weather conditions are likely to be more frequent and more extreme, it is essential that there are the appropriate legislative instruments in place to protect workers with clear roles and responsibilities for policy-makers, employers and trade union representatives.

The temperature challenges facing workers in Europe vary greatly, as do the rights to which they have recourse for protection. Those engaged in strenuous and arduous work are at particular risk of extreme temperatures as the inherent difficulties are compounded by the additional stress factors caused by the work – though definitions of what constitutes arduous work across Europe remain opaque.

The protections that workers enjoy across Europe vary greatly. ETUC data has recently shown that there is a wide range of minimum temperatures permissible in European workplaces across different member states and different sectors – from just 4°C to as high as 20°C depending on the type of work. Likewise, maximum limits show significant variance from as low as 18°C to as high as 35°C. Some of these limits are statutory, some are collectively bargained while others are a combination.

ETUC plan of action

ETUC affiliates overwhelmingly support action at the European level to protect workers from high temperatures and to prepare for a future in which these challenges are likely to present more frequently.

The ETUC therefore commits:

– To work, through the ETUC Health and Safety Committee, to identify a series of actions to promote the issue of safe and healthy working temperatures. This will include developing guidance to issue to affiliates that will address different work environments and temperatures;
– To raise the issue of unsafe working temperatures with both the European Agency for Safety and Health at Work (EU-OSHA) and the Advisory Committee on Health and Safety at Work (ACHS) with a view to raising the profile of this risk;
– To launch a day of action in June 2019, timed to coincide with the June ETUC Executive Committee, which will generate publicity for the demands;
– To call upon the European Commission to introduce a legislative instrument that recognises this increased risk to workers and provides a framework for protecting workers. Weather conditions do not respect national borders and so European action is required;
– Demands that European employers' organisations take this issue seriously by issuing guidance to their affiliates on how they can protect their workers from unsafe temperatures for work both indoors and outdoors. The ETUC is ready to work with the employers in developing this;
– Commits to pursuing these objectives throughout the course of the next European Commission and Parliament mandate.

Annex 3

An agreement for a company action plan

The following is a synthesis of a series of sectoral guides for representatives developed by ISTAS-CCOO.

Workers' representatives can demand companies develop, with their participation and the participation of affected workers, action plans that address heatwaves and extreme heat events. A plan could be developed in line with the following steps:

– Creation of a working group to prepare the plan, composed of representatives of the company and of workers. The working group should gather information on the initial situation (data, events and complaints in recent years, applied and proposed measures, etc.) and seek the advice of technical staff in occupational risk prevention and of trade unions. It will identify all of the positions and tasks subject to possible exposure;
– Agreement on a method to determine, at any given moment, the level of ambient risk. A valid method must be adopted; if it is not possible to use the WBGT index, other methods such as the Heat Index can be used. In either case, the aim is to agree on a method for ranking the severity of the actual ambient situation and to compare it to predefined scenarios which identify, for example, four levels of action: caution; extreme caution; danger; and extreme danger. It is not advisable to restrict the assessment to a calendar period, as heat events can occur outside the traditionally hottest months;
– An agreement about a system for the communication of the level of risk to any workers, at any location, by an agreed means (for example, SMS, WhatsApp, etc.), as a means to instigate the implementation of the pre-planned measures. Heat warnings directed at the general population can serve as an alert but cannot substitute for the assessment of local environmental conditions taking into consideration local factors;
– Selection of appropriate preventive measures for each task and each scenario or level of action, and preparing the resources required for them. Measures should be defined for each work position, each task, each space and each level of action to ensure that work does not affect health. To do this, a sheet should be prepared for every position, task and space with exposure levels (see example and summary sheet below). These take into account the danger of other heat stress factors and the characteristics of workers. The group will place all of the agreed measures on each sheet so they can be activated as the level of risk increases. Depending on the case, measures such as the following (examples) should be adopted:
  - technical measures (on environmental conditions);
  - measures to reduce physical effort e.g. mechanical aids, dividing the task amongst several people, staggering tasks over time, etc.;
  - organisational and material measures for promoting hydration;
  - organisational measures: modifying the content of tasks or the ways

in which they are executed; postponing them to a time when there is less risk (another day, timetable, shift, etc.), especially if they require physical effort, contact with sources of heat or the use of PPE; reducing the intensity or the rhythm of work; increasing breaks; reorganising schedules.

