Bulletin n°38

Veille thermique
Période : juin 2026

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.

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EPI, matériaux protecteurs/réchauffants

X. L. Jiang, D. Xie, C. H. Wang and J. N. Guo.

Assessing thermal comfort and heat strain in multilayer chemical protective clothing under varied environmental conditions.

BUILDING AND ENVIRONMENT. 2026;302.

https://doi.org/10.1016/j.buildenv.2026.114884

Chemical protective clothing can significantly alter internal microclimate, physiological responses, and subjective thermal perception, yet comprehensive evaluation of thermal strain under such conditions remains limited. This study investigated thermal responses of healthy adults wearing multilayer chemical protective clothing in controlled climate chamber experiments, simultaneously measuring internal temperature, relative humidity, mean skin temperature, heart rate, and subjective perceptions across different environmental conditions and activity levels. Results demonstrated that internal microclimate parameters strongly influenced thermal sensation, moisture perception, and thermal comfort, while physiological responses reflected thermal strain and correlated closely with subjective comfort. Correlation analyses further revealed that internal clothing conditions and physiological variables collectively dominated thermal perception, with a greater effect than ambient temperature. A Chemical Protective Clothing Thermal Strain Index (CPC-TSI) was preliminarily developed to integrate thermal, moisture, and physiological responses within the present experimental dataset, providing an exploratory framework for characterizing thermal strain under controlled chemical protective clothing conditions. These findings highlight the combined effects of internal microclimate and physiological responses in driving thermal sensation under sealed protective ensembles and may inform future studies on protective clothing design and occupational thermal safety.

Y. W. Dou, Z. W. Zhang, L. P. Zhang, J. S. Du and J. Qian.

CFD Simulation of Thermal-Moisture Comfort of Clothing Fabrics in Hot-Dry Climate.

TEXTILE RESEARCH JOURNAL. 2026.

https://doi.org/10.1177/00405175261450339

To investigate the effect of clothing fabrics on human thermal and moisture comfort in dry-hot environments, computational fluid dynamics (CFD) was employed to analyze the thermal-moisture coupling mechanisms within the human-clothing-environment system. Nine commercially available fabrics of different materials were selected, and their performance parameters were tested. Four fabrics with similar specifications were then selected, and a clothing simulation was conducted under constant dry-hot environmental conditions of 35 degrees C and 30% relative humidity (RH). By monitoring the dynamic changes in the under-garment microclimate (temperature and relative humidity) in sweat-prone areas of the human torso, including the front chest, back, and abdomen, we investigated the effect of different fabric materials on human thermal and hygroscopic comfort in a dry-hot environment. The results indicate that F4, containing Lyocell, demonstrated the best under-garment temperature and humidity regulation performance across the three key areas. Its steady-state temperatures in the abdomen and front chest were approximately 0.5-0.6% lower than those of F5, and the amplitude of fluctuations was significantly smaller than that of other fabrics. The under-garment relative humidity of F4 was generally maintained within the range of 55-70% RH, which is approximately 15-30% lower than that of F2, enabling more effective maintenance of a relatively stable microenvironment. This indicates that in dry and hot summer environments (such as the Xinjiang

region), Lyocell fabric can have a positive effect on human thermal and humidity comfort. This study provides a theoretical basis and data reference for the selection and design of functional clothing materials in such environments.

X. L. Chen and C. Y. Nie.

Design for Multi-Layer Thermal Protective Clothing Based on Numerical Simulation of Heat Transfer.

MATERIALS. 2026;19(12).

https://doi.org/10.3390/ma19122478

It is well-known that high-performance thermal protective clothing is crucial for personnel working in high-temperature environments, such as firefighters. Thermal protective clothing design usually integrates textile materials' type, thickness, physical and chemical properties (such as thermal conductivity), ergonomics, and environmental adaptability. In this study, the heat transfer process and the optimal thickness are mainly discussed for providing some references on the design of this clothing. The thickness design of thermal protective clothing fabrics is carried out via numerical heat transfer simulations based on experimental data obtained from manikin tests. Firstly, one heat transfer model for thermal protective clothing, including three textile materials' layers and one air layer, is constructed according to Fourier's law of heat conduction, Newton's law of cooling, and the Stefan-Boltzmann law, with appropriate boundary conditions assigned. Secondly, the finite volume element method, which has the important advantage of preserving conservation properties for physical quantities, is employed to discretize the heat transfer model. Thirdly, the convective heat transfer coefficient, which characterizes heat exchange between fluid and solid surfaces, is determined approximately by the least-squares method based on the given data, while the heat transfer process is simultaneously simulated. Fourthly, the thicknesses of the second and fourth layers are critical to the performance of thermal protective clothing. Two optimization algorithms are proposed to determine the optimal thickness configuration that effectively balances thermal insulation and wearing comfort. From the above results, it is recommended to use multilayer textile composite materials incorporating aerogel insulation layers and phase-change material interlayers.

A. F. Malaquias and J. Campos.

Influence of PCM incorporation on thermal performance of fire protective clothing subject to wet exposures.

