

Aggravated Occupational Heat Stress Recognition and Mitigation in Slovenia



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Abstract Global warming is strongly reflected in an increase in the number of hot days and, consequently, heat waves—their occurrence over a wider time frame, their duration, intensity and frequency. Changed characteristics were studied at two locations in Slovenia, confirming the increase. The problem of heat stress, health risks and labor productivity loss experienced by workers is well studied in hot locations, but not enough in Europe. Heat stress relies on both environmental and individual factors and it is important to understand how the general public and workers perceive heat risk, since this information may be helpful in preparing or updating heat stress mitigation strategies. Two studies were conducted in Slovenia in the frame of the Horizon 2020 Heat-Shield project, the first analyzing already experienced heat stress symptoms and health issues, productivity loss and self-initiative measures among workers in various sectors (N = 687), and the second investigating workers' knowledge of heat stress, its impact and preventive measures (N = 117). Workplace temperature in a large majority of cases was considered not suitable, negative heat stress impacts were recognized and already experienced. The results of the two studies show the importance of the problem, which is expected to worsen due to climate change, making mitigation of heat stress an unavoidable issue.

Keywords Heat stress · Climate change · Occupational health · Mitigation Workers

1 Introduction

Summertime episodes with extremely high air temperatures, lasting for several days or longer, are often referred to as “heat waves” (Lau and Nath 2012). They are addressed as climatic events, an anomaly of temperature (Pascal et al. 2013) that is short-term and uncomfortable (Zuo et al. 2015). Defining a heat wave is in general a

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problem that is difficult to resolve, involving a choice of thresholds, minimum duration, and possibly various variables (Robinson 2001). Pascal et al. (2013) concluded that the use of the high percentile of the meteorological indicators' distribution would be a good option for defining thresholds when no study of the temperature-mortality relationship has been done.

According to IPCC (2014), the frequency of extreme meteorological events is projected to increase in the future. In Central and Eastern Europe, projected changes in temperature extremes result from changes in both the mean and the shape of probability distributions (Schär et al. 2004). In the Carpathian Region, heat wave events have shown a general increase in the period 1961–2010, in terms of intensity, duration and severity (Spinoni et al. 2015). Extended heatwaves will become more common with rising global mean temperatures and could occur in any country in Europe (Russo et al. 2015). For example, in Eastern Europe, including the European part of Russia, summer 2010 was exceptionally hot and, additionally, eastern European countries have lower adaptive capacity in general than western or northern European countries (IPCC 2014). Morabito et al. (2017) presented study results supporting a call for heat-related mitigation and adaptation strategies, in order to counteract the effects of heat waves in most EU capitals, with priority given to southeastern cities. In addition to the increase in temperature, the population is aging (Pascal et al. 2013). Although the impacts of climate change and heat on public health, the environment and human activities are quite well documented, this cannot be said of the impact on the working population (Adam-Poupart et al. 2013), especially in Europe. Occupational heat stress can be directly associated with productivity losses (Ioannou et al. 2017; Nybo et al. 2017), so the need to analyze heat waves and their impact on workers is even stronger (UNDP 2016; Nybo et al. 2017). Studies of workers in heat conditions in Europe have only recently started in the frame of the Heat-Shield project (Ioannou et al. 2017; Piil et al. 2017; Pogačar et al. 2017): it is becoming clear that heat is already a problem for European workers in agriculture, industry and other sectors.

Heat impacts on workers' health and productivity can be direct or indirect. In general, exposure to high environmental temperatures causes an increase in body temperature; an increase of body temperature from 38 to 39 °C increases the risk of exhaustion and symptoms of heat stress occur (Adam-Poupart et al. 2013). Heat stroke mainly occurs when the body temperature reaches 40 or 41 °C (LoVecchio et al. 2007). Indirect impacts mean higher risks of injuries due to reduced attention and fatigue. Physical discomfort may cause a change of emotional state, such as inexplicable anger leading to a lower level of work safety (Tawatsupa et al. 2010). Dehydration can cause reduced cognitive, visual and motoric abilities, short-term memory and attention (Adam-Poupart et al. 2013).

The aim of this research was first to examine the occurrence of heat waves in Slovenia leading to aggravated occupational heat stress and, secondly, to analyze the state of heat stress recognition and self-mitigation among workers in Slovenia. It can serve as an example for other European countries with similar climate and working conditions.

