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Heat: An Interdisciplinary Annotated Bibliography

North American Research (fssssg(H28 (e)4 (a)4 (t)-2 n S)-4 (t)-2 (r)3 ecssnd H28 (e)4 (a)4 (l)-2 (t)-2 hy aogn

manufacturing sector, as well as roofers and firefighters. These occupations would merit special attention for an investigation and evaluation of the potential effects on workers' health.

Calkins, M. M., et al. (2019). "A case-c

method to reduce heat-related illness. Occupational heat-related illnesses and death may be mitigated by targeted cooling intervention and workplace controls among workers of vulnerable occupational groups and industries.

Dong, X. S., et al. (2019). "Heat-related deaths among construction workers in the United States." Am J Ind Med 62(12): 1047-1057.

BACKGROUND: Heat is a severe hazard for construction workers and may be worsening with global warming. This study sought to explore heat-related deaths among U.S. construction workers and a possible association with climate change. METHODS: Heat-related deaths in the Census of Fatal Occupational Injuries from 1992 to 2016 were analyzed. Denominators estimated from the Current Population Survey were matched with demographic and occupational categories in rate calculations. Statistical tests were used to examine heat-related deaths in relation to time, geographic region, and temperature. RESULTS: Construction workers, comprising 6% of the total workforce, accounted for 36% (n = 285) of all occupational heat-related deaths from 1992 to 2016 in the U.S. Mean temperatures from June to August increased gradually over the study period. Increasing summer temperatures from 1997 to 2016 were associated with higher heat-related death rates (r = 0.649; 95% confidence interval: 0.290, 0.848). Compared to all construction workers (risk index = 1), statistically significant elevated risk of heat-related death was found among Hispanics (1.21), in particular workers born in Mexico (1.91). Occupations with a high risk index included cement masons (10.80), roofers (6.93), helpers (6.87), brick masons (3.33), construction laborers (1.93) and heating, air conditioning, and refrigeration mechanics (1.60). CONCLUSIONS: U.S. construction workers are at a high risk of heat-related death, and this risk has increased with climate change over time. Effective workplace interventions, enhanced surveillance, and improved regulations and enforcement should accompany broader efforts to combat global warming. The construction industry can help reduce global warming through increased implementation of green building principles.

Evoy, R., et al. (2022). "The impact of wildfire smoke and temperature on traumatic worker injury claims, Oregon 2009-2018." Health Sci Rep 5(5): e820.

BACKGROUND AND AIMS: As average temperatures rise and wildfire events

present. When the maximum Heat Index was 75 degrees F or greater, the IRR significantly increased as temperatures increased. When the maximum Heat Index was above 80-84 degrees F, All workers had an IRR of 1.04 (95% CI: 1.01-1.06) while Ag/construction workers had an IRR of 1.14 (95% CI: 1.08-1.21) with risk increasing with increased temperatures. In joint models, heat remained associated with injury rates, but not wildfire smoke. No multiplicative interactions between exposures were observed. CONCLUSION: Increasing temperature was associated with increased rates of traumatic injury claims in Oregon that were more pronounced in Ag/Construction workers. Future work should focus on further understanding these associations and effective injury prevention strategies.

Fortune, M. K., et al. (2013). "Work-attributed illness arising from excess heat exposure in Ontario, 2004-2010." Can J Public Health 104(5): e420-426.

OBJECTIVE: To describe the incidence of occupational heat illness in Ontario. METHODS: Heat illness events were identified in two population-based data sources: work-related emergency department (ED) records and lost time claims for the period 2004-2010 in Ontario, Canada. Incidence rates were calculated using denominator estimates from national labour market surveys and estimates were adjusted for workers' compensation insurance coverage. Proportional morbidity ratios were estimated for industry, occupation and tenure of employment. RESULTS: There were 785 heat illness events identified in the ED encounter records (incidence rate 1.6 per 1,000,000 full-time equivalent (FTE) months) and 612 heat illness events identified in the lost time claim records (incidence rate 1.7 per 1,000,000 FTE months) in the seven-year observation period with peak incidence observed in the summer months. The risk of heat illness was elevated for men, young workers, manual workers and those with shorter employment tenure. A higher proportion of lost time claims attributed to heat illness were observed in the government services, agriculture and construction sectors relative to all lost time claims. CONCLUSIONS: Occupational heat illnesses are experienced in Ontario's population and are observed in ED records and lost time claims. The variation of heat illness incidence observed with worker and industry characteristics, and over time, can inform prevention efforts by occupational health services in Ontario.

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spatially examined the case-

Morrissey, M. C., et al. (2021). "Heat Safety in the Workplace: Modified Delphi Consensus to Establish Strategies and Resources to Protect the US Workers." Geohealth 5(8): e2021GH000443.

The purpose of this consensus document was to develop feasible, evidence-based occupational heat safety recommendations to protect the US workers that experience heat stress. Heat safety recommendations were created to protect worker health and to avoid productivity losses associated with occupational heat stress. Recommendations were tailored to be utilized by safety managers, industrial hygienists, and the employers who bear responsibility for implementing heat safety plans. An interdisciplinary roundtable comprised of 51 experts was assembled to create a narrative review summarizing current data and gaps in knowledge within eight heat safety topics: (a) heat hygiene, (b) hydration, (c) heat acclimatization, (d) environmental monitoring, (e) physiological monitoring, (f) body cooling, (g) textiles and personal protective gear, and (h) emergency action plan implementation. The consensus-based recommendations for each topic were created using the Delphi method and evaluated based on scientific evidence, feasibility, and clarity. The current document presents 40 occupational heat safety recommendations across all eight topics. Establishing these recommendations will help organizations and employers create effective heat safety plans for their workplaces, address factors that limit the implementation of het limitommet limit theatiol (me)6 (tom -2 (y t)in1 (ecbome)6 (tom -2 (

boilermakers and ironworkers, while individual personal environments should be investigated for pipefitters and welder-fitters.

Riley, K., et al. (2018). "Mortality and Morbidity during Extreme Heat Events and Prevalence of Outdoor Work: An Analysis of Community-Level Data from Los Angeles County, California." Int J Environ Res Public Health 15(4).