INTERNATIONAL COMMUNICATIONS IN HEAT AND MASS TRANSFER. 2026;175.

https://doi.org/10.1016/j.icheatmasstransfer.2026.111043

Firefighters tend to face a diverse set of environments comprised, not exclusively, by high heat intensity exposures. Hazards caused by water exposure such as steam burns may occur but have only been studied for a limited set of conditions. Sudden water exposure to a donned fire protective clothing (FPC) assembly in the post-fire phase has been recently shown to be hazardous to firefighters, causing second-degree burns. To mitigate this effect, in this work, the incorporation of PCMs in the textile layer near the skin (i.e. thermal liner) of the FPC is modeled and suggested as a potential solution. More specifically, a heat and mass transport model of an FPC incorporating PCMs is elaborated and utilized to compute heat and mass flux debits as well as PCM phase change in the post - fire phase. Heat and mass transfer mechanisms are identified in the post - fire phase as well as second-degree burn occurrence is checked for utilizing the Henriques burn criterion. The influence of PCM mass

incorporation (i.e. textile latent heat) and PCM melting/solidification temperature on water exposure hazard prevention is established through parametric analyses. A textile fiber latent heat of 70 JPCM/gtextile obtained by Rubitherm (R) RT44 HC PCM incorporation into the thermal liner ensures no skin burn occurrence. Furthermore, if the thermal liner fiber fraction is increased by just 4% (i.e. 4% decrease in porosity of the thermal liner), PCMs with melting and solidification temperatures up to 70 degrees C can be safely incorporated for skin burn prevention.

A. N. Miao and D. H. Xu.

Mathematical Formulation and Numerical Study of Parameter-Performance Relationships for Thermal Protective Clothing Under Windy Conditions.

MATHEMATICAL METHODS IN THE APPLIED SCIENCES. 2026.

https://doi.org/10.1002/mma.70851

This study focuses on developing a coupled heat transfer model in the Environment-Clothing-Human body system under realistic firefighting conditions, which shows how ambient temperature, wind velocity, and perspiration rate influence skin-burn injury. The model, consisting of a three-layer fabric, a single air gap and a double-layer skin structure, is derived based on Darcy's law and the Bernoulli equation for airflow. The existence of weak solutions to the resulting nonlinear PDE system is mathematically proved via the Galerkin approximation, energy estimates, and compactness arguments. Uniqueness is established using the classical energy method combined with Gr & ouml;nwall's inequality. Numerical simulations are performed with a mixed explicit-implicit finite difference scheme, and Henriques' burn integral is employed to evaluate skin burn injury and predict the longest safe working time. The numerical simulation results indicate that burn injury increases with higher wind velocities and meanwhile decreases with greater perspiration rates when the parameters are chosen from engineering applications. These results provide a scientific basis for the design of firefighting protective clothing and enhance the interpretability of the model.

P. M. Stegerhoek, J. van der Zande, N. Dontje, T. H. Ijzerman, P. Kuijer and E. Verhagen.

Moisture-wicking clothing but not a spacer garment improves perceived thermal strain in Dutch military personnel.

ERGONOMICS. 2026.

https://doi.org/10.1080/00140139.2026.2682431

This study evaluated the effects of moisture-wicking clothing and spacer garments on heat strain among Royal Netherlands Marechaussee personnel. In a within-subject design, 19 participants (4 females, 15 males) stationed in the Dutch Caribbean participated in the study; were scheduled to complete 4 shifts while wearing their usual gear, a spacer garment, a moisture-wicking garment, or both a spacer garment and a moisture-wicking garment. Thermal sensation and comfort were assessed hourly, and skin temperatures were continuously monitored. Linear mixed models showed that moisture-wicking clothing without a spacer garment improved thermal comfort (-3 to +3) by 0.49 points (95% CI: 0.16 to 0.82) without affecting mean skin temperature, while standard gear with a spacer garment reduced thermal comfort by 0.36 points (95% CI: -0.68 to -0.04) and increased chest skin temperature by 0.41 degrees C (95% CI: 0.04 to 0.78). Moisture-wicking clothing enhances perceived comfort, whereas spacer garments may increase thermal strain.

M. T. Aktek and M. Ali.

Optimization of durable, multifunctional and skin-sensed mechanical comfort properties of green hybrid nano fluids treated cotton fabric.

CELLULOSE. 2026.

https://doi.org/10.1007/s10570-026-07102-3

Promoting medical textiles with skin-sensed mechanical comfort for biomedical applications, cost-effectively utilizing bio-inspired hybrid nano fluids, is exceptionally challenging. Addressing durable multifunctionality with respect to skin-sensed mechanical comfort properties, the present research incorporates three different formulations of bioinspired Ag-SiO2 hybrid nano fluids. The hydrodynamic performance of these hybrid nano fluids is explored by Dynamic light scattering (DLS) where Ag-SiO2(10 g/L)-bis hybrid nano fluid shows the highest dispersion stability -25.5 mV among the three formulations. The surface morphology, chemical composition, and diffraction pattern of untreated and treated fabric are assessed by Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersive Spectroscopy (EDX), and X-ray diffractometers (XRD), respectively. Among functional properties, antibacterial properties, UV protection ability, flame retardancy, and thermal stability are evaluated. The outcomes of these functional properties are also found satisfactory for Ag-SiO2(10 g/L)-bis treated fabric in most cases. More specifically, around 99.9% antibacterial efficacy, 14.25 UPF value and the highest thermal stability are achieved by Ag-SiO2(10 g/L)-bis treated fabric. In addition, skin-sensed wear comfort properties are investigated to determine thermal-mechanical sensory properties like softness, smoothness, and warmth of fabric, respectively. From these values, global sensory indices are obtained and are very close to the pristine one for Ag-SiO2(10 g/L)-bis treated fabric. Besides, cytotoxicity of Ag-SiO2(10 g/L)-bis treated fabric is also assessed and exhibits non-cytotoxicity. The outcomes of this study suggest that Ag-SiO2(10 g/L)-bis treated fabric can be utilized for both medical and thermal protective clothing with suitable wear comfort properties.

Maladies liées à la chaleur

C. Sorensen, D. D. Magalhaes, M. DePhillips, N. H. Nimmagadda, J. Sullivan, V. Tikmani, K. Hadley, H. N. W. Weinstein, N. Shree, U. K, S. B. Syam, M. O'Donnell and A. Chaudhuri.

Building heat resilience through district-wide training of frontline health workers in India: a pre-post evaluation of the climate care champions programme in Ananthapuramu district.