2 Methods and Material

2.1 Heat Wave Analysis

A new general definition of heat wave has been in use in Slovenia since 2017 (before there was no common definition), defining three different thresholds of daily average temperature, depending on the climate of the area (classification in Kozjek et al. 2017): for a wet or moderate climate in a hilly region the threshold is 22 °C, for the subcontinental region 24 °C, and for the submediterranean region 25 °C. Thresholds approximately correspond to the 96th percentile for the period 2006–2015 or to the 97th percentile for the period 1986–2015. A heat wave occurs if the threshold is reached on at least three consecutive days. The definition was confirmed in agreement with the Slovenian Environment Agency, University of Ljubljana, National Institute of Public Health and other contributors. An analysis of heat waves was carried out for meteorological stations in Bilje and Celje (in the vicinity of part of two surveys), based on the aforementioned heat wave regulations. Average daily air temperature data were collected from the archive of the Slovenian Environment Agency. Heatmaps were modeled in Python programming language, days with higher temperatures are colored darker on these maps.

2.2 Surveys Among Workers

The first survey was conducted in the summer and autumn of 2016 among 687 workers, investigating their workplace (Fig. 1) heat load, heat stress symptoms and health problems experienced, and preventive measures taken within the company or by themselves. There were 400 workers from industry (factory producing rear automotive lights) near Celje, 230 farmers (not necessarily full time), and 57 tourist guides, both of the latter from all over Slovenia. Men prevailed among farmers (62%), and women in the other two sectors (65% in industry, 52% among tourist guides). One-fifth of all workers were above 50 years old .

The second survey was conducted in the summer of 2017 among 117 workers working in hot conditions inside (industry: 45 workers) or outside (agriculture: 29, construction: 19, tourism: 18, transport: 6; Fig. 2). Workers were asked about their knowledge of heat stress warnings, symptoms, and their own sensitivity. Among them, 30% were older than 50 years. Answers were analyzed using SPSS tools for statistical analysis.



Fig. 1 Workplace in factory near Celje, and a typical working place for a tourist guide in Ljubljana, where part of the first survey was conducted



Fig. 2 Outside workplace in agriculture (Bilje) and construction site (Ljubljana), where part of the second survey was conducted

3 Results and Discussion

3.1 Heat Wave Presentation for Bilje and Celje

The analysis of heat waves in the period 1981–2015 (Fig. 3) shows the distinctive characteristics of both locations: Bilje in southwestern Slovenia in the submediterranean region, and Celje in northeastern Slovenia in the continental region. Although the threshold for a heat wave is set 1 °C higher in Bilje, the prevalence of heat waves in all their characteristics in comparison with Celje is impossible to overlook. However, it is even clearer in Celje that the frequency of heat waves is increasing. Since 1998 there has been at least one heat wave every year except 2009 and 2014; before that, years with heat waves were very rare (1988, 1992, 1993, 1994). It can be seen in both locations that heat waves have started to occur earlier in recent years, from the beginning of June and, especially in Bilje, they occur even in late August (and September—not shown in the Figure). Heat waves are becoming longer and more intense—reaching higher air temperatures.

