PLOS CLIMATE

RESEARCH ARTICLE

Safety awareness and adaptation strategies of Nigerian construction workers in extreme heat conditions

Haruna Musa Moda[1,2]*, **Mahmud Bello Zailani**[3], **Ravi Rangarajan**[1], **Pauline Hickey**[1], **Mu'awiya Abubakar**[3], **Joy Maina**[4], **Yahaya Ibrahim Makarfi**[5]

1 Department of Environmental Health and Safety, University of Doha for Science and Technology, Doha, Qatar, **2** Department of Health Professions, Manchester Metropolitan University, Manchester, United Kingdom, **3** Department of Building, Ahmadu Bello University, Zaria, Nigeria, **4** Department of Architecture, Ahmadu Bello University, Zaria, Nigeria, **5** Department of Quantity Surveying, Ahmadu Bello University, Zaria, Nigeria

* haruna.moda1@gmail.com

OPEN ACCESS

Citation: Moda HM, Zailani MB, Rangarajan R, Hickey P, Abubakar M, Maina J, et al. (2024) Safety awareness and adaptation strategies of Nigerian construction workers in extreme heat conditions. PLOS Clim 3(4): e0000380. https://doi.org/10.1371/journal.pclm.0000380

Editor: Asif Qureshi, Indian Institute of Technology Hyderabad, INDIA

Received: November 2, 2023

Accepted: March 18, 2024

Published: April 17, 2024

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pclm.0000380

Data Availability Statement: Minimal data set uploaded as Supporting information file.

Funding: This work was funded by the Department of Health Professions, Manchester Metropolitan

Abstract

The nature of most construction activities exposes workers to health and safety risks associated with extreme hot weather conditions especially within developing countries in the global south. Considering the magnitude of health and safety risks associated with extreme heat exposure and the prevailing safety culture, and attitude among workers that impede adaptation to safe work practices under extreme heat conditions, it is imperative that serious attention is given to workplace climate change impact on construction workers. The current study provides empirical evidence on safety awareness and practices among Nigerian construction workers, those often exposed to extreme hot weather conditions. A structured questionnaire was used to elicit data from 576 respondents using random sampling technique and the data was analysed using descriptive and inferential statistical tools. As part of the study outcome, 57.3% of the respondents raised concerns regarding the non-availability of potable water source on sites, which directly impacts their level of fluid intake while working in extreme heat conditions. To improve safety and enhance productivity, construction organisations need to prioritise workers' safety through the implementation of sustainable adaptive strategies that include the development of early warning systems related to heat stress at work, development of tailored intervention and adaptive measures and enhancement of heat stress awareness among workers. The study provides evidence on the impact of heat stress among construction workers and the need to improve safety awareness and mitigation against climate change driven extreme heat conditions especially among workers in tropical countries.

Introduction

Ambient temperature increases associated with climate change has the potential to increase the frequency of occupational hazards especially among outdoor workers [1–3]. The

University, UK [grant numbers O-20047.C, 2021 to HMM]. The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

construction industry is a high-risk sector experiencing an exponential increase in workplace health and safety concerns due to the impact of global warming, especially in the developing countries [4–6]. With climate change, occurrence of extreme events like heat waves increases the frequency of adverse health effects and such changes in the climate due to variability in direct and indirect factors will pose safety and health challenges especially among outdoor workers [7,8].

Notwithstanding the growing body of research and development in the areas of public health and environmental dynamics of climate change, there exists a need to place closer attention to risks related to heat exposure, other workplace associated hazards and opportunities related to climate change adaptation, especially among outdoor workers in the global south [9,10]. Outdoor workers (in construction, agriculture, forestry, mining, municipal work, etc.) are often directly exposed to the effects of heat exposure at much higher rate, which in the long-term results in increased prevalence and severity of associated occupational health hazards, and possible development of new hazards [7,8,11–13]. Relatedly, the magnitude of health risks among workers exposed to extreme work environments include skin cancer, chronic kidney disease, high blood pressure, heat stroke, influenza, psychosis and possibly, neurosis. The probability of these health effects will likely increase with the added duration of exposure to excessive heat at work [12–14]. In this regard, the World Health Organization has emphasised the need to take decisive action aimed at addressing health impacts associated with climate change [15]. In addition, the United Nations Sustainable Development Goals (SDGs 3 and 8) advocate organisations to establish values around decent work and the promotion of workplace safety and workers' welfare across industries [16]. Recently, as part of the fundamental principles and rights at work by the International Labour Organisation (ILO), member states were tasked with committing to a safe and healthy working environment. At a continental level, the strategic framework for achieving wide-ranging and sustainable economic progress and development in Africa, "Agenda 2063-The Africa we want", itemised key priority expanses that include decent work as part of its 50 years' development strategy [17,18]. These efforts, among others, have pushed hazardous industries, such as the construction sector, to adopt counter safety measures, such as the development of Construction Hazards Prevention through Design (CHPtD) where engineers and architects explicitly consider safety of construction projects at the design phase [19]. In furtherance, high-risk industries are experiencing a drive towards the vision of zero workplace accidents through the promotion of safe work and attainment of safety excellence especially in developed countries [20]. These measures, if properly incorporated into workplace safety practices, will aid climate change adaptation and promotion of workers' wellbeing, reduce the chance of heat-related morbidity occurrences and consequences.