BMJ PUBLIC HEALTH. 2026;4(2).

https://doi.org/10.1136/bmjph-2025-004475

Introduction Extreme heat is a growing public health emergency in India, with rural and low-income communities most at risk. Early symptoms are often overlooked, delaying care and increasing mortality risk. Frontline health workers (FHWs) are critical for prevention and early intervention yet major knowledge and preparedness gaps persist. This study aimed to evaluate a district-wide training programme designed to improve FHWs' knowledge and confidence in identifying, managing and preventing heat-related illnesses.Methods The Climate Care Champions Programme (CCCP) was designed to strengthen the capacity of FHWs to detect, manage and prevent heat-related illnesses. In February 2025, a 2-day Training of Trainers workshop prepared 90 trainers from Ananthapuramu District, Andhra Pradesh, India, who went on to train 2266 FHWs across 76 primary health centres, reaching an estimated 4.5 million residents. A baseline household survey (n=1007, including 241 FHWs) explored knowledge and perception before the training. Longitudinal surveys evaluated confidence and knowledge among trainers and trainees in four heat-vulnerable blocks.Results Although 70% of FHWs reported prior climate-health training and most expressed confidence in providing preventive advice, knowledge deficits were identified. During CCCP, a longitudinal evaluation revealed improvements in knowledge: recognition of early symptoms increased from 19% to 70%, severe symptoms from 42% to 95% and infant-specific signs from 32% to 89%. Misconceptions around first-aid priorities were corrected, and confidence rose across all domains. Data from 1453 FHWs confirmed effective knowledge transfer across the cascade training model, particularly in protective actions (+29.5%) and understanding heat-illness aetiologies (+18.6%).Conclusion These results demonstrate that localised, evidence-based training can strengthen frontline health worker capacity and close critical knowledge gaps. Scaling such programmes-supported by policy, infrastructure and sustained government commitment-is essential to protect health, reduce inequalities and strengthen community resilience in the face of escalating extreme heat.

M. Cirillo, C. Zoccali, C. Garofalo, S. Borrelli, C. Ruotolo, F. Marzano, R. Minutolo, L. De Nicola and G. Conte.

Disparity in the regulation and prevention of water versus sodium imbalance in heat-stress nephropathy: a phylogenetic perspective.

CLINICAL KIDNEY JOURNAL. 2026;19(6).

https://doi.org/10.1093/ckj/sfag151

The progressive rise in global temperature has led to an increase in heat-related illness and has brought heat-stress nephropathy (HSN) to the forefront as an emerging cause of both acute kidney injury (AKI) and chronic kidney disease (CKD). HSN is characterized by tubulo-interstitial damage and linked to disturbances in water and sodium homeostasis. Observational studies indicate that young, otherwise healthy workers exposed to heat are less likely to develop AKI when hypovolaemia due to sweating is corrected with sodium chloride-containing solutions rather than water alone. This narrative review first

summarizes the clinical spectrum, epidemiology, pathophysiology, and prevention of HSN in the context of climate change and the broader epidemic of heat-associated CKD described in several tropical and temperate regions. Then, it examines, in a phylogenetic perspective, the evolution of the two main regulatory systems governing body fluid homeostasis: the antidiuretic hormone (ADH)-thirst axis (water balance) and the renin-angiotensin-aldosterone system (RAAS)-salt appetite axis (sodium balance). In aquatic environments, large external osmotic gradients drove early renal adaptations primarily focused on water handling. Approximately 600 million years ago, ADH-like nonapeptides emerged, enabling tight regulation of plasma osmolality. With the transition to terrestrial life, the development of long loops of Henle, a hypertonic renal medulla, and exquisitely sensitive thirst mechanisms allowed mammals to conserve water very efficiently. By contrast, the RAAS system, central to sodium conservation and effective circulating volume, appeared later (around 400 million years ago) and remains slower and less sensitive, with no behavioural drive equivalent to thirst. The mineralocorticoid receptor is present in fish, but its specific ligand aldosterone first appears in terrestrial vertebrates. The net result is a phylogenetically more refined defence of water than of sodium. We propose that this evolutionary asymmetry underlies the particular renal vulnerability observed in HSN, in which inadequate sodium replacement and suboptimal control of volaemia may predispose to ischaemic tubular injury. Understanding these evolutionary roots may help explaining why, in the era of global warming, the prevention of HSN requires not only water but also appropriate salt replacement and targeted protection of vulnerable populations.

Z. L. Wang, J. Yan, J. Xiao, W. J. Guo and M. L. Deng.

Gut microbiota modulation in the prevention and treatment of heat stroke.

FRONTIERS IN IMMUNOLOGY. 2026;17.

https://doi.org/10.3389/fimmu.2026.1837970

In recent years, heat stroke (HS) have been reported with increasing frequency, and this trend is hard to separate from broader environmental changes, including climate change, recurrent extreme heat events, and air pollution. When people are exposed to high-temperature environments for a prolonged period, especially during intense physical activity, the condition may progress to HS. HS is an acute and potentially fatal disorder that can deteriorate rapidly if not treated in time. The intestine appears to be particularly vulnerable during HS. HS can disrupt intestinal tight junctions and weaken the barrier function of the gut, leading to what is commonly described as a "leaky gut." Once this barrier is compromised, microbial products such as lipopolysaccharides can enter the bloodstream. These molecules may then activate immune cells, promote excessive cytokine release, and eventually drive a systemic inflammatory response. In severe cases, this inflammatory process can develop into systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction syndrome (MODS). Current evidence increasingly suggests that intestinal injury is not simply a secondary result of HS. Rather, it may serve as an important early event in the development and progression of the disease. Still, it should be noted that much of the available evidence comes from preclinical studies, and strong clinical confirmation is still limited. Probiotics have attracted attention because they may help reduce the occurrence and severity of HS by maintaining gut microbiota balance and regulating intestinal immune responses. However, since most supporting data are still derived from animal experiments, their protective effects in humans need to be interpreted carefully. Another point worth emphasizing is that the gut is not working alone. Through gut-organ communication networks, the intestinal microbiota can interact with distant organs, including the liver, lungs, and brain. These gut-liver, gut-lung, and gut-brain axes may help explain how HS leads to injury beyond the intestine itself. In this review, we summarize current findings on how modulation of the gut microbiota may improve intestinal thermotolerance and strengthen barrier function, with the aim of providing useful insights for the prevention and treatment of HS in clinical practice.