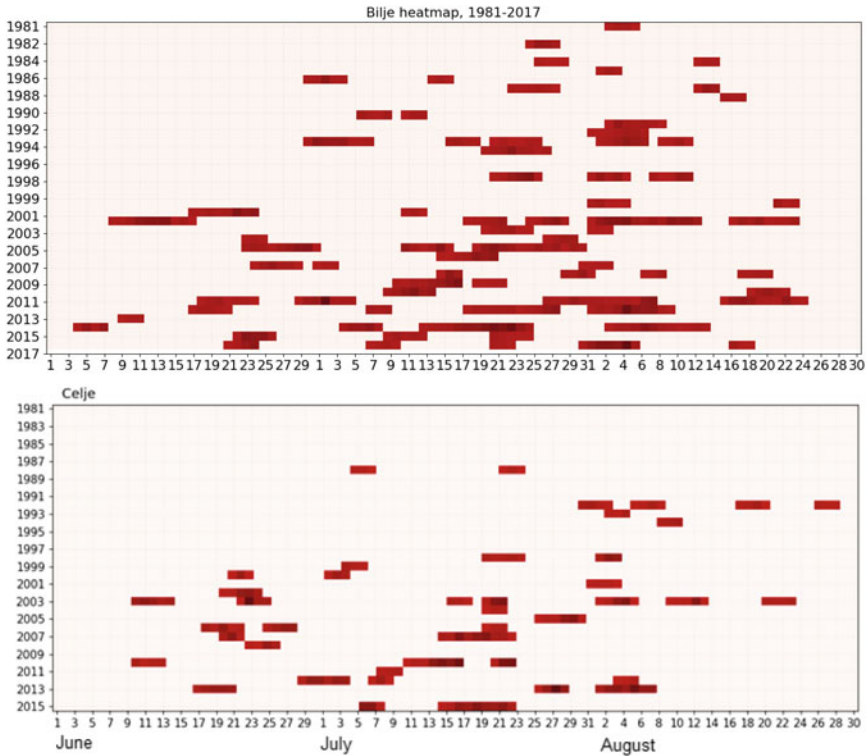


Fig. 3 Heat wave map for Bilje (upper) and Celje (lower) stations from 1 June to 31 August in the 1981–2015 period (days of heat wave are colored, higher temperatures are darker)

These findings are in agreement with those of the Slovenian Environment Agency (ARSO 2017), where analyses of climate change in Slovenia show a statistically significant increase in mean air temperature and the number of hot days. According to Kuglitsch et al. (2010), the intensity, length and number of heat waves in the eastern Mediterranean have increased by a factor of 6–8 since the 1960s.

3.2 Heat Stress Impact in Various Workplaces

The first survey showed that thermal comfort was worst in the factory. Working conditions during heat waves were very hot for 45% employees, and hot for 20%. Working temperatures could be as high as 35 °C. Working outside during heat waves felt very hot for 27% and hot for 36% of agricultural workers. Negative impacts of heat stress in current conditions were already reported, with no significant differences related to the age of workers. The impact on well-being and concentration was most perceived

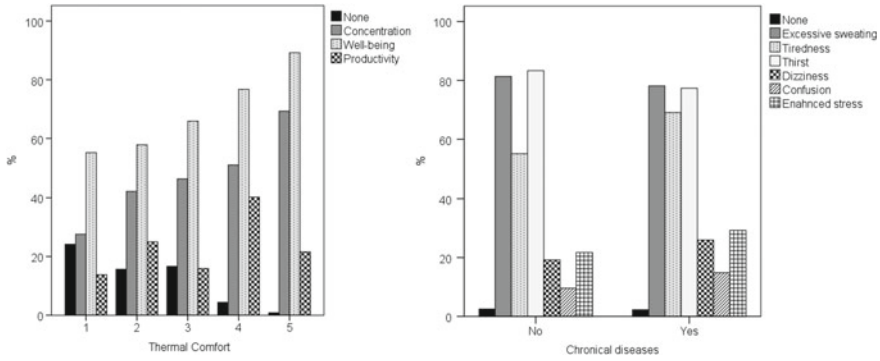


Fig. 4 Left: negative impact of heat stress at workplace in relation to thermal comfort (1—neither warm nor cool, 2—slightly warm, 3—warm, 4—hot, 5—very hot; productivity only assessed by farmers); right: perceived symptoms of heat stress during work in summertime in relation to workers with and without a chronic disease

by industrial workers (more than 75 and 67%, respectively), followed by tourist guides (72 and 44%, respectively), and farmers (68 and 34%, respectively). Negative impact on productivity was only assessed by farmers (experienced by 68%), since workers in industry have to maintain norms and productivity is difficult to define for tourist guides. However, 17% of tourist guides described their working abilities during heat waves to be reduced by more than 30%. Workplace heat causing significant labor loss was confirmed in Europe for grape-pickers in Cyprus (Ioannou et al. 2017). The more uncomfortable the workers were at their workplace, the higher the noticeable impact of heat waves (Fig. 4 left). The connection is quite straightforward, except for the impact on productivity, which was obviously not easy to assess for agricultural workers. Piil et al. (2017) showed that heat per se has little impact on simple motor or cognitive test performance but complex motor performance is impaired, especially when multiple tasks are combined.

