**Climate change, heat stress and work: epidemiology and associated costs.**

Authors: Alessandro Marinaccio1, Michela Bonafede1, Marco Morabito2 and Worklimate working group

1 Italian National Institute for Insurance against Injuries at Work (INAIL), Rome, Italy

2 Institute of Bioeconomy, National Research Council (IBE-CNR), Florence, Italy

According to the World Health Organization, between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from malnutrition, malaria, diarrhoea, and heat stress alone, and the direct damage costs to health are estimated to be between US$ 2–4 billion per year by 2030 [1]. Increasing heat stress due to climate change is directly harming the health of workers, especially those employed in outdoor sectors, such as agriculture, mining, and construction, but also indoor workers without access to cooling. Furthermore, there is clear evidence that heat stress negatively affects labour supply, productivity, and capacity in most countries across the globe. According to the recent International Labour Organization (ILO) report, 231 million workers were globally exposed to heatwaves in 2020, and 4,200 workers lost their lives. Improved safety and health measures to prevent injuries from excessive heat in the workplace could save up to US$361 billion in lost income and medical treatment expenses and the heat stress affected global regions differently.

The looming threat of climate change’s effects on work has been recently identified as one of the substantial emerging challenges in the occupational health and safety field of research and the need of adaptation measures for protecting workers has been highlighted5. Occupational climate related hazards can be synthetized as increased exposure to high temperature, air pollution, ultraviolet radiation, extreme weather events and vector-borne diseases [2], and the prevention strategies for reducing the heat waves impacts on workers’ risk of injuries and diseases are crucial [3]. Systematic reviews of epidemiological studies and meta-analyses have identified the outdoor workers as the most vulnerable group and the International Labor Organization enhanced the need for health programs and actions to preserve the health of workers in extreme hot environments [4].

Recently, the report of Lancet Countdown provides evidence of 470 billion potential labour hours lost globally in 2021 due to heat exposure, with income losses equal to 0.72% of the global economic production. Heat exposure at workplaces has a large effect on labour productivity and the change in labour capacity has been fixed as one of the parameters (indicator 1.1.4) for monitoring the changing health profile and climate change effects [5]. Furthermore, the total cost of work injuries includes wage, productivity and gross domestic product losses, but also medical and insurance expenses, as social costs for the communities. The need of tools to better quantify the co-benefits of climate action to support the decision-making process, has been highlighted, considering the full benefits of policies that touch on the climate change agenda, but few studies focused on the loss of labour productivity during the hottest periodsand the declination of co-benefits of climate change adaptation in the occupational field still lacks. In Italy, a country greatly involved in the climate change adaptation challenge, the relative risk of occupational injury due to the exposure to extreme heat at workplaces has been estimated 1.09 (95% CI 1.07 to 1.12) with an attributable number of work-related injuries of 4,016 per year and the occupational exposure to extreme temperatures is a real concern, especially for agriculture and construction workers [6-8].

According to the epidemiological findings, an occupational surveillance system for providing a heat warning framework during days potentially stressful for workers due to heat-stress and identifying territories and vulnerable occupational groups has been developed in the framework of Worklimate 2.0 research project (a synergy between Italian national institute against injuries at work and the Italian national research council), using the Wet Bulb Globe Temperature (WBGT) index, and a meteorological deterministic model (MOLOCH) [9]. The spatial and temporal resolutions of the model are of 2 km and 72 hours, respectively. The forecasts are at four time (8:00 and 12:00 am; 4:00 and 8:00 pm) and the percentage ratio between the predicted WBGT and the WBGT threshold of a standard worker (175 cm tall, 75 kg weigh) provides the predicted heat-risk level, modulated by the intensity of physical activity and the modalities of the exposure to solar radiation. Based on these results, during the summer of 2024 in correspondence with intense and early heat waves, the public health authorities in 15 regions forbidding the working activities in agriculture, constructions and other economic sectors in the areas identified by the Worklimate project, as at high heat risk level according to a national warning system, based on weather forecasts and WBGT index. These public health measures have impacted more than 20 million inhabitants. The development of an occupational surveillance system able to provide a heat warning framework during days with potentially stressful conditions for workers due to heat, which identifying territories and vulnerable occupational groups, must be considered as a priority, considering climate change scenarios.