H. A. Brown, K. John, J. D. Elliott, T. A. Deshayes, D. Gagnon, O. Jay, B. Clark and J. D. Périard.

Impact of age, cardiorespiratory fitness, and regular physical activity on physiological strain and cognitive performance during a 6-h extreme heat exposure.

JOURNAL OF APPLIED PHYSIOLOGY. 2026;140(6):1721-31.

https://doi.org/10.1152/japplphysiol.00105.2026

Aging, cardiorespiratory fitness, and habitual physical activity influence thermoregulation and cognition, yet their combined impact during prolonged extreme heat exposure is not well understood. This study investigated how these factors influence thermal strain and cognitive performance across the adult lifespan under extreme heat stress. Sixty-one participants (27 females; 20-79 yr) wore an accelerometer for 7 days, completed a graded exercise test to determine peak oxygen uptake (Vo(2peak)), and underwent a 6-h heat exposure (43 degrees C, 25% relative humidity) with episodic exercise to simulate daily living tasks. Rectal (T-re) and skin temperature, heart rate, whole body sweat rate, and cognitive performance (episodic memory, executive function, attention, and processing speed) were measured. Time, age, Vo(2peak), moderate-vigorous physical activity (MVPA) level, and sex were entered into linear mixed-effects models (mean [95% CI]). Advancing age exacerbated the rise of T-re (per decade: 0.08 degrees C [0.04, 0.13], P < 0.01) and reduced whole body sweating (per decade: -6 g & centerdot;m(-2)& centerdot;h(-1) [-10, -1], P < 0.01). Cognitive performance reduced with advancing age, independent of heat exposure (P < 0.01). Higher cardiorespiratory fitness improved whole body sweat rate (per 10 mL & centerdot;kg(-1)& centerdot;min(-1): 11 g & centerdot;m(-2)& centerdot;h(-1) [2, 19], P = 0.01) and reduced end-exposure heart rate (per 10 mL & centerdot;kg(-1)& centerdot;min(-1): -4 beats/min [-8, -1], P = 0.03). Weekly MVPA and sex showed minimal association with outcome variables. Across adulthood, advancing age exacerbated the rise in T-re and lowered whole body sweating during a 6-h extreme heat exposure. Cardiorespiratory fitness improved whole body sweating but did not offset age-related increases in T-re. Therefore, physiological strain during extreme heat exposure develops progressively across the lifespan, with cardiorespiratory fitness moderating, but not preventing, age-related susceptibility. NEW & NOTEWORTHY Advancing age is associated with progressive increases in the rise in core temperature during extreme heat exposure, and this trajectory is evident across the entire adult lifespan rather than emerging only in older adults. Thermoregulatory capacity declines steadily with each decade, leading to greater thermal strain even in mid-adulthood. Although higher cardiorespiratory fitness enhances sweating, it does not eliminate the age-related increase in core temperature, underscoring that heat vulnerability may develop gradually throughout adulthood.

J. Boadi and Y. A. Boafo.

Occupational heat exposure and self-reported heat-related outcomes among female head porters (Kayayei) in Accra, Ghana.

DISCOVER PUBLIC HEALTH. 2026;23(1).

https://doi.org/10.1186/s12982-026-02150-3

Female head porters (Kayayei) in Accra undertake strenuous load-carrying work under prolonged outdoor heat exposure, yet occupational heat-related illness in this group remains poorly documented. This study examined occupational heat exposure and its associations with self-reported health and livelihood outcomes among Kayayei in Accra.MethodsA mixed-methods cross-sectional study was conducted among 222 Kayayei in Makola and Agbogbloshie markets. Structured questionnaires captured work conditions, sun exposure, heat-related symptoms, menstrual irregularities, missed work due to heat, and healthcare utilisation. Multivariable logistic regression models were used to examine

associations between occupational exposure indicators and selected outcomes. Qualitative interviews with five key informants complemented the quantitative findings.ResultsMost participants reported working more than 8 h/day (84.7%) and under direct sun exposure (96.4%). A high proportion (96.8%) reported at least one heat-related symptom, with headaches (85.6%), muscle cramps (74.8%), heat rashes (62.6%), and dizziness (59.0%) being the most common. Menstrual irregularities were reported by 75.1% of respondents, and 93.2% reported missing work due to heat-related symptoms. Working more than 8 h/day was consistently associated with higher odds of reported heat-related illness, menstrual irregularities, missed work, and healthcare utilisation. Several estimates had wide confidence intervals, indicating limited precision.ConclusionsKayayei experience substantial occupational heat exposure alongside a high burden of self-reported heat-related symptoms and work disruption. Longer working hours were consistently associated with multiple reported outcomes. These findings highlight the need for further longitudinal and intervention-based research and suggest that shaded workspaces, rest opportunities, and improved occupational support may be relevant areas for action in informal urban labour settings.

Outils et capteurs de mesure

A. J. E. Bach, N. R. Morris, S. Sabapathy, D. N. Borg, I. Ennever, P. Sharma and F. K. O'Connor.

Accuracy of next-generation wireless skin temperature sensors during exercise-heat stress.

