Bulletin n°29

Veille thermique
Période : août 2025

Objectifs :

L'INRS est de plus en plus sollicité sur des questions concernant les activités en entreprise par forte chaleur : les activités en extérieur, l'été en période de canicule, mais aussi les activités en intérieur, dans des lieux aux conditions thermiques extrêmes. L'objectif de cette veille est de se tenir informé sur ces thématiques, dans une période où la problématique thermique croît avec les changements climatiques.

La bibliographie extraite de la base de données INRS-Biblio, permet la consultation des ressources en version PDF.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Sommaire :

EPI, matériaux protecteurs/refroidissants

Ambiance thermique chaude

X. F. Jiang, X. Q. Li, H. B. Zhang, Z. L. Hu, S. Y. Jia, G. W. Meng, P. C. Hsu, W. L. Guo and Z. H. Zhang.

Sweat-sensitive adaptive warm clothing.

SCIENCE ADVANCES. 2025;11(33).

https://doi.org/10.1126/sciadv.adu3472

Thermal regulation in warm clothing is essential for enhancing human comfort in cold environments. However, traditional warm clothing lacks the ability to adapt to dynamic changes in the human body's microenvironment. Here, we present an adaptive warm cloth, featuring a filling made of a natural bacterial cellulose membrane that responds to human sweating. The cloth's thickness automatically adjusts from 13 millimeters (under low humidity and no sweating conditions) to 2 millimeters (under high humidity and sweating conditions), expanding the thermal regulation capability by 82.8% compared to traditional warm clothing with an unchanged thickness of 13 millimeters. Modeling results further suggest that deploying this adaptive warm clothing across 20 cities in China could extend the duration of the no thermal stress zone by an average of 7.5 hours. Combining exceptional thermal regulation, high stability, and scalability, this clothing represents a notable supplement to existing thermal management technologies.

Ambiance thermique froide

Y. Z. Qian, M. Q. Yuan, K. Yan, Y. Y. Li, X. F. Wang and H. Wu.

Effects of emergency rescue clothing on wearers' physiological and perceptual responses in hot-humid environments.

FRONTIERS IN PUBLIC HEALTH. 2025;13.

https://doi.org/10.3389/fpubh.2025.1648763

Introduction To improve the work efficiency and reduce heat-related illness of emergency rescue personnel, the effects of emergency rescue clothing on physiological and perceptual responses were investigated.Methods Thirteen participants were recruited to perform human trials in a climate chamber wherein the ambient temperature and relative humidity was controlled at 35 degrees C and 75%, and 25 degrees C and 65%, respectively. Moreover, participants wearing emergency rescue clothing (ERC group) and T-shirts and shorts (CON group) walked at 4 and 6 km/h on a treadmill. During the trials, physiological responses and subjective responses were obtained, and then physiological strain index (PSI) and perceptual strain index (PeSI) were calculated.Results The results showed significant differences between the ERC and the CON in parameters such as core temperature, mean skin temperature, heart rate, PSI, although some data differences were slightly. There was a positive correlation between PeSI and PSI, as well as between mean skin temperature and thermal sensation vote, with R values of 0.93 and 0.94 (ERC), respectively.Discussion Correlation analysis shows that PeSI had a potential to predict PSI. This study can replace complex and cumbersome physiological indicators by calculating the perception indicators of emergency response personnel working on site, promoting the development of the safety industry engaged in certain intensity physical labor in humid and hot environments.

B. B. Hu, L. Y. Xu, Y. W. Zuo, C. S. Tang and X. H. Li.

Heat transfer simulation and parametric design for firefighter protective clothing under high heat exposure.

JOURNAL OF INDUSTRIAL TEXTILES. 2025;55.

https://doi.org/10.1177/15280837251369753

The purpose of this study was to investigate the heat transfer of fire-resistant fabric and to propose an objective-driven optimization approach for parametric design. A finite volume method (FVM) model was developed to predict the thermal response within the fabric-air gap-skin system under flash fire exposure. Parametric correlations were conducted to identify crucial variables, and optimization designs were performed using surrogate models combined with non-dominated sorting genetic algorithm II (NSGA-II) based on numerical simulations. The results demonstrated that the numerical model accurately predicted the skin temperature with a relative error of 5.0% for single-layer fabrics and 1.8% for muti-layer combinations. Fabric thickness was the dominant parameter affecting skin burns, followed by air gap width and thermophysical properties. Emissivity and transmissivity were not significantly correlated with second-degree burn time. Multi-objective optimization revealed an optimal configuration for single-layer fabric: a 22.0% increase in thickness and a 20.0% increase in porosity, which extended second-degree burn time by 32.1% without compromising weight efficiency. Additionally, textiles with a thickness of 1.38 mm (MB) and a volumetric heat capacity of 1.16x106 J/(m3 K) (TL) exhibited considerable potential for high thermal protection and lightweight design. Research findings in this study will provide a novel approach for intelligent optimization of firefighter protective clothing, and the proposed methodology can also be extended to the development and multifunctional applications of industrial textiles.

W. Pennington, Y. Martinez, K. Hobbs-Murphy, J. Rosecrance and M. Valley.

The Most Important Thing is to Know What to Wear When Working in the Sun.