Heat is a well-

underascertainment, national surveillance databases underestimate the true burden of occupational HR-AKI. Clinicians should consider kidney risk from recurrent heat stress. Employers should provide interventions, such as comprehensive heat stress prevention programmes, that include acclimatisation protocols for new workers, to prevent HR-AKI.

Sinyai, C. and G. Barlet (2020). "Designing Occupational Safety and Health Training Materials for Clear Communication." J Occup Environ Med 62(6): 431-438.

INTRODUCTION: Printed materials are an essential part of occupational safety and health programs. Public health professionals at the Centers for Disease Control and Prevention (CDC) have created a Clear Communication Index (CCI) to guide design of health education materials for the general public. METHODS: We revised an existing handout on heat exposure hazards in construction using the CCI and tested the old and new versions of the handout with an audience of 425 construction apprentices and journey-level workers. RESULTS: Some features recommended by the CCI-such as the use of subheadings, numbering, and other visual cues-strongly conditioned the readers' understanding of the main message. CONCLUSIONS: Design and layout have a significant impact on the delivery of messages in written materials. A communications-based rubric such as the CCI can help writers preparing written occupational safety and health materials for workers and general audiences.

Smith, D. J., et al. (2022). "Using Occupational Histories to Assess Heat Exposure in Undocumented Workers Receiving Emergent Renal Dialysis in Georgia." Workplace Health Saf 70(5): 251-258.

BACKGROUND: Immigrants often work in jobs that are known as dirty, demanding, and dangerous. Globally, the agricultural occupations have been associated with the emergence of chronic kidney disease of unknown etiology (CKDu) primarily in outdoor worker populations. The disease has also been reported in immigrants in the United States who work in agricultural occupations, but little research has been done outside of agricultural workers to determine whether immigrants who work other occupations are at risk for developing CKDu. METHODS: This study assessed the self-reported occupational histories of undocumented immigrants receiving frequent, emergent-only dialysis in Atlanta, GA. We assessed demographics, employment status, and work history, using the Grady Dialysis Questionnaire and the Occupational/Environmental Health History Form. RESULTS: Fifty undocumented immigrants receiving frequent, emergent-only hemodialysis were recruited for this study. The average age was 49.5 years (SD +/o-ford

health professionals, public health authorities, employers, dialysis providers, and clinicians who see undocumented workers is required to understand and develop appropriate prevention measures for this population.

assess thermal stress in construction environments. Scheduling of the work earlier or later (after sunset) along with breaks for rest on cool shaded areas are recommended.

Al-Bouwarthan, M., et al. (2019). "Assessment of Heat Stress Exposure among Construction Workers in the Hot Desert Climate of Saudi Arabia." Ann Work Expo Health 63(5): 505-520.

OBJECTIVES: Excessive heat exposure poses significant risks to workers in hot climates. This study assessed the intensity and duration of heat stress exposure among workers performing residential construction in southeastern Saudi Arabia (SA) during the summer, June-September 2016. Objectives were to: identify work factors related to heat stress exposure; measure environmental heat exposure at the construction sites; assess the heat stress risk among workers using the wet bulb globe temperature (WBGT) index; and determine if temperature-humidity indices can be appropriate alternatives to WBGT for managing heat stress risk at the construction sites. METHODS: Worksite walkthrough surveys and environmental monitoring were performed, indoors and outdoors, at 10 construction sites in Al-Ahsa Province. A heat stress exposure assessment was conducted according to the American Conference of Governmental Industrial Hygienists (ACGIH(R)) guidelines, which uses the WBGT index. WBGT measurements from two instruments were compared. Alternative heat stress indices were

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(44%) and 91(78%) outdoors. High-risk HRR occurred on 26 and 36 person-days indoors and outdoors, respectively. The HSE metric showed higher sensitivity for HRR >/=30% outdoors (89%) than indoors (58%) and greater specificity indoors (59%) than outdoors (27%). Workload intensity was generally moderate, with light intensity work more common outdoors. The ability to self-pace work was associated with a lower frequency of HRR >/=30%. USG concentrations indicated that workers began and ended their shifts dehydrated (USG >/=1.020). CONCLUSIONS: Construction work where WBGTOEL is commonly exceeded poses health risks. The ability of workers to self-pace may help reduce risks.

Al-Bouwarthan, M., et al. (2020). "Risk of Kidney Injury among Construction Workers Exposed to Heat Stress: A Longitudinal Study from Saudi Arabia." Int J Environ Res Public Health 17(11).

Saudi Arabia (SA) is one of the hottest countries in the world. This study was conducted to assess the impact of summer heat stress in Southeastern SA on short-term kidney injury (KI) among building construction workers and to identify relevant risk factors. Measurements of urinary albumin-creatinine ratio (ACR), height, weight, hydration, symptoms, daily work and behavioral factors were collected in June and September of 2016 from a cohort of construction workers (n = 65) in Al-Ahsa Province, SA. KI was defined as ACR >/=30 mg/g. Multivariate linear regression analysis was used to assess factors related to cross-summer changes in ACR. A significant increase in ACR occurred among most workers over the study period; incidence of KI was 18%. Risk factors associated with an increased ACR included dehydration, short sleep,

temperatures affect construction workers performance. METHOD: A sample of 120 randomly selected workers (age range 22-35 years) from a large construction company in Dubai participated in this study. Since construction workers performance cannot be directly measured due to the nature of work involved, performance of 60 participants was measured on a task battery involving single reaction time and choice reaction time in summer months before starting work and 5.5 h after starting work. Then the same procedure was repeated on 60 workers in winter months. Accident reports for one full year within the same company were also collected and analyzed. RESULTS: Results show that performance on both tasks before starting work was significantly lower in summer than in winter months possibly due to accumulated fatigue resulting from the high ambient temperature in summer. Results also show that performance on both tasks significantly deteriorated during the first 5.5 h of work to a greater extent in summer months than in winter months. Results also indicate that accidents showed an increasing trend in summer months. CONCLUSIONS: Accumulated fatigue due to high ambient temperature in Summer is thought to cause this drop in performance and increase in accidents. PRACTICAL IMPLICATIONS: Based on the findings, recommendations to enhance construction workers performance and reduce accidents are given.

Bolliet, C., et al. (2015). "Effect of Temperature and Process on Quantity and Composition of Laboratory-generated Bitumen Emissions." J Occup Environ Hyg 12(7): 438-449.