EXPERIMENTAL PHYSIOLOGY. 2026.

https://doi.org/10.1113/EP093856

Skin temperature is fundamental in characterising human thermoregulatory responses. Wired probes, although accurate, restrict movement and are impractical outside laboratory settings. The iButton (DS1922L; Maxim Integrated, USA) is a widely used wireless alternative but does not meet the precision recommended by ISO 9886 and permits only retrospective data retrieval. A recently developed wireless sensor, the eTemp Performance (BodyCAP, France), claims to address these limitations but has not been validated independently. Here, we compared the eTemp and iButton against a wired thermocouple reference (SST-1; Physitemp, USA) during rest, exercise and recovery in the heat [mean (SD): 35.0 (0.5)degrees C, 40.6 (1.5)% relative humidity]. Twenty-six adults (10 women) completed seated rest (15 min), cycling at fixed heat production (30 min) and passive recovery (15 min). Mean skin temperature was calculated using the Ramanathan four-site formula. Across all periods, the eTemp showed a small negative bias (mean difference, -0.04 degrees C; 95% limits of agreement, -0.33 degrees C to 0.25 degrees C; concordance correlation coefficient, 0.986), whereas the iButton showed a small positive bias (+0.11 degrees C; 95% limits of agreement, -0.23 degrees C to 0.46 degrees C; concordance correlation coefficient, 0.974). The eTemp met all a priori acceptability thresholds for mean skin temperature. The iButton met the acceptability threshold for mean bias in all periods and was statistically equivalent to the reference; however, the 95% confidence interval on the upper limit of agreement marginally exceeded 0.5 degrees C during exercise, recovery and overall. These findings provide the first independent validation of the eTemp Performance sensor and support the use of both wireless devices for mean skin temperature measurement during exercise-heat stress, notwithstanding the known limitations in accuracy of the iButton against the ISO 9886 standard.

Y. Z. Zhao, W. H. Li and J. H. M. Bergmann.

Data-driven estimation of core body temperature during physical activity under heat exposure: A systematic review and standardized evaluation.

BUILDING AND ENVIRONMENT. 2026;297.

https://doi.org/10.1016/j.buildenv.2026.114591

Accurate, real-time estimation of core body temperature (CBT) during physical activity is essential for monitoring heat strain and mitigating the risk of heat-related illness under hot environmental conditions. Although numerous data-driven algorithms using wearable sensors have been proposed, their practical reliability remains unclear due to substantial methodological heterogeneity and the absence of standardized evaluation. This study combined a systematic review with a standardized quantitative benchmark. A total of 38 studies employing non-invasive inputs for CBT estimation were identified. Of these, 14 eligible models, including Kalman filter-based methods, statistical models, and machine-learning approaches, were re-implemented and evalu ated under identical preprocessing and evaluation settings using two independent datasets: Dataset 1 (treadmill walking, n = 16) and Dataset 2 (cycling, n = 13). The benchmark revealed notable differences between originally reported performance and reproduced per formance under standardized conditions. For the widely used heart-rate-based extended Kalman filter, the root mean square error (RMSE) increased from typically

reported values of similar to 0.21-0.41 degrees C to 0.41 degrees C on Dataset 1 and 0.66 degrees C on Dataset 2. Incorporating skin temperature improved tracking accuracy in some configurations, but performance gains were highly dependent on measurement site and dataset. Sensitivity for detecting elevated CBT (>= 38.0 degrees C) varied markedly across methods, particularly for the cycling protocol. In conclusion, no single CBT estimation approach consistently outperformed others across all settings. Heartrate-only models provided a stable baseline under limited sensing conditions, whereas multimodal approaches offered conditional benefits in more controlled scenarios. This work establishes a standardized benchmark frame work to support fair comparison, method selection, and future development of (wearable) CBT estimation technologies.

Travail dans une ambiance thermique extrême

C. Manley, E. Teka, P. Vasudevan and E. S. McClure.

Documenting Experiences of Black Aluminum Smelting Workers in West Badin, North Carolina: A Community-Engaged Survey Approach.

NEW SOLUTIONS-A JOURNAL OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH POLICY. 2026;36(2):211-27.

https://doi.org/10.1177/10482911261455061

Between 1917 and 2007, Alcoa operated an aluminum smelting plant in Badin, North Carolina, resulting in hazardous occupational and environmental exposures in West Badin, a predominantly Black community. We partnered with the Concerned Citizens of West Badin Community to document the experiences of prior employees and their families. We used a community-engaged survey approach to summarize residents' workplace and community-level experiences. Fourteen interviews were coded for recurring themes. Potroom work was the most frequently reported job. Occupational exposures included asbestos, extreme heat, and dust inhalation. Additional workplace stressors included take-home exposures and racism. Most participants expressed concerns about environmental exposures as well. Health conditions most frequently reported included cancer, heart disease, and lung disease. Badin residents experience cumulative impacts of occupational and environmental hazards resulting from Alcoa's operations. This survey served as a tool for documenting their experiences, identifying ongoing environmental concerns, supporting community organizing, and highlighting the resilience of the West Badin community.

J. Mathew, G. Subbaiyan and H. Krishnan.

Impact of Building Height and Window Configurations on Ventilation Performance and Temperature Distribution: A CFD Study of an Institutional Kitchen Environment.