JOURNAL OF AGROMEDICINE. 2025;30(4):692-700.

https://doi.org/10.1080/1059924X.2025.2540576

Objective: Crop workers face increasingly hot working conditions. Wearing light-colored, single-layer breathable clothing and wide-brimmed hats, on top of having water, rest, and shade, can reduce the risk of heat illness among crop workers. Clothing preferences and limited access may prevent crop workers from wearing optimal work apparel. However, little is known about crop workers' workplace clothing preferences or their clothing acquisition barriers (e.g., access to retailers, cost). This qualitative study aimed to document Spanish-speaking crop workers' ideal work clothing and understand the primary barriers that prevent them from wearing clothing that reduces heat-related illness risk.MethodsFour focus groups were conducted in Spanish on vegetable farms in Colorado during August and September 2023. Two researchers thematically analyzed qualitative focus group data.ResultsThere were 54 Spanish-speaking crop workers who participated in focus groups during August and September 2023. Findings show participants know which work clothing options protect from heat-related illnesses. Participants purchased their work clothes primarily at second-hand stores. They preferred clothes made of light but durable materials and complete pieces that cover the head, neck, and trunk with long sleeves and pants that facilitate movement. Barriers to wearing worker-defined ideal clothing described include costs and the difficulty in finding the specific style of clothing at their preferred retail outlets. Participants described an interest in partnering with employers to purchase ideal clothing to prevent heat-related illness.ConclusionSpanish-speaking crop workers have

a clear understanding of ideal work clothing and the link between clothing and heat illnesses prevention. However, based on thematic analysis of focus groups with crop workers in Colorado, cost and access to ideal clothing are the biggest barriers. Strategies that facilitate access to appropriate clothing for working in hot environments and involvement of employers in apparel choice are potential methods to promote worker safety and reduce the risk of heat-related illnesses among agricultural farmworkers.

Maladies liées à la chaleur

M. T. Esfahani, I. Awolusi and Y. Hatipkarasulu.

Examining the Influence of Heat Stress Prevention Training on the Knowledge and Health-Related Behavior of the Construction Workforce.

JOURNAL OF STRUCTURAL DESIGN AND CONSTRUCTION PRACTICE. 2025;30(3).

https://doi.org/10.1061/JSDCCC.SCENG-1658

Although several research studies have investigated heat stress prevention in the construction industry, a limited number of studies have examined the efficacy of heat stress training interventions in enhancing heat-related knowledge and the resultant effects on the construction workforce's heat-related behavior. This study evaluated the impacts of heat stress and heat-related illnesses (HRIs) prevention training on heat-related knowledge and perception improvement of the construction workforce and examined its effect on their health-related behavior based on the Health Belief Model (HBM). A total of 164 participants were trained in 10 training sessions, and assessments were administered before and after training. Learning objectives (LOs) and a total of 18 questions were designed to address the research hypotheses developed based on HBM determinations, which were to (1) learn and perceive susceptibility by understanding heat stress risk factors and heat-related hazards; (2) learn and perceive severity through the awareness of HRIs, their symptoms, and possible outcomes (such as dying from heat stroke); (3) learn and perceive the benefits of taking action, and how easy it is to reduce heat-related hazards (such as by drinking cold water); and (4) learn the heat stress and HRI prevention options and use them to take healthy actions. Statistical analysis, including paired Student's t-tests, revealed significant improvements in knowledge for Determinations 1, 3, and 4, whereas Determination 2 had no significant change. Overall, there was a substantial increase in heat-related knowledge ($p<0.001$, effect size=0.635), highlighting the training's positive impact on the improvement of health-related behavior. A further emphasis on instructing trainees to perceive the severity of heat stress and HRIs is necessary to ensure that training effectively enhances health-related behavior. These findings offer novel insights into the effectiveness of heat stress prevention training in enhancing health-related behavior through improved knowledge and perception.

S. Y. Chen, Y. F. Liu, Y. Y. Yi, Y. L. Zheng, J. Yang, T. T. Li, T. C. Chan, R. Duan, S. J. He and C. Guo.

Long-term impacts of heatwaves on accelerated ageing.

NATURE CLIMATE CHANGE. 2025;15(9).

https://doi.org/10.1038/s41558-025-02407-w

Climate change and population ageing are both urgent global challenges. Yet the interaction between these, such as associations between long-term exposure to heatwaves and biological age acceleration (BAA), is unclear. Here we analysed data from 24,922 adults in a longitudinal cohort in Taiwan (2008-2022) and used linear mixed models to show heatwaves accelerate ageing. Heatwaves were defined using both relative and absolute thresholds. BAA was calculated as the difference between biological and chronological age. Each interquartile range increase in the cumulative exposure to heatwaves was associated with a 0.023- to 0.031-year increase in BAA. Moreover, the participants demonstrated gradual adaptation to heatwave impacts over the 15-year period. Furthermore, manual workers, rural residents and participants from communities with fewer air conditioners were more susceptible to the health impacts. This study highlights the need for targeted policies and interventions to strengthen adaptive capacity, delay ageing and promote healthy ageing.

M. Y. Cheng, Q. T. Vu and L. K. Yang.

Multidimensional fall risk assessment for the real-time monitoring of construction site Worker safety.

INTERNATIONAL JOURNAL OF CONSTRUCTION MANAGEMENT. 2025.

https://doi.org/10.1080/15623599.2025.2546018

The construction industry has a significantly higher risk of fatal accidents than other sectors. According to the 2024 Taiwan Safety and Health Administration report, falls account for 60.04% of all construction-related incidents. These accidents often result from working at heights, particularly on platforms or near unprotected openings. While interventions focus on physical safety, they often overlook worker's mental and physiological conditions. Factors such as mental fatigue, reduced concentration, and excessive heat exposure significantly increase accident risk. This study develops a fall risk assessment model tailored to construction, integrating three key factors: area risk, psychological fatigue, and physiological stress. Area risk is determined using historical accident data and Building Information Modeling (BIM) to identify high-risk zones. Psychological fatigue is assessed through brainwave analysis using Fourier transform, while physiological stress is evaluated based on the US National Institute for Occupational Safety and Health (NIOSH) heat stress guidelines, incorporating Wet Bulb Globe Temperature (WBGT) and heart rate data. By combining these dimensions, the model generates a real-time fall risk matrix, allowing proactive risk management and reducing fall accidents on construction sites.