Symptoms of heat stress were perceived by the great majority, especially milder symptoms such as thirst (79%), excessive sweating (79%) and tiredness (65%), and in a smaller proportion enhanced stress (27%), dizziness (24%) and confusion (13%). Only 2% of all workers stated that they had not perceived any kind of heat stress symptoms. There were no statistically significant differences between younger and older workers, but most symptoms were more pronounced among women than men. Having a chronic disease appears to make workers more sensitive to tiredness, dizziness, confusion and enhanced stress (Fig. 4 right). Further work at high temperatures without additional measures to mitigate heat stress can lead from basic heat stress symptoms to more serious heat-induced health problems. The most prevalent symptoms already experienced by workers were exhaustion (57%) and headache (53%) and, to a much smaller extent, nausea or vomiting (17%), prickly heat (12%), fainting (7%), muscle cramps (5%) and heat cramps (1%), while only one person had suffered

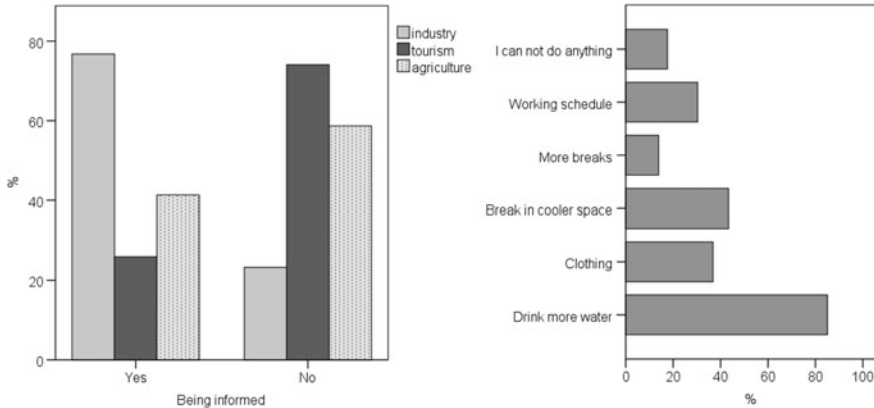


Fig. 5 Left: Answers of workers to the question of whether they had been informed about heat stress impacts; right: how they could reduce exposure to heat stress (option ‘more breaks’ was not available for industry)

heat stroke. Chronic diseases have the highest impact on heat-induced headache and nausea or vomiting.

Even though problems due to heat stress obviously exist, information on heat stress impacts and possible measures at the workplace are not easy to find. The highest share of workers informed about heat stress was in the factory (77%). Awareness was much lower among farmers (41%) and tourist guides (26%), since they both work as self-employed (Fig. 5 left). On the other hand, despite being poorly informed, workers try their best to protect themselves when they start to feel the first heat stress symptoms that they can recognize on their own. There were no statistically significant differences between men and women, nor younger and older workers about taking precautionary measures. Eighteen percent of workers claim that they cannot do anything to reduce heat stress (Fig. 5 right). Factory workers have the duty to follow regulations in terms of clothing, working schedule and number of breaks. Only small variations are allowed. Workers in agriculture can be most flexible about the working schedule, but there are still some tasks that cannot be rescheduled. The majority of workers try to drink more water (85%). Increased fluid intake was also the most frequently reported protective measure in other observational studies (Cuesta et al. 2017; Van Loenhout and Guha-Sapir 2016).

In the first study, 37% of workers did not feel that heat stress has been getting worse in recent years. The others recognized changes and related them to climate change (42%), their own aging (15%) and/or change of their workplace (11%). In the second study, workers were more convinced; 81% of them said that temperature has been increasing lately and 11% were not sure. A solid majority (89%) of those that said temperature is not increasing described themselves as not at all sensitive to heat (Fig. 6 left). On the other hand, the largest share (45%) of those who have noticed a temperature increase, feel that they are partly sensitive to heat; a similar

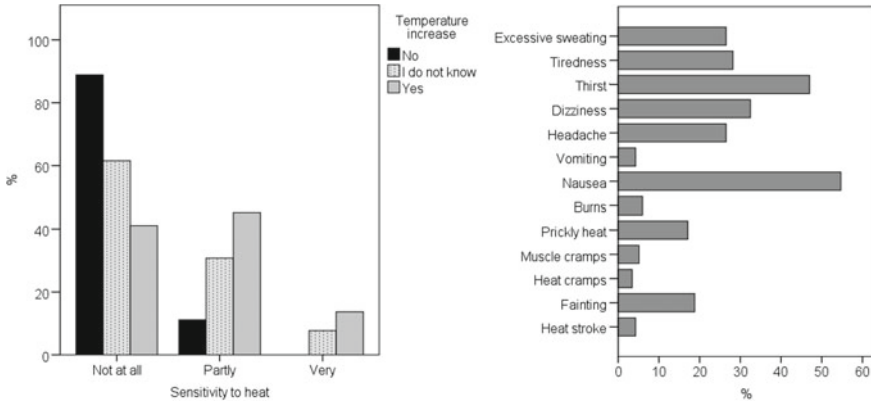


Fig. 6 Left: Opinion on temperature increase in the last years in relation to self-assessed sensitivity to heat; right: knowledge of heat stress symptoms and heat-induced diseases (no options were available, workers needed to list them)

share (41%) not at all and a minority (14%) very sensitive. Only 12% of all survey contributors described themselves as very sensitive to heat.