JOURNAL OF DAYLIGHTING. 2026;13(1):143-66.

https://doi.org/10.15627/jd.2026.9

Institutional kitchens often experience inadequate thermal comfort and indoor air quality (IAQ) due to intense heat generation and pollutant emissions from cooking activities, increasing workers' exposure to heat stress and related health risks. Providing adequate ventilation is essential to ensure acceptable IAQ and comfortable working conditions. Enhancing natural ventilation through architectural design can reduce reliance on mechanical systems and energy consumption. This study investigates the influence of two key design parameters, building height and window configuration, on ventilation performance and thermal environment in institutional kitchens. A validated computational fluid dynamics (CFD) model developed in ANSYS Fluent was used to evaluate airflow patterns, IAQ, and temperature distribution across 53 design configurations that varied in height, cross-ventilation pattern, window-ventilator combination, and window distribution. The impact of these variables was assessed using a performance score derived from Principal Component Analysis. Results indicate that the configuration with a 4 m building height and 40% window-to-wall ratio (WWR) on both windward and leeward sides achieved the best performance, whereas the configuration with a 4.5 m height, 40% WWR on the windward side, and 10% on the leeward side performed the poorest. The findings provide design insights for improving natural ventilation and thermal comfort in institutional kitchens.

S. Vosoughi, E. S. Alamshah, I. Alimohammadi, J. A. Talkhooncheh and B. Souri.

Modeling the effect of heat on job burnout and mental workload in the oil industry: A confirmatory factor analysis approach.

WORK-A JOURNAL OF PREVENTION ASSESSMENT & REHABILITATION. 2026.

https://doi.org/10.1177/10519815261459038

Background Workers in tropical and subtropical regions are exposed not only to hot and humid weather but also to occupational stressors that can exacerbate heat stress, leading to physiological, cognitive, and psychological consequences.Objective This study investigated the relationship between thermal stress, mental workload, and occupational burnout among oil industry employees during summer work shifts.Methods A total of 234 male employees were selected through convenience sampling. Participants completed demographic questionnaires, the Maslach Burnout Inventory, and the NASA-TLX mental workload questionnaire. Heat stress and environmental variables were measured with a WBGT device in accordance with the ISO 7243:2017 standard for assessing occupational heat stress. Measurements were conducted under indoor and outdoor conditions. Data analysis included Spearman correlation, independent t-tests, ANOVA, and confirmatory factor analysis to explore direct and indirect relationships between workload, burnout, and their dimensions.Results The average WBGT index exceeded ISO occupational exposure limits in 80.77% of cases. Machine operators, control room engineers, firefighters, and maintenance personnel were most frequently exposed to excessive heat. A significant negative relationship was found between work experience and emotional exhaustion among employees within the ISO-recommended exposure range. Cognitive workload, particularly time pressure and mental demand, was strongly associated with occupational burnout.Conclusion Heat stress indirectly influenced occupational burnout through increased cognitive workload. Greater mental pressure corresponded with higher scores across other workload subscales and burnout dimensions. These findings underscore the need for preventive strategies and improved work-rest schedules in hot industrial environments.

Y. Bao, X. Y. Wu, Z. J. Lin, X. W. Fan and H. X. Xu.

The Stress-Seepage Field and Hygrothermal Environment Evaluation of a High Geothermal Tunnel in Southeast China.

BUILDINGS. 2026;16(12).

https://doi.org/10.3390/buildings16122390

The southeastern coastal region of China is extensively influenced by the circum-Pacific geothermal activity, particularly during the excavation of deep-buried tunnels, where the confined space leads to the accumulation of heat flow, resulting in high-temperature and high-humidity environments. These conditions are detrimental to both the physical and mental health of workers and the safe operation of equipment. Based on this, the Lijiashan deep-buried high-temperature tunnel along the Wen-Yu High-Speed Railway (Wenling-Yuhuan) was selected as a case study. Field monitoring was conducted to assess the surrounding rock stress, temperature distribution characteristics of the surrounding rock and structure, and the humid and high-temperature environment within the tunnel during construction. A comprehensive evaluation index considering both temperature and humidity was employed to evaluate the tunnel construction environment. The results indicate the following: (1) During tunnel excavation, the maximum surrounding rock pressure occurs at the arched shoulder, and the fractures induced by blasting effectively relieve stress, mitigating the risk of rockburst. (2) The seepage paths of the surrounding rock are redistributed during excavation, converging towards the invert, with the osmotic pressure being approximately 10 times that of the upper structure. (3) The temperature at the tunnel

face, secondary lining, and surrounding rock is significantly influenced by the heat released from concrete hydration. The closer the surrounding rock is to the support structure, the higher the temperature, with the secondary lining reaching up to 58.6 degrees C and the working area up to 35.2 degrees C. (4) Water spraying can reduce the temperature in the construction area by approximately 0.65% at the Kelvin temperature conditions, but it increases humidity by about 16%. The average humidity levels within the tunnel are 75.3% during the day and 87.5% at night. (5) Evaluation of workers' physiological parameters reveals that the humid and high-temperature environment during tunnel construction is consistently unfavorable for workers' health.

C. Manley, E. Teka, P. Vasudevan and E. S. McClure.

Documenting Experiences of Black Aluminum Smelting Workers in West Badin, North Carolina: A Community-Engaged Survey Approach.

NEW SOLUTIONS-A JOURNAL OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH POLICY. 2026;36(2):211-27.

https://doi.org/10.1177/10482911261455061

Between 1917 and 2007, Alcoa operated an aluminum smelting plant in Badin, North Carolina, resulting in hazardous occupational and environmental exposures in West Badin, a predominantly Black community. We partnered with the Concerned Citizens of West Badin Community to document the experiences of prior employees and their families. We used a community-engaged survey approach to summarize residents' workplace and community-level experiences. Fourteen interviews were coded for recurring themes. Potroom work was the most frequently reported job. Occupational exposures included asbestos, extreme heat, and dust inhalation. Additional workplace stressors included take-home exposures and racism. Most participants expressed concerns about environmental exposures as well. Health conditions most frequently reported included cancer, heart disease, and lung disease. Badin residents experience cumulative impacts of occupational and environmental hazards resulting from Alcoa's operations. This survey served as a tool for documenting their experiences, identifying ongoing environmental concerns, supporting community organizing, and highlighting the resilience of the West Badin community.