J. Friedrich, T. S. Schick, F. Mess and S. Blaschke.

Wearable device-based interventions in heat-exposed outdoor workers - a scoping review and an explanatory intervention model.

BMC PUBLIC HEALTH. 2025;25(1).

https://doi.org/10.1186/s12889-025-24262-2

Background: Global climate change poses a challenge to the health prevention of heat-exposed outdoor workers. Interventions with mobile or wearable devices monitoring physiological and environmental parameters may be one solution to maintain and promote their health. Based on the recognized potential of wearables in mitigating heat stress, a detailed analysis of the contextual factors, mechanisms, and outcomes of wearable device-based interventions is lacking. A scoping review was carried out to address the objectives of contextual analysis, fundamental mechanisms, and an assessment of outcomes to propose an explanatory intervention model based on the findings.MethodsWeb of Science and PubMed databases were searched by search strings related to (1) wearables (2), outdoor workers, and (3) heat stress. Study characteristics and relevant data regarding the context-mechanism-outcome configurations were extracted and analyzed.ResultsOut of 410 articles detected, 19 publications were eligible for in-depth review. Wearables are well-accepted for the prevention of heat stress symptoms. By recording relevant indicators, i.e., heart rate and temperature, real-time health alerts can be issued as risk-based early warnings, and personalized feedback or recommendations towards behavior adaptation can be generated. A high risk of occupational heat stress was identified for construction, agriculture, and groundwork workers. Heat-exposed outdoor workers were mainly young to middle-aged males and often overweight or obese, with increased heart and breathing rates in hot work environments. Wearable device-based interventions are particularly effective if a mindset of safety culture is present in the workplace and environmental health literacy is promoted to increase heat risk awareness and willingness to change

work health behavior.ConclusionBased on these findings, we developed an explanatory intervention model. This model draws on well-established frameworks, theories, and models. It helps to identify, describe, and explain what works, for whom, and under what circumstances in the context of wearable usage in heat-exposed outdoor workers. Incorporating environmental health literacy and precision prevention in occupational health approaches with continuous monitoring of environmental and physiological parameters will allow for real-time, tailored feedback, leading to more effective heat stress prevention.

Outils et capteurs de mesure

Y. M. Fu, H. Liu, G. Y. Chen, Y. X. Wu and B. Z. Li.

Effect of thermal acclimatization on occupants' thermal responses in dynamic thermal environments after exercise in summer.

BUILDING AND ENVIRONMENT. 2025;282.

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To explore effects of thermal acclimatization in cold and severe cold (CSC) and hot summer cold winter (HSCW) climates on thermal responses. Subjects are recruited from northern China (CSC climate) and southern China (HSCW climate). Differences in thermal responses between northern population (NP) and southern population (SP) during indoor recovery after outdoor exercise are analyzed through climate chamber. A total of 24 subjects participates in experiment, with a north-south ratio of 1:1. Both groups live in their original residence places for more than 20 years. Physiological monitoring and subjective questionnaire are used to assess subjects' physiological and subjective responses. The results show that mean skin temperature (MTsk) and core temperature (T-core) increase as indoor temperature (T-in) rises for two groups, and MTsk and T-core of SP are always higher than that of NP. Dynamic environment of 24 - 26 degrees C makes thermal sensation of two groups closer to neutral with respect to 24 degrees C. Moreover, dynamic environments significantly improve thermal comfort vote (TCV) of two groups when outdoor temperature (T-out) is 36 degrees C (P < 0.001), and TCV of NP and SP increases by maximal values of 0.65 and 0.70, respectively. NP could be more prone to thermal discomfort over time according to thermal sensation prediction models proposed in present study. Finally, Physiological Strain Index (PSI) is adopted for evaluating comprehensive heat stress of recovery phase. NP generally requires more full recovery time to decrease PSI below baseline of Physiological Stress Index (PSI0) for the same environment cases.

E. Mihalcin, S. Schiavon and N. Ravanelli.

Examining the physiological strain with electric fans during high indoor heat stress.

BUILDING AND ENVIRONMENT. 2025;282.

https://doi.org/10.1016/j.buildenv.2025.113261

Fans have been positioned as a low-cost, sustainable, and accessible heat resilience solution during extreme heat. Many health agencies caution against fan use when air temperature exceeds skin temperature (e.g. >= 35 degrees C) suggesting they will accelerate body heating compared to still air. However, the increased evaporative efficiency with a fan likely mitigates greater rises in core temperature and cardiovascular strain compared to still air when the air temperature is >35 degrees C. The present study evaluated the physiological responses with and without fans when indoor air temperature exceeded skin temperature to elucidate the safe upper limit. In a randomized crossover design, 10 healthy adults (4 females, 24 +/- 4 y, 1.8 +/- 0.1 m, 75.8 +/- 10.1 kg) were exposed to a simulated indoor overheating scenario whereby air temperature increased linearly from 38 degrees C to 47 degrees C over 3 hours, with a fan (similar to 5.5 m/s) or still air (<0.2 m/s). Heart rate and core temperature were significantly greater with a fan compared to still air when air temperature was >= 44 degrees C and >= 45 degrees C, respectively. Mean skin temperature and skin blood flow were statistically higher with a fan. While a fan increased whole-body sweat rate, the additional sweating can be counterbalanced with increased fluid intake (similar to 250 mL/h at 43 degrees C) to mitigate dehydration. In conclusion, fans result in a higher heart rate or core temperature compared to still air

in healthy adults when indoor air temperature >43 degrees C; similar to 3-11 degrees C greater than guidance from various health agencies globally. Future work in other age groups and heat-vulnerable populations is needed, including field-based evaluation.