In this study we investigated the impact of temperature on emissions as related to various bitumen applications and processes used in commercial products. Bitumen emissions are very complex and can be influenced in quantity and composition by differences in crude source, refining processes, application temperature, and work practices. This study provided a controlled laboratory environment to study five bitumen test materials from three European refineries; three paving grade, one used for primarily roofing and some paving applications, and one oxidized industrial specialty bitumen. Emissions were generated at temperatures between 140 degrees C and 230 degrees C based on typical application temperatures of each product. Emissions were characterized by aerodynamic particle size, total organic matter (TOM), simulated distillation, 40 individual PACs, and fluorescence (FL-PACs) spectroscopy. Results showed that composition of bitumen emissions is influenced by temperature under studied experimental conditions. A distinction between the oxidized bitumen with flux oil (industrial specialty bitumen) and the remaining bitumens was observed. Under typical temperatures used for paving (150 degrees C-170 degrees C), the TOM and PAC concentrations in the emissions were low. However, bitumen with flux oil produced significantly higher emissions at 230 degrees C, laden with high levels of PACs. Flux oil in this bitumen mixture enhanced release of higher boiling-ranged compounds during application conditions. At 200 degrees C and below, concentrations of 4-6 ring PACs were </=6.51 mug/m(3) for all test materials, even when flux oil was used. Trends learned about emission temperature-process relationships from this study can be used to guide industry decisions to reduce worker exposure during processing and application of hot bitumen.

Bustos, D., et al. (2021). "Applicability of Physiological Monitoring Systems within Occupational Groups: A Systematic Review." Sensors (Basel) 21(21).

The emergence of physiological monitoring technologies has produced exceptional opportunities for real-time collection and analysis of workers' physiological information. To benefit from these safety and health prognostic opportunities, research efforts have explored the applicability of these devices to control workers' wellbeing levels during occupational activities.

A systematic review is proposed to summarise up-to-date progress in applying physiological monitoring systems for occupational groups. Adhering with the PRISMA Statement, five databases were searched from 2014 t

was developed and evaluated. The results of all measurements suggest that the new uniform

of the hybrid cooling vest in terms of cooling effect and ergonomic design for occupational

not suitable for heat stress management. Therefore, in Persian Gulf weather, heat stress evaluation based on physiologic variables may have higher validity than WBGT index.

Doueihy, C., et al. (2022). "Occupational Heat Exposure as a Risk Factor for End-Stage Kidney Disease: A Case-Control Study." J Occup Environ Med 64(3): e103-e108.

OBJECTIVE: More patients are reaching end-stage kidney disease without evident cause. This study aims to explore occupational risk factors associated with hemodialysis. METHODS: A multicenter matched case-control study included dialysis patients and age, sex, and diabetes-matched controls (normal kidney function). Conditional logistic regression analysis assessed occupational factors associated with dialysis. RESULTS: Two hundred thirty eight hemodialysis patients and 238 controls were included. History of occupational heat exposure (odds ratio [OR] = 1.93; 95% confidence interval [CI]: 1.24 to 3.00), working as a cook (OR = 12; 95% CI: 1.56 to 92.29), as construction worker (OR = 10; 95% CI: 1.28 to 78.12) were associated with higher risk of dialysis. These results were si9er ris011 (t)-2 (r)3 (u)-11.2 (e)4 c T*[(

METHODS: A systematic review of published peer-reviewed articles that assessed the effects of extreme heat on OI among non-military workers was undertaken using three databases (PubMed, Embase and Scopus) without temporal or geographical limits from database inception until July 2020. Extreme heat exposure was assessed in terms of hot temperatures and HW periods. For hot temperatures, the effect estimates were converted to relative risks (RR) associated with 1 degrees C increase in temperature above reference values, while for HW, effect estimates were RR comparing heatwave with non-heatwave periods. The patterns of heat associated OI risk were investigated in different climate zones (according to Koppen Geiger classification) based on the study locations and were estimated using random-effects meta-analysis models. Subgroup analyses according to workers' characteristics (e.g. gender, age group, experience), nature of work (e.g. physical demands, location of work i.e. indoor/outdoor) and workplace characteristics (e.g. industries, business size) were also conducted. RESULTS: A total of 24 studies published between 2005 and 2020 were included in the review. Among these, 22 studies met the eligibility criteria, representing almost 22 million OI across six countries (Australia, Canada, Ch (,)]T (r)-5 u Tw [(C)-3 (a)4 (na)4 (d)-10 (a)4 R4 (na)2 (or)3 (k]3nT*iJ R4 (na)2 (or)3(ec

BACKGROUND: Our study was aimed at examining disparate exposure to physically demanding working conditions in France, a key objective being to identify the types of employees/jobs requiring high-priority preventive actions. METHODS: We analyzed the data from the 2017 French nationwide cross-sectional survey (SUMER) on occupational hazards to which French employees in various sectors were subjected. The prevalence of several types of physically demanding working conditions (lifting of heavy loads, awkward body postures, vibrations, noise, and extreme temperatures) was explored. Potential associations of individual and job characteristics with these factors of hardship at work were studied by multivariate logistic regression. RESULTS: In total, 48% of employees were exposed to at least one physically demanding working condition and 24.8% were exposed to multiple constraints. While managers and intellectual professionals were exposed relatively infrequently to physical constraints, blue-collar workers experienced the highest frequency of exposure. On the one hand, the role of company size depended on the factor of hardship at work considered; on the other hand, employees in large-scale companies were generally less exposed. As expected, employees in the construction industry were the most exposed to physical constraints; that said, our results also show that some activities in the services sector (e.g., personal care, administrative and support services) were quite significantly affected by a wide array of physically demanding working conditions. CONCLUSION: Notwithstanding the establishment in France of Plans de Sante au travail (preventive workplace health and safety plans), occupational risks were found to be high, and above all, they were unevenly distributed among the various socio-professional categories, and strongly contributed to social inequalities in health. Our results identify the types of publics to be designated as high-priority targets for preventive measures aimed at reducing the adverse impacts of physically demanding working conditions and the incidence of associated musculoskeletal disorders.

Inaba, R. and S. M. Mirbod (2007). "Comparison of subjective symptoms and hot prevention measures in summer between traffic control workers and construction workers in Japan." Ind Health 45(1): 91-99.