In no case should the measures adopted entail transferring responsibility for prevention to workers, nor should they result in a loss of income.

It must be considered that ‘dangerous’ and ‘extremely dangerous’ environmental situations mean a risk may be serious or imminent.

Measures should be agreed to and guidelines such as the following adopted:

– Tasks that can be postponed are identified and detailed in the plan;
– For those tasks that cannot be postponed, written permission systems must be set up which describe in detail the human and material resources necessary to perform the task as well as each risk reduction measure to be adopted. Furthermore, the permission should indicate the amount of time the measure will be in place, the persons to whom the task is assigned and the person who authorises the task;
– It should be established that no work is to be carried out alone;
– Work may only be carried out if measures and means are available that provide maximum protection for the health and safety of workers;
– The type of monitoring used to ensure that people do not suffer from heat strain must be defined. In circumstances of extreme danger, this can only be done by on-site medical personnel;
– Etc.

Those directly affected should be involved in the preparation of these sheets. The working group should encourage the greatest level of participation in identifying risks, choosing preventive measures and assessing their effectiveness.

Preparing the human and material resources necessary for providing first aid for the signs and symptoms of heat-related illness. Likewise, the implementation of emergency measures should be planned, considering that heat stroke is a medical emergency that requires hospital attention. The closest healthcare facility capable of providing the necessary attention and the means of transportation must be identified. It should be determined whether it is necessary to have the means of providing assistance available onsite.

Training and information: The plan should be known by everyone, including contractors where applicable. The group should identify training needs based on collaboration in the development of the action plan and for dealing with heat stress.

Empowered workers can refuse exposure to serious or imminent risk. Representatives should ensure that all workers are trained and able to identify and speak out about hazardous working conditions and to demand the implementation of risk reduction measures.

Training should also cover the recognition of early symptoms of heat illness so that people are capable of recognising them and reacting in the most appropriate manner. Instructions should be posted and training repeated.

Determining onsite responsible persons: the plan should establish the identities of the persons, in every working space, who are to be responsible for the daily monitoring of the danger posed by environmental conditions and for communicating to the entire staff (including contract workers) the level of action to be implemented on that day. Measurements should be recorded and monitored by those in charge.

The responsible persons should, at the beginning of the working day, explain to the staff the anticipated level of danger for the day and should set out the work plan for the day with any modifications to the usual plans, the special measures to be taken and the responsibilities assigned. They should also remind staff of the guidelines for hydration, breaks and rest, as well as of the first aid and emergency plan.

In the event of suddenly rising temperatures, these people are responsible for including in the risk assessment considerations which relate to the acclimatisation of the group or certain individuals (if they have recently joined the team or have been absent due to illness, holiday, etc.).

They should also ask people in each team if they might be affected by potential specific factors which can increase the level of individual susceptibility such as previous discomfort, use of medication, etc.

In addition, they should encourage people experiencing discomfort to stop exposure and take measures to cool off before returning to their work. It should be conveyed to them that the results of risk assessments cannot substitute for signs of individual discomfort. A system of mutual monitoring (buddy system) should also be put into place.

Assessing the effectiveness of the plan and planning improvements: the working group should follow up by reviewing the effectiveness of the plan, at least once a year if no incidents have occurred, identifying the necessary action and assessing worker satisfaction. The plan should be prepared before the arrival of summer.

Medical surveillance specific to exposure to heat stress. There is no specific medical protocol. Medical check-ups should be offered to identify particularly sensitive individuals and monitor the impact of working conditions on health including respiratory, cardiovascular and renal functions. If solar radiation is a factor, skin and eye health must also be checked.