S. Chaki, M. A. Samad, M. A. Mallik and S. M. Q. Hassan.

Forecasting human heat stress: Insights from observations and WRF simulations during Bangladesh heatwaves.

PLOS CLIMATE. 2025;4(8).

https://doi.org/10.1371/journal.pclm.0000690

This study investigates the heatwave conditions in Bangladesh through the lens of thermal stress, and aims to facilitate the forecasting of thermal stress at lead times of 5-9 days using the weather prediction model, WRF. Here, the thermal stress is determined using the widely known bioclimatic index, PET (Physiologically Equivalent Temperature), and is calculated via the RayMan model. The first phase of the study involves a comprehensive analysis of observed thermal discomfort during seven major heatwave events, using data from eight divisional meteorological stations across the country. The findings reveal alarming levels of thermal strain nationwide. In the second phase, the WRF model has been used to simulate those heatwave events at 1-day lead time (D1), and its performance has been tested in predicting heat stress. The comparison of the model simulated values with the observed counterparts illustrated promising results in the employment of WRF model in predicting heat stress, particularly for the month of April. Finally, the same model configuration is used to forecast a heatwave event in April 2021 at extended lead times (D5-D9). Results indicate that the WRF model maintains commendable accuracy in simulating thermal stress even at longer forecast period.

S. Tada, Y. Hashimoto and Y. Nishida.

Investigation of Hollow or Stepped Structures for Lightweighting Prove Cover of Patch Type Core Body Thermometer.

ELECTRONICS AND COMMUNICATIONS IN JAPAN. 2025.

https://doi.org/10.1002/ecj.12496

Core body temperature, which is the temperature inside the body, is a useful biological indicator for understanding changes in various physical activities due to its characteristics of being insensitive to external disturbances. However, the gold standard measurement methods require inserting probes in the body, which is highly invasive and unsuitable during activity. Conversely, a patch-type sensor that estimates core body temperature from heat flow changes near the skin surface has been attracting attention as a suitable method during activity. However, its practical challenge has been to improve robustness to environmental changes. Recently, we have solved this problem by improving the conventional measurement probe. Nevertheless, the weight reduction of the measurement probe has been an additional challenge. Here, we focused on the probe cover, which had previously been identified as a significant obstacle to weight reduction. We investigated the potential of applying a typical lightweight structure, such as a hollow or stepped structure, to the probe cover in order to achieve both weight reduction and high accuracy of the measurement probe.

B. C. McLaughlin, J. T. Aguilera and A. C. D'Lugos.

Validity of the CORE wearable sensor during constant-load cycling exercise in the heat.

JOURNAL OF THERMAL BIOLOGY. 2025;132.

https://doi.org/10.1016/j.jtherbio.2025.104241

Heat exposure is an increasing threat to human health and accurately monitoring core body temperature is vital to avoiding heat-related illnesses during exercise and outdoor occupations. Recently, a wearable device (CORE (TM)) was developed to non-invasively estimate core body temperature (T-C). The purpose of this study was to determine the validity of the CORE sensor and identify subcutaneous fat as a potential contributor to the device's bias. Twenty-four healthy males (n = 13) and females (n = 11) completed 60 min of cycling exercise at 60 % of their maximum aerobic power output (166 +/- 46.5 W) in the heat (35.9 degrees C & 20.7 % relative humidity). During exercise, T-C and skin temperature (T-SK) measures from the CORE sensor were compared to rectal probe and skin surface probe, respectively. Midaxillary subcutaneous fat thickness (MSFT) at the site of the CORE sensor was measured via ultrasonography. Throughout the entire exercise bout, the CORE displayed a non-statistically significant overestimation of T-C (0.15 +/- 0.43 degrees C, p = 0.057). However, CORE significantly overestimated T-C during the third (0.31 +/- 0.43 degrees C, p = 0.002) and fourth (0.36 +/- 0.45 degrees C, p = 0.004) quarters of exercise. CORE also significantly overestimated T-SK (1.28 +/- 0.96 degrees C, p < 0.0001) throughout the entire exercise bout. MSFT was positively correlated with the bias in T-C (overestimation by CORE) during the third (r = 0.438, p = 0.032) and fourth (r = 0.482, p = 0.017) quarters of exercise. In conclusion, compared to rectal temperature, the CORE sensor overestimated T-C during constant-load exercise in a hot environment. Overestimated T-SK and local subcutaneous fat may be potential contributors to bias in the CORE sensor's T-C estimation.

Travail dans une ambiance thermique extrême

J. Gutiérrez-Arroyo, J. A. Rodríguez-Marroyo, F. García-Heras, J. Rodríguez-Medina, G. Villa-Vicente and B. Carballo-Leyenda.

Effectiveness of cooling strategies for emergency personnel: a systematic review and meta-analysis.

SCIENTIFIC REPORTS. 2025;15(1).

https://doi.org/10.1038/s41598-025-15636-y

Emergency personnel operating in high-temperature environments while wearing protective equipment experience substantial thermophysiological strain, impairing performance and increasing the risk of heat-related illnesses. This systematic review and meta-analysis evaluated the effects of cooling interventions on core temperature, skin temperature, heart rate, sweat rate and tolerance time in emergency personnel exposed to heat stress. A comprehensive search was conducted in PubMed-MEDLINE, Web of Science and Cochrane Library databases up to March 2024. Controlled experimental studies published in English or Spanish were included if they assessed cooling interventions (pre-, per-, intermittent, or post-cooling; internal vs. external methods) in participants wearing protective clothing in heat stress conditions (> 28 degrees C), and included a non-cooling control group. Twenty studies met the inclusion criteria. Cooling interventions significantly reduced core temperature (ES = - 0.56, p < 0.001), heart rate (ES = - 0.42, p = 0.001), and sweat rate (ES = - 0.70, p < 0.001), while improving tolerance time (ES = 1.44, p = 0.003). Intermittent and per-cooling approaches, particularly those employing mixed-method strategies (e.g., cooling vests with immersion or ice slurry ingestion), yielded the greatest benefits. No significant changes were observed in skin temperature. Cooling interventions effectively mitigate physiological strain in emergency personnel exposed to heat stress. Intermittent and per-cooling using combined methods appear most effective. Nonetheless, logistical constraints may limit field implementation, highlighting the need for further research to optimize practical cooling protocols.