In the present study, a survey on subjective symptoms and hot prevention measures in summer was conducted in 204 male traffic control workers and 115 male construction workers. Work loads of traffic control workers and construction workers were estimated at RMR 1-2 and RMR 2-4, respectively. A self-

individual health risk level based on fuzzy theory using data acquired from a commercially available smart band. The device contains three sensors (PPG, Acc, and skin temperature), two modules (LoRa and GPS), and a power supply, which are embedded into a microcontroller (MCU). Thus, approved personnel can monitor the status as well as the current position of a construction worker via a PC or smartphone, and can make necessary decisions remotely. The platform was tested in both indoor and outdoor environment for reliability, achieved less than 1% of error, and received satisfactory feedback from on-site users.

Langkulsen, U., et al. (2010). "Health impact of climate change on occupational health and productivity in Thailand." Glob Health Action 3.

BACKGROUND: The rise in global temperature is well documented. Changes in temperature lead to increases in heat exposure, which may impact health ranging from mild heat rashes to deadly heat stroke. Heat exposure can also aggravate several chronic diseases including cardiovascular and respiratory disease. OBJECTIVE: This study examined the relationship between climate condition and health status and productivity in two main categories of the occupational setting -

according to International Monetary Fund data. OBJECTIVE: The aim of this paper is to identify occupations at risk and the potential health impacts of heat on workers in Taiwan. DESIGN: Historical data relating to meteorology, population, the labour force and economy were obtained from publicly available databases from the Taiwanese government. RESULTS: Hot seasons with an average maximum temperature above 30 degrees C and relative humidity above 74%, lasting for four to six months from May to October, pose health threats to construction, farming and fishery workers. In particular, populations of ageing farmers and physically overloaded construction workers are the two most vulnerable worker categories in which high temperature impacts on health and productivity. CONCLUSIONS: Currently,

work permits granted to Indians working in the private sector in Oman increased from 47,928 in 1976 to 80,787 in 1980. An estimated 110,000 Indians were working in Oman in 1982, the great majority in the construction and public works sector. A few hundred Indian women were employed by the government of Oman, as domestics, or in other capacities. No accurate data is

The Environmental Ergonomics Unit at the P.O.W. provided a forum for the discussion and consolidation of ideas regarding the origins, current progress and the future development of the Clothing Ventilation Index. Crockford et al (1972) first developed the concept of clothing ventilation. The basic technique employs a trace gas dilution method for measuring the ventilation of the clothing microclimate. Ventilation is vital to the removal of sensible and insensible heat and, therefore, an important determinant of thermal comfort. Two techniques (Lotens and Havenith, 1986, 1988; Reischl et al, 1987) have subsequently been developed. The former method results in an average ventilation value for the total clothed-body surface area, whereas the latter method also takes into consideration regional changes in garment design as separate entities from the total ventilation, allowing for local modification in garment design. The Clothing Ventilation Index is a quantitative, relatively inexpensive, fast, reliable and repeatable technique. It can be used in context, in the working environment to predict the effectiveness, preference and suitability of garments and clothing assemblies; firstly, to ensure that protective clothing is worn and used correctly, and secondly, to improve performance by minimising heat strain, sweat retention and thermal discomfort. Further work on validating the techniques in terms of human responses to the thermal environment is required. Questions were also raised as to whether human beings or manikins should be used. The use of human beings in dynamic situations is of paramount importance; however, manikins could be used for purely

indicated that these workers worked under a positive heat load condition. Whole day work study was conducted on 11 adult female workers performing concreting operation. They were having age of 28-32 years with 5-7 years of work experience. These workers were mainly performing two types of operations in the field: (A) asymmetric lifting during concreting a boundary wall formwork of a lift unit and (B) carrying the concrete mixture. During asymmetric lifting, the average field working heart rate (HR) was calculated as 124.1+/-12.5 beats min(-1), equivalent to 45.03+/-6.93% of VO(2) max level. These working heart rates (HRs) were significantly (p<or=0.005) correlated with pause time (P.T.) and lifting frequency, but not with lifting time. A method was proposed to determine the average steady P.T. from fluctuating working HR and the lifting frequency was calculated as 6.1 lifts min(-1). This type of load handling task showed lower work efficiency and higher relative HR (%RHR). The required resting time was calculated as 61.47%, whereas the actual rest time (R.T.) in the field was 23.56+/-10.28%. Using Neibel and Frivalds equation, the rest allowance (RA) due to muscular fatigue and environmental load were calculated as 50.46% and 45.02 min/h, respectively. These results showed that the workers were not getting sufficient rest in the field. With work parameter modification, in optimum condition, the RWL value could be achieved as 7.19 kg, which was much lesser than the actual lifted load of 12.02 kg. Therefore, modification of workplace and work methods was suggested to compensate the health hazard conditions.

Marinaccio, A., et al. (2019). "Nationwide epidemiological study for estimating the effect of extreme outdoor temperature on occupational injuries in Italy." Environ Int 133(Pt A): 105176.

BACKGROUND: Despite the relevance for occupational safety policies, the health effects of temperature on occupational injuries have been scarcely investigated. A nationwide epidemiological study was carried out to estimate the risk of injuries for workers exposed to extreme temperature and identify economic sectors and jobs most at risk. MATERIALS AND METHODS: The daily time series of work-related injuries in the industrial and services sector from the Italian national workers' compensation authority (INAIL) were collected for each of the 8090 Italian municipalities in the period 2006-

vulnerable jobs, activities and workers in order to define prevention plans and training to reduce occupational exposure to extreme temperature and the risk of work-related injuries.

Messeri, A., et al. (2019). "Heat Stress Perception among Native and Migrant Workers in Italian Industries-

that heat stress management without considering the real hydration status of workers, is insufficient.

Moohialdin, A., et al. (2022). "Physiological impacts on construction workers under extremely hot and humid weather." Int Arch Occup Environ Health 95(2): 315-329.

to quantify thermal strain. The highest average muscular strain was found in the wrist flexor (24 +/- 1.5%MEMG) and extensor (21 +/-

Poulianiti, K. P., et al. (2019). "Metabolic energy cost of workers in agriculture, construction, manufacturing, tourism, and transportation industries." Ind Health 57(3): 283-305.