While improving workers' safety related to extreme heat exposure is deemed urgent and necessary considering the magnitude of associated risks, the prevailing culture and attitude of construction workers in the global south has been highlighted as likely to impede prompt awareness and adaptation to good working practices [8]. Studies have opined that the likelihood and magnitude of the occurrence of risks on the job site exponentially declines when there is increased awareness on the risks involved, and continuous efforts are made towards ensuring safety [21]. Relatedly, studies have earlier identified the general lack of effort from both workers and their employers in the Nigerian Construction Industry (NCI) to achieve these goals [22–24]. Furthermore, low levels of safety related attitude and behaviour amongst construction workers in the country often impede their ability to recognise key health and safety hazards on the jobsite [25]. This, according to a recent study [24] is an indicator of employers' poor commitment to a positive safety climate in the work environment. In addition, architectural practitioners in the NCI recently rated focusing on health and safety issues

as the least among 45 Key Performance Indicators for project success [26]. As such, there is the need for the development of resilient approaches towards managing safety challenges among Nigerian construction workers [27], especially due to the persistent changing dynamics in the work environment which pose novel and unprecedented challenges.

Attainment of positive safety climate could only be achieved through active stakeholder engagements which will help provide insights on the current level of awareness, and extent of unsafe work practices that present further safety challenges in unfavourable work conditions. Hence, the present study aims to provide empirical evidence on the knowledge, awareness, and extent of safety practices among Nigerian construction workers often exposed to extreme hot weather conditions. This is achieved by assessing workplace practices, perceptions and safety practices to mitigate against extreme heat at work. Findings of the study will provide the foundation for the development of an early warning system that could help in curbing imminent health and safety challenges among construction workers especially in global south countries like Nigeria in the era of anthropogenic climate change.

Climate change and risk of extreme weather in Nigeria

With a population of over 200 million and covering an area of 923,769 sq. km (356,669 sq. mi), Nigeria is regarded as one of the fastest growing populations in the world [28]. The terrain in the country is largely characterised by lowlands in the southern regions, rising plateaus and hills in the central regions and levelled plains in the northern region. In general, the country is characterised by a typical monsoon climate [29].

Over decades, several studies have provided insights into the mechanisms and perception of climate change in west Africa [30,31]. A rise in average air surface temperature of between 1–2˚C has been predicted to occur by the year 2050, which is indicative of an incremental rise in terrestrial surface temperature in the country [32]. In addition, the modelled potential impact of climate change on atmospheric conditions in Nigeria, with increasing temperatures over all ecological zones across the country, indicates an increase in intensity of extreme events coupled with differing levels of climate change driven variations across the heterogenous climatic regions of the country [33,34]. Vulnerability and variability analysis demonstrate that the northern region experiences higher degrees of vulnerability to climate change and variability in atmospheric conditions than the southern region [35]. Evidence from longitudinal studies also show a consistent surge in temperature, variability in rainfall, rise in sea level and flooding, drought and desertification, land degradation, and frequent occurrence of extreme weather conditions [5,36,37]. Observed temperature increases in Nigeria have been slightly faster in the last decade, resulting in variable recorded temperature range across the country especially between June and November of each year [38].