S. V. Esmaeili, F. Paridokht, A. Shalili, A. Mohsenian and H. Dehghan.

Improving heat stress prevention through targeted education in hot and humid workplaces: a study in a foundry industry.

BMC PUBLIC HEALTH. 2025;25(1).

https://doi.org/10.1186/s12889-025-23851-5

Background Heat-related illnesses and deaths are predictable and preventable, while lack of education can increase the associated risks. The aim of this study was to improve heat stress prevention through targeted education in hot and humid workplaces. Method This intervention study with a pre-posttest design was conducted in 2023 on 50 workers in a foundry industry. Initially, by literature reviewing valid scientific databases, factors related to the perception and awareness, knowledge, and functionality (PAKF) of the workers were identified. Subsequently, the face validity of the questionnaire was determined based on the opinions of nine experts in the field of occupational heat stress. The content validity and reliability of the questionnaire were determined using the Content Validity Ratio (CVR), Content Validity Index (CVI), and Cronbach's alpha coefficient. A two-session (180 min each) educational intervention related to preventing occupational heat stress was implemented, and the results were compared using covariance analysis. Gathered data were analyzed using Excel v.2019 and SPSS v.26 software. Result The study results indicated that out of 53 items designed, ultimately 27 items

were confirmed, with CVI, CVR, and Cronbach's alpha coefficient values of 0.94, 0.78, and 0.76, respectively. Conducting exploratory factor analysis led to the confirmation of 7 factors explaining 50% of the total variance, and all 27 questionnaire items showed acceptable intercorrelations. Furthermore, implementing a heat stress management program resulted in improvement in the PAKF of the intervention group compared to the control group (P < 0.001). Conclusions The results of this study demonstrate that a comprehensive educational program related to the prevention of heat stress can lead to an improvement in the level of the PAKF of workers in hot working environments. Therefore, there is a need to enhance the PAKF of workers regarding heat-related hazards, strengthen training, and update current heat prevention policies to ensure compliance and implementation.

S. Y. Liu, W. T. Wu, X. Q. Sun, H. X. Tian, J. W. Li, R. H. Zhou, B. D. Dembele and X. Shen.

Investigation of temperature and humidity impact on thermal comfort in deep underground tunnel during construction in hot climate: A case study in an underground hydropower station.

TUNNELLING AND UNDERGROUND SPACE TECHNOLOGY. 2025;162.

https://doi.org/10.1016/j.tust.2025.106669

This study investigates the thermal and humidity conditions and their impact on workers' thermal comfort during the construction of underground tunnels in hot climates. Wall temperature, air temperature, and humidity were measured within an underground hydropower station tunnel. The wall temperature at the tunnel entrance and bottom end was found to be 4 degrees C higher than in the middle section. Air temperature stabilized at 450 m from the entrance, while humidity stabilized at 1450 m from the entrance. A Computational Fluid Dynamics (CFD) model was employed to simulate these conditions, with results demonstrating good agreement with on-site measurements for both air temperature and humidity. Simulation outcomes revealed a vertical temperature difference of up to 20 degrees C near heat sources, underscoring the potential of increased ventilation rates as a viable solution to mitigate high temperatures at tunnel ends. Evaluations based on PMV (Predicted Mean Vote) and WBGT (Wet Bulb Globe Temperature) criteria indicated that areas adjacent to heat sources do not meet thermal comfort standards, highlighting that reliance on dry bulb temperature alone is insufficient for assessing thermal comfort during underground tunnel construction activities. These findings can inform the optimal design of ventilation and air conditioning systems throughout the construction of underground tunnels.

Travail par fortes chaleurs et périodes de canicule

E. W. Ansah, E. Ankomah-Appiah and T. Hormenu.

Assessing heat stress, ambulatory hypertension and thermal symptoms in fish smokers along coastal areas in Ghana: a cross-sectional study.

BMJ PUBLIC HEALTH. 2025;3(2).

https://doi.org/10.1136/bmjph-2024-001378

*Background Many workplace illnesses are increasing exponentially because of the rapid change in climate and associated workplace heat exposure that lead to heat stress and ambulatory hypertension among workers. Fish smoking is a common livelihood among people residing along the coastal areas in developing countries who work outdoors and in extreme heat.
 Objective The objective of this study is to assess the prevalence of heat stress and ambulatory hypertension among fish smokers in coastal areas of Ghana and to identify work-related factors that influence these conditions.
 Methods This exploratory cross-sectional survey sampled 2018 fish smokers from various communities along the coastal areas of Ghana. Using a convenient sampling method to select the workers, data were collected with a questionnaire, collecting anthropometric information like weight, height and physiological parameters, including blood pressure, heart rate and body temperature using sphygmomanometer and thermometer. Also, the Wet Bulb Globe Temperature index was used to measure heat stress exposure among the workers. The data were analysed using descriptive statistics, Kruskal-Wallis H test, in SPSS V.25.0.
 Results The study found that 87.6% of fish smokers in coastal Ghana reported high levels of heat stress, and 59.0% recorded ambulatory hypertension. Workers on the afternoon shift showed higher levels of heat stress compared with those on morning and evening shifts. The number of workdays per week was also linked to severe ambulatory hypertension. The analysis confirmed significant differences in heat stress across shifts (chi(2)=103.51, p<0.001, eta(2)p=0.165) and in ambulatory blood pressure among workers based on workdays (chi(2)=96.04, p<0.001, eta(2)p=0.352), showing moderate-to-large effects.
 Conclusions The study emphasises the importance of creating safe and healthy work environments that protect fish smokers from health hazards associated with heat exposure. There is the need for fish smokers to adopt less heat emission ovens for fish smoking and regularly cool their bodies during the afternoon shift as they pay attention to rehydration.*