Example of contents of a sheet for task heat adaptation

Task: (name/description)
The task is carried out in a space affected by solar radiation:
Yes ___ No ___
Level of physical effort required to perform task Personal protective equipment and/or special clothing in use (describe)
Other non-environmental sources of heat can be present:
(example: working equipment that gives off heat) No/Yes (description)

Measures to adopt for each level of the heat index, considering whether the above-mentioned heat stress factors are present

'Caution' level – basic measures:
'Extreme caution' level – additional precautionary measures/increased level of alert:
'Danger' level – Additional protective measures:
'Extreme danger' level – Greater protective measures than the previous level:

The information on each sheet can be summarised on a short sheet, shown in the example below, and placed in a visible location:

Protective measures against heat stress (shortened sheet) Position: …………………………………………………… Applicable to the following task/s: ……………………………………… …….	
'Caution' level	Basic measures ……………………………………… …………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………… ……………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………
'Extreme caution' level	Additional precautionary measures and heightened awareness ……… ……… ………… ……………… …………… ………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………… ……………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………
'Danger' level	Additional protective measures ……………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………… ……………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………
'Extreme danger' level	Even more aggressive protective measures than at the previous level ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………………………………………………………………… ……………………………… ……………………………………………………… ……………………………………………………………………………………… ………………………………………………………………………………………

Annex 4

Exposure to UV radiation and protective measures

In addition to producing heat and to the risk of burning the skin, excessive exposure to solar radiation causes the majority of types of skin cancer and premature ageing of the skin.

The estimated strength of solar radiation for a given day for each given area is communicated to the population by means of the UV index, on a scale of 1 to 11+; beside the time of the day, the value has to be adjusted to take into account any applicable local factor (World Health Organization 2002):

– altitude: cancer-related ultraviolet (UV) rays are more intense at higher altitudes;
– cloud cover: clouds reduce radiation but UV rays can still get through to the ground;
– sunlight reflection off surfaces such as water, sand, snow, pavements, etc.

Preventive measures against UV radiation[13]

Apart from the strength of the radiation, the amount of UV a person receives depends on the duration of exposure and on the protective measures taken. Shade should be the first choice measure because it protects against both heat stress and excessive UV radiation. Shade, to be effective, must block out sunlight especially during the hours around the middle of the day. Materials to provide shade via awnings, parasols, etc. made of fabric must state their UV radiation protection factor (on a scale from 15 to 50+). Wicker materials and artificial materials which imitate wicker do not offer the protection provided by those with a solid weave.

When shade is not available, a protection plan against skin cancer can include protective clothing or products (lotions, creams, ointments, gels, aerosols, wipes, lip balms, etc.). But clothing and products should not be considered as at-source measures as they are only filters: while they do offer some protection against UV radiation, they do not block it completely, especially in the case of products (see below).

The protection offered by clothing depends on the type of fabric and its condition. Thicker and darker fabrics offer better protection than fabrics with a looser weave, but they can have a higher impact in terms of heat stress which must be assessed. Dry clothes generally provide better protection than damp ones: the accumulation of sweat in clothing reduces the effectiveness of the protection it provides against solar radiation. There are currently lightweight, comfortable garments on the market which protect against exposure to UV rays even when damp.

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13. These recommendations are based primarily on the cancer.org site, specifically on How Do I Protect Myself from Ultraviolet (UV) Rays?

Regarding glasses, in order to reduce the probability of developing certain eye diseases and to protect the delicate area around the eyes, those than can block between 99 per cent and 100 per cent of UVA and UVB rays should be selected. Labels that state 'UV absorption up to 400 nm' or 'Meets ANSI UV Requirements' mean that the lenses block at least 99 per cent of UV rays. They need not necessarily be dark, as UV protection does not depend on the colour or darkness of the lenses.

Hats or caps should also be worn to protect the eyes and the skin around them. Hats should preferably be wide brimmed so that they protect areas like the ears, eyes, forehead, nose and scalp. A dark, non-reflective underside on a hat brim can also help to reduce the amount of UV radiation reaching the face from reflective surfaces such as water. A baseball cap protects the front and back of the head but not the neck or ears, where skin cancers commonly originate. Hats are available with fabric which hangs down on the sides to create shade over the ears and neck. This effect can also be achieved by placing a scarf under a baseball cap.