Nigeria's future climate projections reveal a significant increase in temperature over all its ecological zones [31,39]. This is worrisome as continuous variations in the physical variables of the environment such as temperature, humidity and air pressure have been shown to be mostly responsible for the swift proliferation of health and safety challenges, especially among outdoor workers [5]. Climate change has been associated with decrease in the ozone layer at the stratospheric level, which in turn affects the Ultra-Violet (UV) radiation level at the earth's surface, posing significant health and safety risks such as adverse eye effects, skin cancer, and possibly immune dysfunction to exposed workers [3,40–42]. In extreme hot working conditions, high temperatures as seen in Nigeria often promote dehydration amongst exposed workers, leading to multiplicity of health hazards to the heart and lungs, such as chronic obstructive pulmonary disease, asthma, coronary heart disease, and diabetes [43]. Excess heat has also been reported to influence thought processes and productivity, largely because the brain,

heart, and lungs are all sensitive to heat stress and malfunctioning is probable when overly exposed [44–46].

Adaptive strategies for climate change mediated extreme conditions

Evidently, a persistent increase in global warming due to climate change poses thermal discomfort that endangers the health and safety of workers exposed on their respective jobsites [47]. Earlier studies have found a strong correlation between thermal comfort and workers' productivity, advocating a need for adaptive measures and sustainable practices that would allow the mitigation of such environmentally induced losses in workers' productivity when exposed to extreme conditions [48]. In a study that focused on farmers working in extreme weather conditions, demographic background of workers played an integral role in their ability to adopt efficient adaptive strategies to curb the imminent challenges of their work environments under excessive heat conditions [49]. Studies have also found that education level, experience, awareness, and access to relevant information significantly influenced the utilisation of adaptive strategies to climate change [7,50]. In this regard, few studies have also pointed out the need to integrate climate change adaptation through increased awareness and knowledge, which would set the precedence towards equipping workers exposed to extreme climatic conditions with necessary skills and information to enhance their adaptation [49,51]. However, failure of disseminating adequate and timely information through mainstream media sources and academia that raises community awareness towards climate change impact in Nigeria has resulted in very low level of awareness and adaptation across different sectors of the economy, including the construction industry [52]. This lack of knowledge and awareness on climate change impacts amongst workers definitively necessitate the development of early warning systems and adaptation strategies targeting climate change mediated extreme environmental conditions [35,53].

Methodology

Ethics statement

Ethics approval was granted by the Committee on Use of Human Subjects for Research, Ahmadu Bello University, Zaria, Nigeria [ABUCUHSR/2021/28]. The research and subsequent treatment of obtained data was performed in accordance with the principles stated in the Declaration of Helsinki. Prior to data collection, all participants were briefed on the study rationale and verbal consent was obtained. For each participant, this was documented with a date note in their respondent survey sheet as a confirmation of when the consent was discussed and agreed upon.

Study design

A quantitative research approach was adopted for the study, using a structured questionnaire to elicit data from construction workers in Nigeria. The questionnaire was categorised into three sections (Sections A, B and C). Section A asked questions regarding the safety background of the respondents, which entails their distinct demography, prior safety training, and the nature of their work environments. Section B was designed to ascertain the knowledge and awareness levels of construction workers regarding health and safety risks in extreme work conditions. Lastly, Section C was designed to provide insights into the prevalent practices and adaptive strategies adopted by construction workers when working in extreme work environments.

The survey was carried out from 1st March to 31st July 2022 among frontline construction workers across the geopolitical zones in Nigeria which coincided with the dry hot season experienced in most parts of the country. To achieve the required sample size of 385 based on fisher's formula [24], a deliberate contact and sensitisation approach was adopted among the target population and completion of the survey was made voluntary without the use of any form of incentive to encourage participation among the target population. A random sampling technique was adopted, which involved distributing the questionnaires to construction workers stationed in projects within different geopolitical zones of the country using approaches that included face to face distribution and use of social media platforms to raise awareness around the study, and solicit participation. Sequel to the successful completion of the exercise, a total of 576 responses were derived from the study population. Data derived from the survey was analysed using descriptive statistical methods, and the results are presented as frequency and percentage. In addition, a one-way analysis of variance (ANOVA) was performed to ascertain variances across the means of workers' responses to injuries and health risks of working in extreme heat conditions. The statistical significance for the ANOVA was defined at 95% with $p < .05$. Statistical Package for Social Sciences (SPSS) ver. 28.0.1.0. software (IBM SPSS Statistics for Windows, IBM Corp., Armonk, By, USA) was used for the data analysis. Results from the analysis conducted are presented in the subsequent sections.

Analysis and results

Background of respondents and work environment

Table 1 provides background context to the study findings with descriptions of the study demographic, safety training, and work environment of the respondents. Overall, the demography of the respondents presents a reflection of work force typology within the Nigerian construction sector. Male respondents constituted the majority (79.2%) with only 20.8% respondents belonging to the female gender. With regards to the age of the respondents, there was a balanced spread across legal working age brackets, with most of the respondents falling within the age range of 26–30 (37.5%) while 28.1% fall within 31–40 years of age. 12.5% of the respondents identified themselves as between the age of 18–25 while those within the age range between 41 to 50 and those over 50 constituted 15.6% and 6.3% respectively.