D. Kwaro, N. Kassem, S. Munga, J. Okoth, H. C. Gunga, S. Barteit and M. A. Maggioni.

Burden of heat stress on residual work capacity among farmers living with chronic HIV in Siaya county, Kenya: a longitudinal observational study protocol.

BMC PUBLIC HEALTH. 2025;25(1).

https://doi.org/10.1186/s12889-025-24373-w

Introduction: Sub-Saharan Africa, including Siaya County in Kenya, has a high prevalence of chronic HIV infection, which may increase vulnerability to climate-induced heat stress among agricultural workers. Understanding how HIV moderates the relationship between environmental heat exposure and labour capacity is essential for designing targeted, equitable public health interventions in climate-vulnerable settings. This study aims to quantify the effects of heat exposure on labour capacity and sleep, assess whether physiological strain mediates these effects, and examine whether HIV status and sex affect the observed relationships.MethodsThis is an ongoing 24-month longitudinal observational study involving 124 participants (62 male-female pairs) stratified by HIV status. HIV-positive participants are

recruited from the Wagai Health Centre's HIV clinic, and HIV-negative participants are recruited from the general population via the Siaya County Health and Demographic Surveillance System (HDSS) registry. The participants are aged 20-45 years and engaged in agricultural livelihoods. Environmental heat exposure (indoor and outdoor wet bulb globe temperature), actigraphy (physical activity and sleep), and physiological metrics (heart rate and core body temperature) are continuously or periodically monitored using research-grade wearables. GPS data and monthly questionnaires on thermal comfort, work timing, and heat-related symptoms are collected to contextualize physiological responses. Data collection occurs sequentially-first 12 months for the HIV-negative group and then another 12-months for the HIV-positive group-ensuring seasonal alignment across cohorts. Mixed-effects models will assess the associations between heat exposure and residual labour capacity (primary outcome) and sleep quality (secondary outcome), examining mediation by physiological strain and moderation by HIV status and sex. The models will be adjusted for age, body composition, and other potential confounders.DiscussionThis study will generate novel evidence on the impact of heat stress on labour capacity and sleep in HIV-positive populations, addressing a critical gap in climate-health research in sub-Saharan Africa. Findings will inform equitable adaptation strategies, such as work-rest cycles and hydration protocols, tailored to vulnerable subgroups, including women and individuals living with HIV.

World Meteorological Organization (WMO) and World Health Organization (WHO).

Climate Change and Workplace Heat Stress. (Changement climatique et stress thermique au travail.). 2025:85.

https://library.wmo.int/idurl/4/69616

Le rapport aborde l'augmentation globale des températures due au changement climatique et l'intensification des épisodes de chaleur extrême, en mettant l'accent sur leurs conséquences pour la santé, la sécurité et la productivité des travailleurs exposés à la chaleur, tant en intérieur qu'en extérieur. Il vise à fournir une analyse actualisée des impacts sanitaires, socio-économiques et productifs du stress thermique au travail, et à offrir des recommandations pratiques aux décideurs de santé publique, employeurs et travailleurs. Le document est développé en plusieurs parties : la première décrit les relations entre l'évolution du climat, l'exposition à la chaleur et les mécanismes physiologiques impliqués dans la production et la dissipation de la chaleur lors du travail physique. La seconde partie analyse la morbidité, la mortalité et l'impact sur la productivité, associés au stress thermique. La troisième partie, sur la prévention et l'atténuation du stress thermique, propose des plans d'action sanitaire au travail, avec des mesures d'élimination/substitution, de formation, de surveillance environnementale et médicale, ainsi que des stratégies d'ingénierie et d'organisation du travail pour limiter l'exposition à la chaleur. La quatrième partie présente les différentes méthodes d'évaluation (WBGT, UTCI, indice de chaleur, PHS), la surveillance physiologique (température, fréquence cardiaque, hydratation), l'identification des facteurs de risque individuels et professionnels, et les protocoles de retour au travail après pathologie liée à la chaleur. En conclusion, le stress thermique lié au changement climatique est désormais un défi mondial pour la santé et la productivité des travailleurs ; il exige des actions urgentes et coordonnées pour adapter les politiques, les pratiques et la prévention afin de protéger efficacement les plus exposés face à l'intensification de la chaleur extrême.

K. G. Gayathri, P. Vijayalakshmi, S. Krishnan, S. Rekha and V. Venugopal.

Climate induced heat stress and its psychological effects among South Indian workers.

ARCHIVES OF ENVIRONMENTAL & OCCUPATIONAL HEALTH. 2025.