Economic losses due to extreme temperatures were computed as total and as separate components for cold and heat in Spain, which estimated a total annual cost of 366 million of Euros, most of them associated with costs of pain and suffering associated with the level of disability due to accidents occurred under heat exposure. Borg and colleagues estimated the economic costs of illness and injuries associated with the heatwaves in Australia, quantifying $AU4.3 million, annually. There is a need to evaluate the compensation payments per year due to heat related occupational injuries, including the management and personnel costs, connected to the public insurance system, the health, familial, social costs and undirect losses of the national gross domestic product caused by days of leave. The implementation of prevention measures could have not only a health impact but also an economic one.

The impact of heat temperature and heatwaves on injuries risk has been repeatedly confirmed. Considering the climate change scenario, the need of actions to protect workers health and safety is a public health priority. There is a range of low cost and available measures which must be considered, such as assured access to drinking water in workplaces, frequent rest breaks in shady/cool places, availability of adequate protective equipment (ventilation jackets or cooling garments) and consider rescheduling work activities, preferring cooling periods of the day for more demanding tasks. The prevention measures and the adaptation strategies for contrasting the occupational exposure to extreme temperatures can contribute to contain both the risk of injuries and both to avoid the productivity loss in a co-benefit perspective.

References

[1] World Health Organization. Climate change and health. Published October 30, 2021. Accessed July 11, 2023. Available at https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

[2] Schulte PA, Bhattacharya A, Butler CR, Chun HK, Jacklitsch B, Jacobs T, Kiefer M, Lincoln J, Pendergrass S, Shire J, Watson J, Wagner GR. Advancing the framework for considering the effects of climate change on worker safety and health. J Occup Environ Hyg. 2016 Nov;13(11):847-65. doi: 10.1080/15459624.2016.1179388. PMID: 27115294; PMCID: PMC5017900.

[3] UNDP, 2016. Climate change and labor: impacts of heat in the workplace. Available at: http://www.undp.org/content/undp/en/home/librarypage/climate-and-disasterresilience-/tackling-challenges-ofclimate-change-and-workplace-heat-for-dev.html, Accessed date: 14 December 2023.

[4] INTERNATIONAL LABOUR OFFICE (ILO), The role of the ILO in addressing climate. Governing Body, 338th Session, Geneva, 12–26 March 2020 GB.338/POL/1, Policy Development Section Employment and Social Protection, 24 February 2020. Available at: <https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---relconf/documents/meetingdocument/wcms_736774.pdf>

[5] Romanello M, Di Napoli C, Drummond P, et al. The 2022 report of the Lancet Countdown on health and climate change: health at the mercy of fossil fuels. Lancet. 2022 Nov 5;400(10363):1619-1654. doi: 10.1016/S0140-6736(22)01540-9.

[6] Marinaccio A, Scortichini M, Gariazzo C, et al. Nationwide epidemiological study for estimating the effect of extreme outdoor temperature on occupational injuries in Italy. Environ Int. 2019 Dec;133(Pt A):105176. doi: 10.1016/j.envint.2019.105176. Epub 2019 Oct 22. PMID: 31654985.

[7] Gariazzo C, Taiano L, Bonafede M, et al. Association between extreme temperature exposure and occupational injuries among construction workers in Italy: An analysis of risk factors, Environment International, Volume 171, 2023, 107677, <https://doi.org/10.1016/j.envint.2022.107677>.

[8] Di Blasi, C.; Marinaccio, A.; Gariazzo, C.; et al. Effects of Temperatures and Heatwaves on Occupational Injuries in the Agricultural Sector in Italy. Int. J. Environ. Res. Public Health 2023, 20, 2781.

[https://doi.org/10.3390/ijerph20042781](https://doi.org/10.3390/ijerph20042781%20%20%20%20%20%20%20%20)

[9] Research project Worklimate 2.0. Available at [www.worklimate](http://www.worklimate).it (last access August, 9, 2024)