Products for skin protection should be chosen to give broad-spectrum protection against UVA and UVB rays and with a sun protection factor (SPF) of 30 or above. Products must be applied correctly; great care should be taken to cover the face, ears, lips (there are special products for lips), neck, arms and any other area of the body which is not covered by clothing. The protection these products can provide is limited if not enough product is applied. Another problem is that the product is removed through sweating (even when the product states that it is waterproof) or when people wipe their faces. Even when it is not removed it generally needs to be replaced every two hours. The product must be protected from heat as it can lose its effectiveness. Certain sun protection products can irritate the skin. Labelling such as 'hypoallergenic' or 'dermatologically tested' is not a guarantee that some people will not be affected. A test should be carried out by applying a small amount to the skin on the arm on the inside of the elbow for three consecutive days. If the skin does not become red, tender or itchy, the product may be suitable for that person.

Annex 5

A glossary – a selection of terms from NIOSH (2016)

- **Acclimatisation**: The physiological changes that occur in response to a succession of days of exposure to environmental heat stress and reduce the strain caused by the heat stress of the environment; and enable a person to work with greater effectiveness and with less chance of heat injury.
- **Body Heat Balance**: Steady-state equilibrium between body heat production and heat loss to the environment.
- **Body Heat Balance Equation**: Mathematical expression of relation between heat gain and heat loss, expressed as $S = (M - W) \pm C \pm R \pm K - E$
- **Body Heat Storage**: The change in heat content (either + or –) of the body.
- **clo**: A unit expression of the insulation value of clothing. A clo of 1 is equal to the insulation required to keep a sedentary person comfortable at 21°C (~70°F).
- **Convective Heat Transfer**: The net heat exchange by convection between an individual and the environment.
- **Evaporative Heat Loss**: Body heat loss by evaporation of water (sweat) from the skin, expressed as kcal or W.
- **Evaporative Heat Transfer**: Rate of heat loss by evaporation of water from the skin or gain from condensation of water on the skin, expressed as kcal·h-1, W·m-2, or W.
- **Heat Cramp**: A heat-related illness characterised by spastic contractions of the voluntary muscles (mainly arms, hands, legs and feet), usually associated with restricted salt intake and profuse sweating without significant body dehydration.
- **Heat Exhaustion**: A heat-related illness characterised by elevation of core body temperature above 38°C (100.4°F) and abnormal performance of one or more organ systems without injury to the central nervous system. Heat exhaustion may signal impending heat stroke.
- **Heat Index or Humidex**: examples of 'apparent temperature' or 'feels like' indices. Both take into consideration combinations of temperature and relative humidity to assess what it feels like to our bodies. They apply when temperatures are above +27°C and are calculated for shady areas.
- **Heat Strain**: The physiological response to the heat load (external or internal) experienced by a person in which the body attempts to increase heat loss to the environment in order to maintain a stable body temperature.
- **Heat Stress**: The net heat load to which a worker is exposed from the combined contributions of metabolic heat, environmental factors and the clothing worn which results in an increase in heat storage in the body.