The assessment of energy cost (EC) at the workplace remains a key topic in occupational health due to the ever-increasing prevalence of work-

The impact of heat stress on human health has been extensively studied. Similarly, researchers have investigated the impact of heat stress on workers' health and safety. However, very little work has been done on the impact of heat stress on occupational accidents and their severity, particularly in South Australian construction. Construction workers are at high risk of injury due to heat stress as they often work outdoors, undertake hard manual work, and are often project based and sub-contracted. Little is known on how heat waves could impact on construction accidents and their severity. In order to provide more evidence for the currently limited number of empirical investigations on the impact of heat stress on accidents, this study analysed 29,438 compensation claims reported during 2002-2013 within the construction industry of South Australia. Claims reported during 29 heat waves in Adelaide were compared with control periods to elicit differences in the number of accidents reported and their severity. The results revealed that worker characteristics, type of work, work environment, and agency of accident mainly govern the severity. It is recommended that the implementation of adequate preventative measures in small-sized companies and civil engineering sites, targeting mainly old age workers could be a priority for Work, Health and Safety (WHS) policies.

Ricco, M., et al. (2020). "Air temperatures and occupational injuries in the construction industries: a report from Northern Italy (2000-2013)." Ind Health 58(2): 182-192.

The aim of this study was to assess the relationship between environmental temperatures and occupational injuries (OIs) in construction workers (CWs) from a subalpine region of North-Eastern Italy. Data about OIs from 2000 to 2013, and daily weather for the specific site of the events were retrieved. Risk for daily OIs was calculate through a Poisson regression model. Estimated daily incidence for OIs was 5.7 (95%CI 5.5-5.8), or 2.8 OIs/10,000 workers/d (95%CI 2.7-2.9), with higher rates for time periods characterized by high temperatures (daily maximum >/=35 degrees C), both in first 2 d (3.57, 95%CI 3.05-4.11) and from the third day onwards (i.e. during Heat Waves: 3.43, 95%CI 3.08-3.77). Higher risk for OIs was reported in

work-rest regimen for paced work. The other tool is developed to enable workers' self-regulation during self-paced work.

Rowlinson, S., et al. (2014). "Management of climatic heat stress risk in construction: a review of practices, methodologies, and future research." Accid Anal Prev 66: 187-198.

Climatic heat stress leads to accidents on construction sites brought about by a range of human factors emanating from heat induced illness, and fatigue leading to impaired capability, physical and mental. It is an occupational characteristic of construction work in many climates and the authors take the approach of re-engineering the whole safety management system rather than focusing on incremental improvement, which is current management practice in the construction industry. From a scientific viewpoint, climatic heat stress is determined by six key factors: (1) air temperature, (2) humidity, (3) radiant heat, and (4) wind speed indicating the environment, (5) metabolic heat generated by physical activities, and (6) "clothing effect" that moderates the heat exchange between the body and the environment. By making use of existing heat stress indices and heat stress management processes, heat stress risk on construction sites can be managed in three ways: (1) control of environmental heat stress exposure through use of an action-triggering threshold system, (2) control of continuous work time (CWT, referred by maximum allowable exposure duration) with mandatory work-rest regimens, and (3) enabling self-paced working through empowerment of employees. Existing heat stress practices and methodologies are critically reviewed and the authors propose a three-level methodology for an action-triggering, localized, simplified threshold system to facilitate effective decisions by frontline supervisors. The authors point out the need for "regional based" heat stress management practices that reflect unique climatic conditions, working practices and acclimatization propensity by local workers indifferent geographic regions. The authors set out the case for regional, rather than international, standards that account for this uniqueness and which are derived from site-based rather than laboratory-based research.

Rushton, L. and J. H. S (2017). "The burden of occupationally-related cutaneous malignant melanoma in Britain due to solar radiation." Br J Cancer 116(4): 536-539.

BACKGROUND: Increasing evidence highlights the association of occupational exposure and cutaneous malignant melanoma (CMM). We estimated the burden of CMM and total skin cancer burden in Britain due to occupational solar radiation exposure. METHODS: Attributable fractions (AF) and numbers were estimated for CMM mortality and incidence using risk estimates from the published literature and national data sources for proportions exposed. We extended existing methods to account for the exposed population age structure. RESULTS: The estimated total AF for CMM is 2.0% (95% CI: 1.4-2.7%), giving 48 (95% CI: 33-64) deaths in (2012) and 241 (95% CI: 168-325) registrations (in 2011) attributable to occupational exposure to solar radiation. Higher exposure and larger numbers exposed led to much higher numbers for men than women. Industries of concern are construction, agriculture, public administration and defence, and land transport. CONCLUSIONS: These results emphasise the urgent need to develop appropriate strategies to reduce this burden.

Sett, M. and S. Sahu (2014). "Effects of occupational heat exposure on female brick workers in West Bengal, India." Glob Health Action 7: 21923.

BACKGROUND: Manual brick-manufacturing units in India engage a large number of female workers on a daily-wage basis for a period of 8 month

are mostly unorganized, and the workers are exposed to extreme conditions such as very high seasonal heat. The present trend of increasing temperatures, as a result of global warming and climate change, will put an additional burden on them. OBJECTIVE: This study aims to evaluate the effect of workplace heat exposure on the well-being, physiological load, and productivity of female brickfield workers in India. DESIGN: A questionnaire study (n=120), environmental temperature, and weekly work productivity analyses were evaluated for 8 months in the brickfields. Cardiac strain and walking speed (subset, n=40) were also studied and compared in hotter and colder days amongst the female brickfield workers. RESULTS: The subjects experience summer for about 5 months with additional heat stress radiating from the brick kiln. The weekly productivity data show a linear decline in productivity with increased maximum air temperature above 34.9 degrees C. The cardiac parameters (peak heart rate (HRp), net cardiac cost (NCC), relative cardiac cost (RCC), and recovery heart rates) were significantly higher on hotter days (Wet Bulb Globe Temperature (WBGTout) index: 26.9 degrees C to 30.74 degrees C) than on cooler days (WBGTout index: 16.12 degrees C to 19.37 degrees C) for the brick molders; however, this is not the case for the brick carriers. As the brick carriers adapt to hotter days by decreasing their walking speed, their productivity decreases. CONCLUSION: We conclude that high heat exposure in brickfields during summer caused physiological strain in both categories of female brickfield workers. A coping strategy employed by the brick carriers was to reduce their walking speed and thus lose part of their earnings. The lost productivity for every degree rise in temperature is about 2% in the brickfields. This reduction will be exacerbated by climate change and may undermine the quality of life of female brickfield workers.