Assessment of the educational qualifications of the respondents as a reflection of their literacy level showed that 34% have acquired a university degree, 27.1% a diploma, 22.9% a primary school certificate, and 16% a trade certificate from an accredited skills acquisition programme. In addition, 23.6% of the respondents were categorised as career employees, having work experience spanning between 1–5 years. 33% of the study participants had between 6–10 years' work experience within the construction sector, while 3.5% had over 3 decades of work experience. Overall, majority of the respondents (constituting 54.9%) were trained construction professionals that included Architects, Builders, Civil Engineers etc., while 45.1% were trained tradesmen such as Masons, Electricians, Carpenters etc. (Table 1).

Assessment of work environment and exposure to extreme weather condition

Table 2 highlights the prevalent condition of the construction work environment the respondents have been involved in. Majority of the respondents (47.2%) were exposed to the tropical monsoon climatic condition synonymous with the North Central part of the country while 28.5% were often exposed to the variable savannah climate in the Northwest region. In addition, 21.2% of the respondents were exposed to the extreme and variable desert Sahel savannah climatic condition associated with the Northeast region of the country. With regards to the type of work environment the respondents were often engaged in and exposed to; 59.4% reported working completely

Table 1. Demographic background of the study population.

Gender	Frequency	Percent
Male	456	79.2
Female	120	20.8
Total	**576**	**100**
Age		
18–25	72	12.5
26–30	216	37.5
31–40	162	28.1
41–50	90	15.6
Above 51	36	6.3
Total	**576**	**100**
Educational Qualification		
Primary School	132	22.9
Trade Certificate	92	16
University degree (BSc/MSc/PhD/etc.)	196	34
Others (Accredited Diploma or College Certificate)	156	27.1
Total	**576**	**100**
Years of Experience		
0–5 years	136	23.6
6–10 years	190	33
11–20 years	166	28.8
21–30 years	64	11.1
Above 30 years	20	3.5
Total	**576**	**100**

https://doi.org/10.1371/journal.pclm.0000380.t001

outdoors, while 6.9% said their daily work activity was mainly undertaken indoors. Relatedly, 25% affirmed to working around a heat source (i.e., welding and cutting torches or hot asphalt), and within this group, 29.1% were seldom around the heat source, 58.3% were often around the heat source, while only 12.5% were always around the heat source.

Considering the direct relationship between time spent working in an extreme environment and the increased likelihood of health and safety risks, results from the survey revealed that 54.5% construction workers were mostly engaged in average of 8hr work shifts, while 33.3% said they work evening schedules. However, despite the long work hours in an extreme environment, 41.3% of the respondents reported not using recommended clothing or Personal Protective Equipment (PPE) in the workplace, which further exposes them to the risks of heat stress (Table 2). The participants mostly took their lunch breaks at the peak heat period (between 1–3 pm) and due to lack of enough staff facilities, most stated they took rests beneath any available sheds or shaded structures around the work site.

Knowledge and awareness of health and safety risks associated with work extreme conditions

Fig 1 presents the sources of information that the respondents mostly relied upon in making safety decisions during work under excessive heat conditions. The result reveals significant

Table 2. Climatic condition of work environment within the study population.

Geographical location in Nigeria	Frequency	Percent
North Central	272	47.2
Northeast	122	21.2
Northwest	164	28.5
Southeast	14	2.4
Southwest	4	0.7
Total	**576**	**100**
Type of work environment		
Completely outdoors	342	59.4
Mainly outdoors	116	20.1
Completely indoors	60	10.4
Mainly indoors	40	6.9
Total	**558**	**96.9**
Work around heat source?		
Yes	144	25.0
No	432	75.0
Total	**576**	**100**
If yes, how frequent do you work around heat source?		
Seldom	42	29.1
Often	84	58.3
Always	18	12.5
Total	**144**	**100**
Usual work schedule		
Day Shift	314	54.5
Evening Shift	192	33.3
Split shift	20	3.5
Irregular shift/on-call	20	3.5
Rotating shifts	30	5.2
Total	**576**	**100**
Extent of PPE use to reduce exposure		
Never	238	41.3
Seldom	192	33.3
Often	78	13.5
Always	68	11.8
Total	**576**	**100**

https://doi.org/10.1371/journal.pclm.0000380.t002

deficit in the respondents' awareness of health and safety risks associated with work under extreme weather. Unfortunately, 40% of the respondents reported having no source of information regarding safety risks in extreme work environments. These respondents rely on their local knowledge of the weather rather than seeking information to help them cope with work during extreme heat. Friends and families were found to be another source of such information amongst some respondents (19%). Other sources of information reported amongst the workers included workplace directives (17%), colleagues (14%), social media platforms (8%), and radio and television (2%).