J. Mathew, G. Subbaiyan and H. Krishnan.

Impact of Building Height and Window Configurations on Ventilation Performance and Temperature Distribution: A CFD Study of an Institutional Kitchen Environment.

JOURNAL OF DAYLIGHTING. 2026;13(1):143-66.

https://doi.org/10.15627/jd.2026.9

Institutional kitchens often experience inadequate thermal comfort and indoor air quality (IAQ) due to intense heat generation and pollutant emissions from cooking activities, increasing workers' exposure to heat stress and related health risks. Providing adequate ventilation is essential to ensure acceptable IAQ and comfortable working conditions. Enhancing natural ventilation through architectural design can reduce reliance on mechanical systems and energy consumption. This study investigates the influence of two key design parameters, building height and window configuration, on ventilation performance and thermal environment in institutional kitchens. A validated computational fluid dynamics (CFD) model developed in ANSYS Fluent was used to evaluate airflow patterns, IAQ, and temperature distribution across 53 design configurations that varied in height, cross-ventilation pattern, window-ventilator combination, and window distribution. The impact of these variables was assessed using a performance score derived from Principal Component Analysis. Results indicate that the configuration with a 4 m building height and 40% window-to-wall ratio (WWR) on both windward and leeward sides achieved the best performance, whereas the configuration with a 4.5 m height, 40% WWR on the windward side, and 10% on the leeward side performed the poorest. The findings provide design insights for improving natural ventilation and thermal comfort in institutional kitchens.

S. Vosoughi, E. S. Alamshah, I. Alimohammadi, J. A. Talkhooncheh and B. Souri.

Modeling the effect of heat on job burnout and mental workload in the oil industry: A confirmatory factor analysis approach.

WORK-A JOURNAL OF PREVENTION ASSESSMENT & REHABILITATION. 2026.

https://doi.org/10.1177/10519815261459038

Background Workers in tropical and subtropical regions are exposed not only to hot and humid weather but also to occupational stressors that can exacerbate heat stress, leading to physiological, cognitive, and psychological consequences.Objective This study investigated the relationship between thermal stress, mental workload, and occupational burnout among oil industry employees during summer work shifts.Methods A total of 234 male employees were selected through convenience sampling. Participants completed demographic questionnaires, the Maslach Burnout Inventory, and the NASA-TLX mental workload questionnaire. Heat stress and environmental variables were measured with a WBGT device in accordance with the ISO 7243:2017 standard for assessing occupational heat stress. Measurements were conducted under indoor and outdoor conditions. Data analysis included Spearman correlation, independent t-tests, ANOVA, and confirmatory factor analysis to explore direct and indirect relationships between workload, burnout, and their dimensions.Results The average WBGT index exceeded ISO occupational exposure limits in 80.77% of cases. Machine operators, control room engineers, firefighters, and maintenance personnel were most frequently exposed to excessive heat. A significant negative relationship was found between work experience and emotional exhaustion among employees within the ISO-recommended exposure range. Cognitive workload, particularly time pressure and mental demand, was strongly associated with occupational burnout.Conclusion Heat stress indirectly influenced occupational burnout through increased cognitive workload. Greater mental pressure corresponded with higher scores across other workload subscales and burnout dimensions. These findings underscore the need for preventive strategies and improved work-rest schedules in hot industrial environments.

Y. Bao, X. Y. Wu, Z. J. Lin, X. W. Fan and H. X. Xu.

The Stress-Seepage Field and Hygrothermal Environment Evaluation of a High Geothermal Tunnel in Southeast China.

BUILDINGS. 2026;16(12).

https://doi.org/10.3390/buildings16122390

The southeastern coastal region of China is extensively influenced by the circum-Pacific geothermal activity, particularly during the excavation of deep-buried tunnels, where the confined space leads to the accumulation of heat flow, resulting in high-temperature and high-humidity environments. These conditions are detrimental to both the physical and mental health of workers and the safe operation of equipment. Based on this, the Lijiashan deep-buried high-temperature tunnel along the Wen-Yu High-Speed Railway (Wenling-Yuhuan) was selected as a case study. Field monitoring was conducted to assess the surrounding rock stress, temperature distribution characteristics of the surrounding rock and structure, and the humid and high-temperature environment within the tunnel during construction. A comprehensive evaluation index considering both temperature and humidity was employed to evaluate the tunnel construction environment. The results indicate the following: (1) During tunnel excavation, the maximum surrounding rock pressure occurs at the arched shoulder, and the fractures induced by blasting effectively relieve stress, mitigating the risk of rockburst. (2) The seepage paths of the surrounding rock are redistributed during excavation, converging towards the invert, with the osmotic pressure being approximately 10 times that of the upper structure. (3) The temperature at the tunnel

face, secondary lining, and surrounding rock is significantly influenced by the heat released from concrete hydration. The closer the surrounding rock is to the support structure, the higher the temperature, with the secondary lining reaching up to 58.6 degrees C and the working area up to 35.2 degrees C. (4) Water spraying can reduce the temperature in the construction area by approximately 0.65% at the Kelvin temperature conditions, but it increases humidity by about 16%. The average humidity levels within the tunnel are 75.3% during the day and 87.5% at night. (5) Evaluation of workers' physiological parameters reveals that the humid and high-temperature environment during tunnel construction is consistently unfavorable for workers' health.

Pages web

IRSST.

Des outils pour éviter les coups de chaleur. 2026.

https://prevenir-coup-chaleur-travail.irsst.qc.ca/?utm_campaign=infoIRSST_fr_24_juillet_2026

Ne vous laissez pas surprendre par un coup de chaleur. Il est important d'en reconnaître les symptômes et les signes, de prévoir les mesures préventives et, au besoin, de déterminer un régime d'alternance travail/repos en ambiance chaude. L'Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) offre des outils pour prévenir les coups de chaleur en milieu de travail.