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Objective: Rising temperatures and extreme weather pose a significant public health threat. Workers in low- and middle-income countries are particularly vulnerable to heat stress, which can lead to psychological repercussions, including climate anxiety. This study investigated the psychological impacts of heat stress and coping strategies among workers in relation to climate anxiety.MethodA cross-sectional survey of 800 indoor and outdoor workers was conducted in 2024. Environmental heat stress was measured using a wet bulb globe temperature (WBGT) monitor, defining heat stress as exceeding task-specific threshold limits. Heat strain indicators (HSIs) such as core body temperature (CBT) and urine specific gravity (USG) were assessed alongside perceived heat stress and psychological impacts using a validated HOTHAPS questionnaire.ResultsThe WBGT exceeded recommended limits for 62% of workers (30.3 +/- 5.0 degrees C). Among heat-exposed workers, 80% reported heat-related health symptoms, with a significant rise in HSIs, including CBT (AOR = 1.9; 95% CI: 1.4-2.7). Psychological symptoms were prevalent in 94% of exposed workers, with heightened risks of climate anxiety (AOR = 2.8), stress (AOR = 2.7), and mental fatigue (AOR = 3.7). Women and summer months showed greater vulnerability.ConclusionHeat stress significantly affects psychological well-being among South Indian workers. Protective workplace policies are crucial to mitigating climate-induced psychological impacts.

S. Sharma, S. Marasini, A. Joshi, N. R. Dangaura, L. R. Timsina, D. Guragain and B. M. Karmacharya.

Exploring outdoor workers' knowledge, attitudes, practices, and perceived risks of heatwaves in Nepal.

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Background The rise in global temperatures due to climate change has intensified the frequency and severity of heat waves, disproportionately affecting outdoor workers. This is particularly concerning in low- and middle-income countries like Nepal, where inadequate policies and limited awareness leave outdoor workers highly vulnerable. This study explores the knowledge, attitudes, practices (KAP), and perceived risks of heatwaves among outdoor workers in Nepal. Methods A cross-sectional mixed-method study was conducted across eight districts in five provinces of Nepal, surveying 356 outdoor workers from five occupational groups: street vendors, agricultural workers, rickshaw drivers/pullers, laborers, and service workers. Eleven focus group discussions (FGDs) were conducted to gain deeper insights. Descriptive statistics were used to assess KAP scores, while Kernel-Based Regularized Least Square (KRLS) analysis examined the variations in practice scores among groups. Thematic analysis was applied to FGDs. The quantitative analysis was done in STATA-14, and the qualitative analysis was conducted manually. Results The average age of participants in the study was 37.2 years (SD = 10.5), and just over half (57%) were male. On average, they had worked outdoors for about 10.7 years (SD = 8.6). Among all participants, 43% had heard of heatwaves, 86.2% were aware of heat-related incidents, and 78.6% had personally experienced them. Awareness about heatwave was positively associated with the practices of heat protection for the overall sample (practice score = 1.46, $p < 0.001$). Age was found to be negatively associated with the practices of heat protection (practice score = -0.03, $p < 0.001$). Compared to females, males had lesser practices of heat protection (practice score = -0.97, $p < 0.001$). Conclusion Heatwaves pose significant health risks, particularly for vulnerable outdoor workers who often lack knowledge about protective measures. This highlights an urgent need for government-led interventions and awareness programs at both community and policy levels to address and mitigate heat stress.

G. Pal and T. Patel.

Physiological responses to heat stress in rice transplanting workers in Northeast India and work-rest schedule recommendations.

WORK-A JOURNAL OF PREVENTION ASSESSMENT & REHABILITATION. 2025.

https://doi.org/10.1177/10519815251365918

Background Heat stress has a detrimental impact on workers' health, resulting in reduced workplace productivity and an increase in heat-related illnesses and fatalities. Manual paddy transplantation in Northeast India (NEI), performed under high heat and humidity, requires significant physical effort, leading to fatigue. Implementing work-rest schedules is a practical approach to minimize heat stress.Objective This study aimed to investigate the efficacy of work-rest schedules for agricultural workers in Northeast India for manual paddy transplanting at various Wet-bulb globe temperature (WBGT) settings.Method Fourteen participants were selected to assess thermal and physiological stress during rice transplanting (summer crop) under WBGT conditions of 27-32 degrees C. Participants were given rest from work once their oral body temperature increased by 0.5 degrees C. Work time was defined as the period leading to this increase, while rest time was the duration needed for oral temperature to normalize, based on ISO 7933 thresholds.Results Oral temperature increased by 0.5 degrees C after 65 min of work, requiring 15 min to normalize at 27-28 degrees C. Recommended work-rest durations were 65 min and 15 min, respectively. At 29-30 degrees C and 31-32 degrees C, work-rest durations were 50 and 20 min, and 35 and 22 min, respectively. These findings provide a critical foundation for future research on climate-resilient occupational health strategies, particularly in regions vulnerable to rising temperatures due to global warming.Conclusions Agricultural workers in Northeast India face heat stress during manual paddy transplantation. It is recommended that customized work-rest schedules be implemented based on WBGT conditions to enhance safety and productivity. Regular monitoring of oral temperature and heart rate is essential to prevent heat-related health issues.

P. Newcomb, G. Alexander, S. Bailey and S. Martin.

Texas Health Care Workers Respond to Climate Change.

PUBLIC HEALTH NURSING. 2025.

https://doi.org/10.1111/phn.70013

Objective: The purpose of this study was to measure healthcare worker awareness of climate change and concern about its impact on health. Design: Cross-sectional population study. Sample: Researchers administered the CHANT Tool to a convenience sample of 691 employees of a large health system in North Texas ranging from 20 to 75 years of age. About 71% were nurses. Measure: The 52-item CHANT 2024: Climate and Health Tool measured engagement with climate change. Subscales measure familiarity with climate concepts, awareness of extreme weather events in respondents' region, concern about impact of climate change, conservation behaviors, and optimism regarding climate change. Respondents rated scaled items on a 5-point Likert-type scale from 0 (most negative or least) to 4 (most positive or greatest). In this sample subscales had acceptable internal reliability with Cronbach's alphas ranging from 0.69 to 0.96. Results: Respondents (79%) were familiar with the existence of climate change, but not that US Healthcare delivery is responsible for a significant proportion of the greenhouse gas emissions associated with it (36%). Most respondents were not optimistic about preparation for the impacts of climate change or preventing further climate change (56% and 59%, respectively). Degree of concern about the health impacts of climate change was significantly associated with six variables, including race, awareness that warming is associated with human activity, awareness that vulnerable populations are more at risk, personal exposure to extreme

heat, observations of heat illness in patients, and observations of mental health in patients related to climate events. Most respondents (>50%) wanted to change practice to prepare for health impacts of climate change. Conclusions: North Texas healthcare workers are familiar with climate change and believe it has potential to harm patients but are generally not optimistic about preparation for its effects or changing its course. However, they wish to change practice to make a positive difference.