Shahzad, A., et al. (2020). "Acute Myocarditis in a Patient with Exertional Heat Illness: A Rare Association." Eur J Case Rep Intern Med 7(12): 002027.

INTRODUCTION: Exertional heat illness (EHI) is common in hot weather among young athletes, outdoor manual workers and military personnel. EHI can involve multiple organs of the body, including the muscles, kidneys and brain; however, myocardium involvement is infrequent. MATERIALS AND METHODS: We present the case of a 26-year-old male construction worker who worked outdoors in a hot arid environment. He presented with acute kidney injury and rhabdomyolysis and was diagnosed with EHI. During his hospital stay, he developed complete heart block, and cardiac MRI showed features of myocarditis. Work-up to identify other aetiologies of myocarditis was normal. This case highlights the effects of EHI on the myocardium. CONCLUSION: It is important to keep in mind the various effects of EHI on the myocardium. Myocarditis due to EHI is rare, and conduction defects resulting from it might persist, necessitating specialist intervention. LEARNING POINTS: Exertional heat illness (EHI) can cause end-organ damage and it is imperative to keep in mind the various effects of EHI on the myocardium.Myocarditis due to EHI is rare, and conduction defects resulting from it might persist, requiring specialist intervention.

Shakerian, S., et al. (2021). "Assessing occupational risk of heat stress at construction: A worker-centric wearable sensor-based approach." Safety Science 142: 105395.

Construction workers are at a high risk of exposure to excessive heat generated by several factors such as intensive physical activities, personal protective clothing, and frequent heat events at construction sites. Previous studies attempted to evaluate the occupational risk of heat stress by concentrating on environmental variables or the self-assessment measures of perceived heat. Despite their potentials, most of these approaches were intrusive, inaccurate,

and intermittent. More importantly, they mainly overlooked the disparities in workers' physical and physiological characteristics. To address these limitations, this study proposes a heat-stress risk-assessment process to evaluate workers' bodily responses to heat – heat strain – based on the continuous measurement of their physiological signals. To this end, workers' physiological signals were captured using a wristband-type biosensor. Subsequently, their physiological signals were decontaminated from noises, resampled into an array of informative features, and finally interpreted into distinct states of individuals' heat strain by employing several supervised learning algorithms. To examine the performance of the proposed process, physiological signals were collected from 18 subjects while performing specific construction tasks under three predetermined environmental conditions with a different probability of exposure to heat stress. The analysis results revealed the proposed process could predict the risk of heat strain with more than 92% accuracy, illuminating the potentials of wearable biosensors to continuously assess workers' heat strain. The long-term implications of this study can be capitalized as guidelines to improve systematic evaluation of heat strain and promote workers' occupational safety and well-being through early detection of heat strain at construction sites.

Sheng, R., et al. (2018). "Does hot weather affect work-related injury? A case-crossover study in Guangzhou, China." Int J Hyg Environ Health 221(3): 423-428.

BACKGROUND: Despite increasing concerns about the health effects of climate change, the extent to which workers are affected by hot weather is not well documented. This study aims to investigate the association between high temperatures and work-related injuries using data from a large subtropical city in China. METHODS: We used workers' compensation claims to identify work-related injuries in Guangzhou, China during 2011-2012. To feature the heat effect, the study period was restricted to the warm seasons in Guangzhou (1 May-31 October). We conducted a time-stratified case-crossover study to examine the association between ambient outdoor temperatures, including daily maximum and minimum temperatures, and cases of work-related injury. The relationships were assessed using conditional Poisson regression models. RESULTS: Overall, a total of 5418 workers' compensation claims were included over the study period. Both maximum and minimum temperatures were significantly associated with work-related injuries, but associations varied by subgroup. One degrees C increase in maximum temperature was associated with a 1.4% (RR = 1.014, 95%CIs 1.012-1.017) increase in daily injury claims. Significant associations were seen for male and middle-aged workers, workers in small and medium-sized enterprises, and those working in manufacturing sector. And 1 degrees C increase in minimum temperature was associated with 1.7% (RR = 1.017, 95%CIs 1.012-1.021) increase in daily injury claims. Significant associations were observed for female and middle-aged workers, workers in large-sized enterprises, and those working in transport and construction sectors. CONCLUSIONS: We found a higher risk of work-

workers recruited between 2003 and 2008. Personal air sampling in the workers' breathing zone was carried out during the shift to measure exposure to vapours and aerosols of bitumen. The majority of workers were engaged in building construction, where exposure levels were lower than in tunnels but higher than at road construction sites. At building construction sites, exposure levels were influenced by the room size, the processing temperature of the mastic asphalt and the job task. The results show that protective measures should include a reduction in the processing temperature.

Szer, I., et al. (2022). "Using meteorological data to estimate heat stress of construction workers on scaffolds for improved safety standards." Automation in Construction 134: 104079.

The analysis of susceptibility of construction workers to heat stress, the results of which are presented in this paper, was an important research module of the large research project focused on safety of workers on construction sites. The paper assesses the possibility of using different sets of data gathered in full scale on the scaffolding and on the meteorological station to estimate the heat stress of people working on scaffolding. The main purpose is to check if the use of public data from meteorological stations can provide reliable estimation. A simplified formula of Universal Thermal Climate Index (UTCI*) is used in analyses. The values of UTCI* calculated on the basis of two sets of input parameters are compared to each other and analysed. The measurements and UTCI* calculations are presented for 24 scaffolding structures located in Poland in Łódź and Lower Silesian provinces. Test results based on construction sites and meteorological stations data are different, but statistical analysis shows their correlation. A stronger correlation occurs for scaffolding structures located in Łódź province, while it is weaker for the results obtained in Lower Silesian province. The results show the possibility of simplified evaluation of comfort/discomfort of people working on scaffolding on the basis of publicly available environmental data measured at meteorological stations.