Actualités juin 2026

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

Vague de chaleur : "Nous avons donné des méthodes de travail à tous nos artisans sur l'ensemble du territoire", détaille le président de la Capeb, Jean-Christophe Repon. Franceinfo.fr, 1 juin 2026

Les travaux de BTP autorisés dès 6 h le matin en Indre-et-Loire. Lanouvellerepublique.fr, 18 juin 2026

Fortes chaleurs : comment aménager sa journée de travail pour rester efficace sans s'épuiser ? Sudouest.fr, 18 juin 2026

Au Net Pressing, Nacera travaille malgré des températures étouffantes. Leprogres.fr, 22 juin 2026

Pendant la canicule, ils travaillent à partir de 6 h du matin sur les chantiers en Indre-et-Loire. Lanouvellerepublique.fr, 23 juin 2026

Canicule : des conditions de travail compliquées au CHU de Nantes selon un syndicat, la direction. Labaule.maville.com, 23 juin 2026

Travail et canicule : des ouvriers pas tous logés à la même enseigne. Estrepublicain.fr, 24 juin 2026

Des chauffeurs de bus pestent contre leurs conditions de travail en cette période de canicule. Lunion.fr, 24 juin 2026

Des Français racontent le manque d'adaptation de leur travail à la canicule : « On doit garder notre doudoune sans manches pour être reconnaissables ». lemonde.fr, 24 juin 2026

Canicule : les carriers indépendants adaptent les conditions de travail de leurs équipes et la gestion de leurs équipements. Lemoniteur.fr, 24 juin 2026

« Je préfère éviter un accident ou un malaise » : à Châteaulin, le couvreur Anthony Kerc'hom a stoppé le travail face à la canicule. Letelegramme.fr, 24 juin 2026

« C'est extrêmement éprouvant » : sur ce chantier morbihannais, la canicule complique le travail des ouvriers. Ouest-france.fr, 24 juin 2026

Canicule. « L'après-midi, le travail se fait en binôme pour diminuer les charges » : coup de chaud sur l'industrie. Ouest-france.fr, 24 juin 2026

Travail et logement : les impacts de la canicule. Le Monde (Presse, pp.-6-8), 25 juin 2026

Canicule : au travail, les artisans s'adaptent. Ouest-france.fr, 25 juin 2026

Canicule : très gros coup de chaud sur les conditions de travail. L'Est Républicain (Presse, p.5), 25 juin 2026

Les chauffeurs de bus suffoquent au volant. Le Parisien (Presse, p.91), 25 juin 2026

Dirinon Canicule : horaires de travail adaptés sur les chantiers. Le Télégramme (Presse, p.3), 26 juin 2026

« Les collègues cuisent sous l'avion » : pendant la canicule, des conditions de travail étouffantes sur les pistes et le tarmac des aéroports parisiens. Lemonde.fr, 26 juin 2026

Canicule dans les usines automobiles : « Les conditions de travail sont insupportables ». Liberation.fr, 26 juin 2026

Au secours, il fait trop chaud sur mon lieu de travail ! Franceinfo.fr, 27 juin 2026

Canicule : « Nous sommes dans un changement de régime climatique, mais aussi un changement de régime du travail ». Liberation.fr, 29 juin 2026

Canicule : trois questions à l'ARACT, l'action régionale pour l'amélioration des conditions de travail. France Bleu, 29 juin 2026

« Le beurre, à 30 °C, il fond, c'est impossible à travailler ». Lanouvellerepublique.fr, 29 juin 2026

Canicule : la chaleur transforme tous les métiers en profondeur, de l'agriculture à l'enseignement. Lemonde.fr, 30 juin 2026

MoL enforces midday break amid soaring temperatures. Pressreader.com, 1 juin 2026

CJ Logistics grants stop-work right, tightens heat safety across Korea. Biz.chosun.com, 15 juin 2026

Chennai Corporation relaxes working hours for conservancy workers owing to heat wave. Thehindu.com, 22 juin 2026

Summer weather is here, are B.C. workplaces ready? Pgdailynews.ca, 22 juin 2026

Gulf States: Migrant Workers' Heat Protections Fall Short. Bignewsnetwork.com, 23 juin 2026

- ## Outils et capteurs de mesure

A miniaturized ingestible temperature sensor for continuous internal monitoring. Nature.com, 15 juin 2026

Un nouveau mini-capteur pour la mesurer : à quoi sert de connaître la température interne ? Pourquoidocteur.fr, 21 juin 2026

Comment mesurer l'exposition à la chaleur des travailleurs ? france24.com, 26 juin 2026

- ## Maladies liées à la chaleur

Dans le cinquième plan Santé au travail, le gouvernement s'attaque aux malaises mortels. Usinenouvelle.com, 5 juin 2026

AVC, troubles cognitifs, déshydratation… Comment la canicule met les corps en surchauffe. Liberation.fr, 22 juin 2026

Construction sites are not ready for extreme heat: 44% of workers said they have experienced a heat-related illness. Medicalxpress.com, 26 juin 2026

- **EPI, matériaux protecteurs/refroidissants**

Fortes chaleurs : les vêtements rafraîchissants sont-ils réellement efficaces ? *rtl.fr*, 10 juin 2026

Le boom des vêtements rafraîchissants, alors que la canicule bat son plein. Franceinfo.fr, 25 juin 2026

Vêtements rafraîchissants ou bracelets d'alerte : voici les équipements qui peuvent aider les travailleurs sous la canicule… mais en dernier recours. Sudinfo.be, 26 juin 2026