In the second study, knowledge was analyzed and not personal experiences. Workers had to list heat stress symptoms or heat-induced diseases without being given possible options (Fig. 6 right). The largest proportion were aware of nausea (47 and thirst (40%), followed by dizziness (27%), tiredness (24%), excessive sweating (22%) and headache (22%), fainting (16%) and prickly heat (15%). Only a few recalled vomiting, muscle and heat cramps, or heat stroke.

In the first study, mainly workers in industry were informed about heat stress prevention measures. In contrast, in the second study mainly workers from agriculture and construction sector claimed to have knowledge about them (Fig. 7 left). The highest shares of workers would think of drinking more water during heat stress at the workplace (67%), wear more appropriate clothes (44%), take a break in a cooler space (26%), try to change working schedule (16%) or take more breaks (13%). Similar results about knowledge of protective measures were found for Brussels and Amsterdam (Van Loenhout and Guha-Sapir 2016) and Lisbon and Madrid (Cuesta et al. 2017).

4 Conclusion

Heat waves are becoming more frequent, and their intensity and duration are increasing. Although the changed summer conditions were shown only for two locations in Slovenia, the same can be expected everywhere with similar climatic conditions. Aggravated occupational heat stress is an inevitable consequence of global warming, and Europe is not an exception.

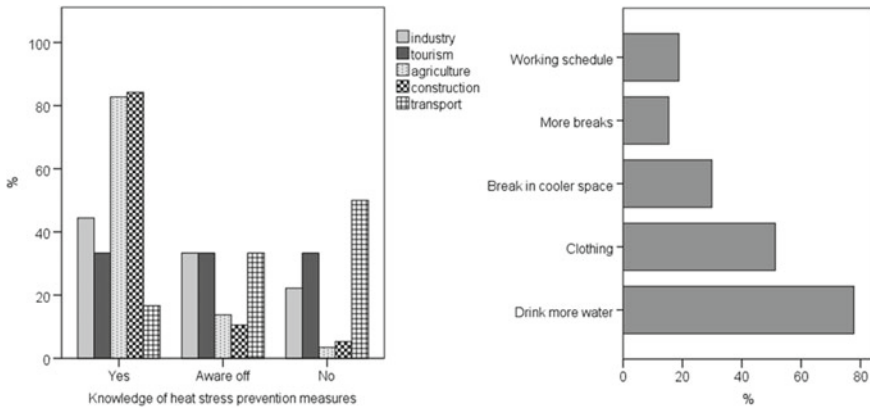


Fig. 7 Left: Knowledge of the existence and content of heat stress prevention guidelines at work; right: knowledge of possible heat stress prevention measures (no options were available, workers needed to list them)

Negative impacts of heat stress have already been reported in current conditions. The impact on well-being and concentration was most perceived by industrial workers. A large proportion perceived symptoms of heat stress and heat-induced illness, especially thirst, excessive sweating, tiredness, exhaustion and headache. Almost one-fifth of workers complained that they cannot do anything to reduce heat stress, others mainly try to drink more water. In the first study, slightly fewer than half of the workers had observed worse thermal conditions recently and related them to climate change, while in the second study almost twice as many. In the second study, in connection with heat workers were mainly aware of nausea, thirst, dizziness, tiredness, excessive sweating and headache. The highest share of workers would consider drinking more water during heat stress at the workplace, followed by wearing more appropriate clothes, and taking a break in a cooler space.

The main limitation of the second study was the small groups of workers in transport, construction and tourism included in the analysis. In the first study there was even an absence of workers in transport and construction. These are certainly very important sectors dealing with occupational heat stress and should be studied in the future. Furthermore, studies should be extended to a broader geographical area.

The first phase of the 5-year Heat-Shield project is finishing, recognizing heat wave conditions in Europe and occupational heat stress impacts, preparing projections and vulnerability maps. It is of great importance additionally to address less knowledgeable or more vulnerable groups when heat-awareness national plans are implemented. In the next phase, the Heat-Shield project will provide a warning system for individual workers, employers, companies and other stakeholders, and develop possible solutions with assessed efficiency for various sectors.

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