J. Friedrich, T. S. Schick, F. Mess and S. Blaschke.

Wearable device-based interventions in heat-exposed outdoor workers - a scoping review and an explanatory intervention model.

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Global climate change poses a challenge to the health prevention of heat-exposed outdoor workers. Interventions with mobile or wearable devices monitoring physiological and environmental parameters may be one solution to maintain and promote their health. Based on the recognized potential of wearables in mitigating heat stress, a detailed analysis of the contextual factors, mechanisms, and outcomes of wearable device-based interventions is lacking. A scoping review was carried out to address the objectives of contextual analysis, fundamental mechanisms, and an assessment of outcomes to propose an explanatory intervention model based on the findings.MethodsWeb of Science and PubMed databases were searched by search strings related to (1) wearables (2), outdoor workers, and (3) heat stress. Study characteristics and relevant data regarding the context-mechanism-outcome configurations were extracted and analyzed.ResultsOut of 410 articles detected, 19 publications were eligible for in-depth review. Wearables are well-accepted for the prevention of heat stress symptoms. By recording relevant indicators, i.e., heart rate and temperature, real-time health alerts can be issued as risk-based early warnings, and personalized feedback or recommendations towards behavior adaptation can be generated. A high risk of occupational heat stress was identified for construction, agriculture, and groundwork workers. Heat-exposed outdoor workers were mainly young to middle-aged males and often overweight or obese, with increased heart and breathing rates in hot work environments. Wearable device-based interventions are particularly effective if a mindset of safety culture is present in the workplace and environmental health literacy is promoted to increase heat risk awareness and willingness to change work health behavior.ConclusionBased on these findings, we developed an explanatory intervention model. This model draws on well-established frameworks, theories, and models. It helps to identify, describe, and explain what works, for whom, and under what circumstances in the context of wearable usage in heat-exposed outdoor workers. Incorporating environmental health literacy and precision prevention in occupational health approaches with continuous monitoring of environmental and physiological parameters will allow for real-time, tailored feedback, leading to more effective heat stress prevention.

Actualités Août 2025

- **Travail par fortes chaleurs et périodes de canicule**

Comment le monde du travail s'adapte à la canicule. Ladepeche.fr, 09 août 2025

Gare de Nantes : malgré les ventilateurs, les températures sont toujours hautes. Ouest-France.fr, 10 août 2025

Vague de chaleur et tenue de travail : "Difficile d'imaginer un banquier en short à fleurs". Lavenir.net, 11 août 2025

Incendie dans l'Aude : les conditions de travail des pompiers restent "difficiles" notamment en raison de la canicule. Franceinfo.fr, 11 août 2025

« Nous sommes beaucoup moins productifs » : face à la canicule, le monde du travail tente de s'adapter. Lefigaro.fr, 12 août 2025

Vague de chaleur : "Les horaires sont adaptés, mais pas (encore) de chômage temporaire". Lavenir.net, 13 août 2025

Vague de chaleur : "La pose d'asphalte, un travail éreintant quand il fait très chaud". Lavenir.net, 13 août 2025

« Notre clim à nous, c'est les courants d'air » : visite avec une inspectrice du travail d'un chantier en pleine canicule. Liberation.fr, 13 août 2025

Canicule : les salariés de la CAF du Loiret respirent au travail grâce au système de géothermie. Francebleu.fr, 13 août 2025

Déchèteries : les horaires adaptés cette semaine. Le Courrier de l'Ouest (presse, p.4, 13 août 2025)

Le débat sur le travail en période de canicule relancé. Lesechos.fr, 13 août 2025

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Vins. "Les efforts d'une saison de travail sont partis en dix jours" : la canicule a bouleversé les vendanges, jusqu'à 40% de pertes pour ce viticulteur. France3-regions.francetvinfo.fr, 22 août 2025

- ## Maladies liées à la chaleur

La canicule, un poids en plus pour les malades chroniques. 20minutes.fr, 13 août 2025

Heat-related illness numbers on par with historical numbers. Saltwire.com, 09 août 2025

Les canicules sont-elles plus dangereuses quand elles durent ? Sciencesetavenir.fr, 13 août 2025

Canicule et mortalité au travail : une réalité encore sous-estimée. Nouvelobs.com, 13 août 2025

Canicule : un ouvrier agricole meurt pendant la cueillette sous plus de 40 degrés... Son employeur déplore "un accident du travail". Lindependant.fr, 14 août 2025

Construction workers account for disproportionate number of heat-related deaths: CPWR. Safetyandhealthmagazine.com, 15 août 2025

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Des vertiges à la mort, l'ONU appelle à protéger les travailleurs des chaleurs extrêmes. France24.com, 22 août 2025

Hot and humid days could be hazardous to your heart, researchers warn. Safetyandhealthmagazine.com, 26 août 2025

- ## EPI, matériaux protecteurs/refroidissants

Cooling garments help workers beat the heat, researchers say. Safetyandhealthmagazine.com, 07 août 2025

La RATP teste des vestes rafraîchissantes pour ses conducteurs de métro en période de canicule. Franceinfo.fr, 13 août 2025