Extreme heat stress has a deep impact on physiological reactions, which results in occupational injuries and deaths. In this paper, an attempt is made to understand the impact of heat stress on construction accidents in Oman. A literature review on heat stress is discussed in the first section followed by an analysis of 623 accidents that occurred in a highway project. The analysis of these accidents reveals that more severe accidents on this project took place from 11:00 to 17:00. The semi-structured interview held with some of the workers involved in these accidents confirmed excessive heat as one of the main reason behind these accidents. The health profile of the same workers is measured in terms of their body mass index and blood pressure. The results show that 80% of the workers from the selected sample were found to be overweight or obese and 40% of the participants were hypertensive. The safety performance of such workers is particularly discussed in relation to heat stress. The effective implementations of day time break in summer, a healthy diet, appropriate sleeping habit, scheduling physically demanding tasks during early morning and evening and adopting light colour and loose fitting uniform could reduce the impact of heat stress.

Vatani, J., et al. (2016). "Applicability of Universal Thermal Climate Index (UTCI) in occupational heat stress assessment: a case study in brick industries." Ind Health 54(1): 14-19.

The present study aimed to investigate the applicability of Universal Thermal Climate Index (UTCI) as an innovative and science-based index in public health researches, in occupational heat stress assessment. All indoor and outdoor workers (20t (m)-2 (b9 H)-8 (e)ng tpprsent-2 (l)-2 I

vibrations, humidity, cold, heat, chemical substances, lifting/carrying heavy loads, transport of equipment, working in non-ergonomic positions and in cramped spaces, as well as climbing.Indeed, statistical analyses showed that, after adjusting for phase of the wind farm, age, nationality, offshore experience, work schedule and type of shift, compared with non-technicians, working as a technician was associated with more frequently lifting/carrying of heavy loads (OR 2.58, 95% CI 1.58 to 4.23), transport of equipment (OR 2.06 95% CI 1.27 to 3.33), working with a twisted upper body (OR 2.85 95% CI 1.74 to 4.69), working overhead (OR 2.77 95% CI 1.67 to 4.58) and climbing (OR 2.30 95% CI 1.40 to 3.77). Working in wind farms under construction was strongly associated with increased and decreased exposure to humidity (OR 2.32 95% CI 1.38 to 3.92) and poor air quality (OR 0.58 95% CI 0.35 to 0.95), respectively. CONCLUSIONS: Workers on offshore wind farms constitute a heterogeneous group, including a wide variety of occupations. The degree of exposure to detrimental physical strains varies depending on the type of job. Technicians are more exposed to ergonomic challenges than other offshore workers.

Venugopal, V., et al. (2016). "The Social Implications of Occupational Heat Stress on Migrant Workers Engaged in Public Construction." The International Journal of the Constructed Environment 7: 25-36.

Health deterioration due to multiple exposures to hazards is not uncommon among construction workers. Migrant workers contribute a lion’s share (~79%) to public construction in India and about two-thirds of the migrant workforce lives in temporary habitats with minimal basic amenities. The implications of occupational heat stress on the health and social lives of the migrant workers engaged in construction of public metro railway was explored. One hundred and forty-two migrant workers were engaged in the study after obtaining informed consent. Quantitative data on environmental heat exposures and qualitative information on the impacts of heat stress on health, productivity losses, and social lives via interviews was collected. Seventy-seven percent of workers reported a range of health impacts and 68 percent reported productivity losses and lost wages due to heat. Seventy-six percent of women workers complained of significant impacts on their social lives in the form of disruptions in children education, addictions, and inability to care for family due to frequent sickness. Women also reported that heat stress, plus lack of access to toilets, further aggravated urinary tract infections and kidney related illnesses. Unsanitary living conditions and competition for limited resources in habitats were reported to increase theft and social violence among adults/children. In an increasingly warmer global climate and an increasing constructed demand, stronger policies to prevent morbidity/mortality among vulnerable migrant workers in the construction sector is imperative. Better health, literacy rates, and decreased crime statistics among migrant community are potential positive implications of protective policies.

Watson, C., et al. (2021). "Industrial workwear for hot workplace environments: thermal management attributes." Int J Biometeorol 65(10): 1751-1765.

Personal protective clothing (PPC) is critical for worker safety and wellbeing from both protection and thermal management perspectives, particularly as PPC typically covers more than 90% of the body. Research of PPC in low-risk categories such as mining, oil, gas, and construction and their thermal management attributes is limited, although these industries represent a significant proportion of the industrial workforce, work across a broad range of major industries, and frequently work in hot and/or humid thermal environments. This study evaluated and characterized the thermal management attributes of a selection of commercial

This study aimed to (1) quantify the respective physical workloads of bar bending and fixing; and (2) compare the physiological and perceptual responses between bar benders and bar fixers. Field studies were conducted during the summer in Hong Kong from July 2011 to August 2011 over six construction sites. Synchronized physiological, perceptual, and environmental parameters were measured from construction rebar workers. The average duration of the 39 field measurements was 151.1 +/- 22.4 min under hot environment (WBGT = 31.4 +/- 2.2 degrees C), during which physiological, perceptual and environmental parameters were synchronized. Energy expenditure of overall rebar work, bar bending, and bar fixing were 2.57, 2.26 and 2.67 Kcal/min (179, 158 and 186 W), respectively. Bar fixing induced significantly higher physiological responses in heart rate (113.6 vs. 102.3 beat/min, $p < 0.05$), oxygen consumption (9.53 vs. 7.14 ml/min/kg, $p < 0.05$), and energy expenditure (2.67 vs. 2.26 Kcal/min, $p < 0.05$) (186 vs. 158 W, $p < 0.05$) as compared to bar bending. Perceptual response was higher in bar fixing but such difference was not statistically significant. Findings of this study enable the calculation of daily energy expenditure of rebar work.

Xiang, J., et al. (2014). "Health impacts of workplace heat exposure: an epidemiological review." Ind Health 52(2): 91-101.

With predicted increasing frequency and intensity of extremely hot weather due to changing climate, workplace heat exposure is presenting an increasing challenge to occupational health and safety. This article aims to review the characteristics of workplace heat exposure in selected relatively high risk occupations, to summarize findings from published studies, and ultimately to provide suggestions for workplace heat exposure reduction, adaptations, and further research directions. All published epidemiological studies in the field of health impacts of workplace heat exposure for the period of January 1997 to April 2012 were reviewed. Finally, 55 original articles were identified. Manual workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress, especially those in low-middle income countries in tropical regions. At risk workers include farmers, construction workers, fire-fighters, miners, soldiers, and manufacturing workers working around process-generated heat. The potential impacts of workplace heat exposure are to some extent underestimated due to the underreporting of heat illnesses. More studies are needed to quantify the extent to which high-risk manual workers are physiologically and psychologically affected by or behaviourally adapt to workplace heat exposure exacerbated by climate change.