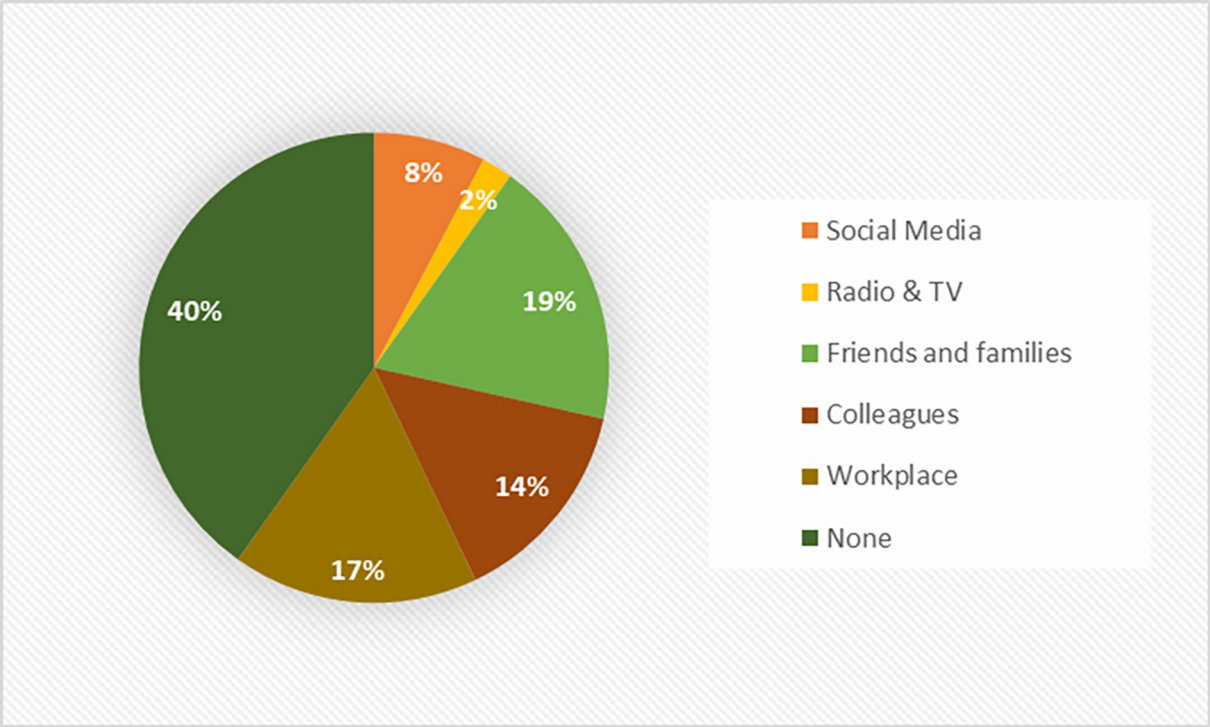

Fig 1.

https://doi.org/10.1371/journal.pclm.0000380.g001

Construction employees are always at greater risk of death, injuries, illnesses, and reduced productivity because of extreme heat exposure at work. Despite this level of risk, 25% of the respondents said they found the nature of their job to be very much physically demanding, while another 26.4% reported their work as moderately demanding (Table 3). The majority of the respondents; 67.9% and 61.8% have either been injured or witnessed a workplace injury of a co-worker caused either by diminished thinking; dizziness; sweaty, slippery hands; slowed response time; muscle fatigue and cramp; and/or blocked vision. In addition, 64.6% of the respondents reported to have experienced a heat-related illness such as heat rash, hyperthermia etc. due to exposure to extreme working conditions (Table 3).