- **Heat Stroke**: An acute medical emergency caused by exposure to heat from an excessive rise in body temperature [above 41.1°C (106°F] and failure of the temperature-regulating mechanism. Injury occurs to the central nervous system characterised by a sudden and sustained loss of consciousness preceded by vertigo, nausea, headache, cerebral dysfunction, bizarre behaviour and excessive body temperature.
- **Heat Syncope**: Collapse and/or loss of consciousness during heat exposure without an increase in body temperature or cessation of sweating, similar to vasovagal fainting except that it is heat induced.
- **Heat Tolerance**: The physiological ability to endure heat and regulate body temperature at an average or better rate than others, often affected by the individual's level of acclimatisation and physical conditioning.
- **Humidity**: In humid conditions, the air feels much hotter because less perspiration evaporates from the skin. It is mostly expressed by relative humidity (RH), the ratio of the water vapour present in ambient air to the water vapour present in saturated air at the same temperature and pressure.
- **Hyperpyrexia**: A body core temperature exceeding 40°C (104°F).
- **Hyperthermia**: A condition where the core temperature of an individual is higher than 37.2°C. Hyperthermia can be classified as mild (37.2-38.5°C), moderate (i.e. heat exhaustion [38.5-39.5°C]), profound (>39.5°C), or profound clinical (i.e. heat stroke [>40.5°C), and death can occur without treatment (at >45°C).
- **Metabolic Rate**: The amount of chemical energy transferred into free energy per unit of time.
- **Metabolism**: The transformation of chemical energy into free energy that is used to perform work and produce heat.
- **Prescriptive Zone**: The range of environmental temperatures where exercise at a given intensity results in thermal equilibrium, i.e. no change in core body temperature.
- **Qualified Healthcare Professional**: An individual qualified by education, training and licence/regulation and/or facility privileges (when applicable) who performs a professional service within his or her scope of practice in an allied healthcare discipline and independently reports that professional service.
- **Recommended Alert Limit:** The NIOSH-recommended heat stress alert limits for unacclimatised workers.
- **Recommended Exposure Limit (REL):** The NIOSH-recommended heat stress exposure limits for acclimatised workers.
- **Rhabdomyolysis**: A medical condition associated with heat stress and prolonged physical exertion, resulting in the rapid breakdown of muscle and the rupture and necrosis of the affected muscles.
- **Sweating, Thermal**: Response of the sweat glands to thermal stimuli.
- **Temperature, Adjusted Dry Bulb**: The dry bulb temperature is the temperature of the air measured by a thermometer that is shielded from direct radiation and convection.

- **Temperature, Ambient**: The temperature of the air surrounding a body. Also called air temperature or dry bulb temperature.
- **Temperature, Ambient, Mean**: The mean value of several dry bulb temperature readings taken at various locations or at various times.
- **Temperature, Core Body**: The temperature of the tissues and organs of the body. Also called Core Temperature.
- **Temperature, Effective**: Index for estimating the effect of temperature, humidity and air movement on the subjective sensation of warmth.
- **Temperature, Globe**: The temperature inside a blackened, hollow, thin copper globe measured by a thermometer whose sensing element is in the centre of the sphere.
- **Temperature, Mean Body**: The mean value of temperature at several sites within the body and on the skin surface. It can be approximated from skin and core temperatures.
- **Temperature, Mean Radiant**: The mean surface temperature of the material and objects surrounding the individual.
- **Temperature, Mean Skin:** The mean of temperatures taken at several locations on the skin, weighted for skin area.
- **Temperature, Natural Wet Bulb**: Wet bulb temperature under conditions of prevailing air movement.
- **Temperature, Oral:** Temperature measured by placing the sensing element under the tongue for 3 to 5 minutes.
- **Temperature, Radiant**: The point temperature of the surface of a material or object.
- **Temperature, Rectal**: Temperature measured 10 centimetres (cm) into the rectal canal.
- **Temperature, Skin**: Temperature measured by placing the sensing element on the skin.
- **Temperature, Tympanic**: True tympanic temperature is measured by placing the sensing element directly onto the tympanic membrane and recording the temperature. Estimates of tympanic temperature are usually obtained by placing a device into the ear canal close to the tympanic membrane.
- **Temperature Regulation**: The maintenance of body temperature within a restricted range under conditions of positive heat loads (environmental and metabolic) by physiologic and behavioural mechanisms.
- **Thermal Insulation, Clothing:** The insulation value of a clothing ensemble.
- **Thermal Insulation, Effective**: The insulation value of the clothing plus the still air layer.
- **Thermal Strain**: The sum of physiological responses of the individual to thermal stress.
- **Thermal Stress**: The sum of the environmental and metabolic heat load imposed on the individual.
- **Total Heat Load**: The total heat exposure of environmental plus metabolic heat.

- **Universal Thermal Climate Index (UTCI)**: This index takes into account the human thermophysiological significance across the entire range of heat exchange and the applicability of whole body calculations including local skin cooling; it is valid in all climates and seasons.
- **Wet Bulb Globe Temperature (WBGT):** This is an environmental temperature arrived at by measuring dry air temperature, humidity and radiant energy (i.e. usually direct sunlight being absorbed by clothing), used to calculate the thermal load on the person.
- **Work**: Physical efforts performed using energy from the metabolic rate of the body.

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