Xiang, J., et al. (2014). "The impact of heatwaves on workers' health and safety in Adelaide, South Australia." Environ Res 133: 90-95.

This study aims to investigate the impact of heatwaves on worker's health and safety; to identify workers at higher risk of prevalent illnesses and injuries due to heatwaves; and to provide evidence for policy-makers and service providers. South Australian workers' compensation claims data for 2001-2010 were transformed into time series format, merged with meteorological data and analysed using generalized estimating equation (GEE) models. For total injury claims there was no significant difference detected between heatwave and non-heatwave periods. However, for outdoor industries, daily claims increased significantly by 6.2% during heatwaves. Over-represented in hot weather were male labourers and tradespersons aged >/= 55 years, and those employed in 'agriculture, forestry and fishing' and 'electricity, gas and water'. Occupational burns, wounds, lacerations, and amputations as well as heat illnesses were significantly associated with heatwaves. Similarly, moving objects, contact with chemicals, and injuries related to environmental factors increased significantly during heatwaves, especially

Developing heat stress interventions for construction workers has received mounting concerns in recent years. However, limited efforts have been exerted to elaborate the rationale, methodology, and practicality of heat stress intervention in the construction industry. This study aims to review previous heat stress intervention research in construction, to identify the major research gaps in methodological issues, and to offer detailed recommendations for future studies. A total of 35 peer-reviewed journal papers have been identified to develop administrative, environmental or personal engineering interventions to safeguard construction workers. It was found that methodological limitations, such as arbitrary sampling methods and unreliable instruments, could be the major obstacle in undertaking heat stress intervention research. To bridge the identified research gaps, this study then refined a research framework for conducting heat stress intervention studies in the construction industry. The proposed research strategy provides researchers and practitioners with fresh insights into expanding multidisciplinary research areas and solving practical problems in the management of heat stress. The proposed research framework may foster the development of heat stress intervention research in construction, which further aids researchers, practitioners, and policymakers in formulating proper intervention strategies.

Yang, Y. and A. P. Chan (2017). "Role of work uniform in alleviating perceptual strain among construction workers." Ind Health 55(1): 76-86.

This study aims to examine the benefits of wearing a new construction work uniform in real-work settings. A field experiment with a randomized assignment of an intervention group to a newly designed uniform and a control group to a commercially available trade uniform was executed. A total of 568 sets of physical, physiological, perceptual, and microclimatological data were obtained. A linear mixed-effects model (LMM) was built to examine the cause-effect relationship between the Perceptual Strain Index (PeSI) and heat stressors including wet bulb globe temperature (WBGT), estimated workload (relative heart rate), exposure time, trade, workplace, and clothing type. An interaction effect between clothing and trade revealed that perceptual strain of workers across four trades was significantly alleviated by 1.6-6.3 units in the intervention group. Additionally, the results of a questionnaire survey on assessing the subjective sensations on the two uniforms indicated that wearing comfort was improved by 1.6-1.8 units when wearing the intervention type. This study not only provides convincing evidences on the benefits of wearing the newly designed work uniform in reducing perceptual strain but also heightens the value of the field experiment in heat stress intervention studies.

break between 12:00 p.m. and 1:00 p.m., and working from 1:00 p.m. to 5:30 p.m. with a 30 min break at 3:00 p.m. is proposed. The proposed work pattern not only maximizes direct-work rates but also minimizes the occurrence of heat stress on construction site. This will enable policy makers to derive solid guidelines for working in hot weather. Because the proposed work pattern is developed specifically for the construction industry, more work is needed to further investigate other industries and other climates to provide a holistic view in the future.

Yi, W. and A. P. C. Chan (2017). "Effects of Heat Stress on Construction Labor Productivity in Hong Kong: A Case Study of Rebar Workers." Int J Environ Res Public Health 14(9).

Global warming is bringing more frequent and severe heat waves, and the result will be serious for vulnerable populations such as construction workers. Excessive heat stress has profound effects on physiological responses, which cause occupational injuries, fatalities and low productivity. Construction workers are particularly affected by heat stress, because of the body heat production caused by physically demanding tasks, and hot and humid working conditions. Field studies were conducted between August and September 2016 at two construction training grounds in Hong Kong. Onsite wet-bulb globe temperature (WBGT), workers' heart rate (HR), and labor productivity were measured and monitored. Based on the 378 data sets of synchronized environmental, physiological, construction labor productivity (CLP), and personal variables, a CLP-heat stress model was established. It was found that WBGT, percentage of maximum HR, age, work duration, and alcohol drinking habits were determining factors for predicting the CLP (adjusted $R^2 = 0.68$, $p < 0.05$). The model revealed that heat stress reduces CLP, with the percentage of direct work time decreasing by 0.33% when the WBGT increased by 1 °C. The findings in this study extend the existing practice notes by providing scientific data that may be of benefit to the industry in producing solid guidelines for working in hot weather.

Yi, W., et al. (2017). "Evaluating the Effectiveness of Cooling Vest in a Hot and Humid Environment." Ann Work Expo Health 61(4): 481-494.

OBJECTIVE: This study aims to evaluate the effectiveness of a newly designed hybrid

31.56 +/- 1.87 degrees C. Compared with the control, physiological and perceptual strain were significantly reduced in the cooling condition during rest and subsequent work periods ($p < 0.05$; $d = 0.24$-1.07, small to large cooling effect). Cooling intervention significantly alleviates heat strain in the construction industry. The effectiveness and practicality of a proposed cooling intervention were tested in a field study. Results provide a reference for setting guidelines and promoting application on a range of construction sites.

Zhao, Y., et al. (2017). "Evaluating the Physiological and Perceptual Responses of Wearing a Newly Designed Cooling Vest for Construction Workers." Ann Work Expo Health 61(7): 883-901.

Construction workers are subjected to heat stress because of the hot environment,nt(s)-1 (2 (i)-2 (i)-2 (i)