In order to compare the means between the participants' responses towards injuries and health risks associated with extreme heat conditions, a one-way analysis of variance (ANOVA) was performed and the results are displayed in Table 4. There was a significant effect observed regarding the age, work experience and the derived source of safety information on extreme heat related responses. However, the respondents' type of work environment seemed to have the least effect on extreme heat related adaptations and responses. Participants' age and the source of safety information were found to be positively influencing their responses to extreme heat adaptation (all p-values <0.001 and relatively higher F values, Table 4) with higher effect sizes. The same applies to the years of experience on the job (High F-values and low p-values). However, their type of work environment categorised as completely outdoors, mainly outdoors, completely indoors and mainly indoors did not seem to have an overall significant effect on their perception towards health risks associated with extreme heat conditions.

Extreme weather safety adaptation strategy and awareness

Table 5 highlights the strategies often adopted by construction workers exposed to extreme work conditions. Based on the responses, 42% reported not being aware of any work safety

Table 3. Injuries and health risks in extreme working conditions.

		Frequency	Percent
Is your work physically demanding?			
Not at all		280	48.6
Moderate		152	26.4
Very much		144	25
Total		**576**	**100**
Had injury while in extreme working conditions?			
Yes		391	67.9
No		185	32.1
Total		**576**	**100**
Witnessed injury to another person/colleague during extreme heat working conditions?			
Yes		356	61.8
No		220	38.2
Total		**576**	**100**
Experienced illness due to exposure to extreme working condition (heat rashes, heat stroke etc.)?			
Yes		372	64.6
No		204	35.4
Total		**576**	**100**

https://doi.org/10.1371/journal.pclm.0000380.t003

policy with regards to extreme conditions in their respective workplaces. Amongst the 58% of the respondents that could ascertain the availability of such a policy, only 24% responded in the affirmative with 34% reporting the absolute lack of such policy in their workplace. Such disregard for employees' safety and health was seen to affect the productivity of workers, with 72.6% reporting working off-pace when faced with such work conditions (Table 5). The lack of organizational concern with regards to the health and safety adaptation strategies promoted among workers exposed to extreme heat at work observed is particularly worrisome.

Table 4. One-way ANOVA measured across participant's responses to injuries and health risks associated with working under extreme heat conditions.

	H1‡	H2‡	H3‡	H4‡	H5‡
Age	F (4, 571) = 12.137 $p < 0.001$* 2 = .078	F (4, 571) = 6.696 $p < 0.001$* 2 = .045	F (4, 571) = 8.305 $p < 0.001$* 2 = .056	F (4, 571) = 12.214 $p < 0.001$* 2 = .079	F (4, 571) = 11.868 $p < 0.001$* 2 = .077
Type of Work Environment	F (3, 554) = 8.618 $p < 0.001$* 2 = .045	F (3, 554) = 1.771 $p = 0.152$ 2 = .010	F (3, 554) = 0.989 $p = 0.397$ 2 = .005	F (3, 554) = 3.185 $p = 0.024$* 2 = .017	F (3, 554) = 7.998 $p < 0.001$* 2 = .042
Years of Experience	F (5, 570) = 5.690 $p < 0.001$* 2 = .048	F (5, 570) = 7.718 $p < 0.001$* 2 = .063	F (5, 570) = 9.844 $p < 0.001$* 2 = .081	F (5, 570) = 2.311 $p = 0.043$* 2 = .020	F (5, 570) = 5.480 $p < 0.001$* 2 = .046
Source of Safety Information	F (5, 562) = 8.267 $p < 0.001$* 2 = .069	F (5, 562) = 13.057 $p < 0.001$* 2 = .104	F (5, 562) = 6.048 $p < 0.001$* 2 = .051	F (5, 562) = 8.872 $p < 0.001$* 2 = .073	F (5, 562) = 7.852 $p < 0.001$* 2 = .065

Partial Eta Squared (2) = effect size

*$p < 0.05$.

‡H1, H2. H3, H4, H5 –Extreme heat focused questions from the administered questionnaire.

https://doi.org/10.1371/journal.pclm.0000380.t004

Table 5. Improvement of extreme weather safety adaptation strategy and awareness.

Variables	Frequency	Percentage
Are there any guidelines in your workplace for working during extreme weather event (heat)?		
Yes	136	23.6
No	196	34
Don't know	244	42.4
Total	**576**	**100**
Extreme work environment affects your work productivity?		
Yes	418	72.6
No	158	27.4
Total	**576**	**100**
Need to adjust work habits and practices to mitigate risks due to extreme heat exposure?		
Yes	99	17.2
No	477	82.8
Total	**576**	**100**
Why Not?		
I do not think it is a serious problem	54	11.3
I do not think I am at risk	46	9.6
Enough has been done already	13	2.7
I have not thought about it	364	76.3
Total	**477**	**100**
Which of the following applies when you are working during very hot weather?		
I drink plenty fluids before starting work	24	4.2
I drink fluids regularly while at work	180	31.3
I only drink fluids when I am thirsty	248	43.1
All the above	124	21.4
Total	**576**	**100**
Is there provision for palatable drinking water on site provided by your organisation?		
Yes	246	42.7
No	330	57.3
Total	**576**	**100**
If no, what is your source of drinking water at work?		
Tap water (from nearby source)	60	18.2
Cold bottled/sachet (purchased from vendor/kiosk)	138	41.8
Well water (nearby)	22	6.7
Bottled water (brought from home)	76	23
Other source	34	10.3
Total	**330**	**100**
Have you been given instructions on first aid procedures for management of extreme weather illnesses?		
Yes	194	45.1
No	222	39.1
Not sure	90	15.8
Total	**506**	**100**

(*Continued*)

Table 5. (Continued)

Variables	Frequency	Percentage
How concerned are you about the risk of extreme weather-related illness at work?		
A little concerned	20	3.5
Moderately concerned	94	16.6
Very much concerned	84	14.8
Extremely concerned	370	65.1
Total	**568**	**100**
How satisfied are you with the present measures adopted in your workplace to reduce risk of extreme weather impact?		
Strongly dissatisfied	62	10.8
Dissatisfied	254	44.1
Satisfied	118	20.5
Strongly satisfied	142	24.6
Total	**576**	**100**
Do you think there is need for more training around working under extreme weather condition?		
Yes	418	72.6
No	12	2.1
No (not sure)	146	25.3
Total	**576**	**100**

https://doi.org/10.1371/journal.pclm.0000380.t005

Lack of workplace policy on extreme working conditions had a negative influence on the respondents' perception about extreme heat exposure at work. 76.3% of the respondents said they have never thought about the need for such adaptive changes whereas 11.3% were of the perception that the magnitude of risk they are exposed to is minimal, while 9.2% did not think they were being exposed to health and safety risks while working in such conditions at all. As part of adaptation strategy practiced among the respondents during extreme heat conditions, 31.3% reported drinking fluids regularly, while 43.1% of the surveyed group reported taking fluids less frequently; only when they feel thirsty and dehydrated. Fluid intake while working is often related to the availability of water sources and workplace personal hygiene facilities at the work site. However, the lack of provision of potable water sources on site is believed to be the single dominant impeding reason for worker's fluid intake. 57.3% of the respondents affirmed that non- provision of drinking water by the management led them to resort to alternative sources that include purchase of sachet/bottled water from vendors (41.8%); others brought water from home at the start of shift (23%), while some workers sourced from nearby locations (18.2%) to help keep them hydrated (Table 5).

Based on excessive heat mitigation strategies on site, 65% of the respondents expressed extreme concern around the current measures aimed at averting workers from experiencing heat-related illnesses while working on site. According on the prevailing measures as assessed by the respondents regarding management approach to extreme weather, 72.6% of the respondents agreed on the need for management to prioritise extreme weather adaptation training and awareness within the organisations (Table 5).

Discussion

Outcome of the study provides further evidence regarding the possible socio-economic impact arising from increased workplace heat exposure in the construction sector and possibly the

national economic development as it highlights on heath related productivity loss within the construction sector. Exposure to higher temperatures with more frequent periods of heat may result in greater heat stress, potentially leading to more cases of heat-related illnesses such as heat stroke, heat exhaustion, increased susceptibility to chemical exposure, and fatigue. Previous research has shown that climate change can contribute to a decrease in the ozone layer at the stratospheric level and affect UV radiation levels at the surface of the earth. This can cause outdoor workers to experience more frequent, intense, and longer exposure to UV radiation, resulting in increased risk of adverse eye effects, skin cancer, possible immune dysfunction, chronic kidney disease of non-traditional origin (CKDnt) and increased risk to injury [13,40–42]. To help mitigate these adverse health effects and the increased societal burden it can bring, there is the need for increased awareness and adaptation strategies regarding extreme heat exposure, safety and health training, and strengthening positive behavior among the workers.

Due to the nature of the construction environment often involving tedious and physically demanding work activities and schedules, it was evident that the majority of the respondents did not see their work as physically demanding which can cause the body to generate excessive heat, thus presenting them with even greater risks of illnesses associated with extreme heat exposure [3,54–56]. Despite the perceived extreme nature of the construction environment, introducing adaptive strategies could significantly mitigate the risks involved, which has the potential to enable adequate inclusion of female gender in the construction environment [57]. Other demographic factors have been found to affect the safety performance of workers exposed to extreme work environments. Workers' age and years of experience were found to have a strong positive influence on the safety attitude and behaviour of construction workers [58,59]. This was also demonstrated among the older and experienced participants in the present study. In addition, earlier studies have established that young and early career construction workers often tend to be more adventurous and negligent in the face of health and safety risks at the workplace as opposed to older and more experienced workers [60].

Relatedly, previous studies assert that prior safety training of the respondents which entails participation in seminars or workshops should be a key focus, as providing knowledge and awareness related to the risks of extreme work conditions and associated health and safety hazards at the workplace can help improve workers' safety performance [10,61]. However, outcomes from the present study show a significantly low rate of participation in safety training programs amongst construction workers surveyed, with only 33.2% of the respondents affirming to have received prior instruction on how to administer first aid to a colleague in the event of an injury in the workplace. This result is worrisome considering the magnitude of risks such workers are exposed to while working in extreme heat environments [62]. Considering that majority of the respondents are located in the northern region of the country, which has higher degrees of extreme work conditions, and vulnerability to more warming due to persistent climate change [35], there is a need for closer attention to employees' safety and health in the face of climate change mediated extreme heat exposure. In addition, exposure to increased temperature can also result in reduced vigilance creating an increased risk of injury or lapses in safety [3,63–65]. Furthermore, elevated temperatures can increase levels of air pollution, including increase of ground-level ozone. Longer exposure to such air pollutants is directly linked to chronic health effects such as respiratory diseases and allergic reaction, subsequently leading to reduced work productivity [41,66–68].

While there is no existing set of policies and regulation with regards to workplace heat stress prevention in Nigeria, the countries national policy on occupational safety and health places duties on employers to ensure "so far as is reasonably practicable the safety, health and welfare of all workers", part of which is the requirement for the provision of relevant information,

instruction, training and supervision to each employee to help guarantee their safety, health and wellbeing at work. From the study outcome, it was clearly evident that the construction companies have challenges complying with the country's health and safety provision in general. In addition, the consequence of an inadequate safety policy aimed at addressing risks associated with extreme heat condition at work as reported by the respondents was consistent with other safety accounts in the construction environment in Nigeria [24,69]. In line with this poor safety policy, there is need for organisations to consider introducing mandatory work-rest regimes to help workers cope with extreme heat conditions and avert accidents and illnesses related to heat stress, just as majority of the respondents reported experiencing injury to themselves, or colleagues while working in extreme hot environments. Such polices are advocated by International Labour Organisation (ILO), and are in practice in developed regions of the world like the Gulf Co-operation Council countries, and needs to be implemented in climate change sensitive countries like Nigeria as essential adaptive strategies pertaining to climate change driven increased heat stress [70,71].

The projected increase in the warming of the outdoor working environment is likely to exacerbate health hazards to workers [5,7,23,56]. Hence, construction sector management should consider the wellbeing needs of their employees especially the vulnerable groups i.e., the ageing work force, young workers, and women etc., who might be more sensitive to the effects of extreme temperature on their productivity levels in the development of related safety policy. Earlier studies have also affirmed the direct correlation between these groups and productivity as well as risk of injury [72–74] which further demonstrate the need for promotion of safety culture framework aimed at addressing workplace extreme heat exposure.

In furtherance, results from the present study reveal a high level of dissatisfaction amongst construction workers regarding the provision of adaptive measures to curb health and safety risks in their respective work environments. While there are no national standards that specifically address extreme weather working conditions in Nigeria, moving forward there is the need for organisations to consider the adoption of heat stress risk level in wet bulb globe temperature (WBGT) guidelines [71]. Similarly, the need to take into cognisance local weather conditions when carrying out risk assessment will ensure workers safety and further demonstrate management commitment towards their employees [72,75]. This will enable development of local adaptation strategies around the effects of heat stress management among outdoor construction workers [8,76], and the approaches can enable employees to adapt to their new work patterns.

In cognizance of the imminent risks involved with extreme work conditions [3,49], the significant role of increasing workers' knowledge and awareness on the adoption strategies to mitigate extreme weather impact on their health is a necessity. The role played by employees' knowledge and awareness on climate change and heat exposure will demonstrate the level of success that heat exposure policy implementation can have in every organisation [73,77]. On the contrary, deficit in knowledge and awareness regarding health and safety risks when exposed to extreme work condition was found amongst construction workers that took part in the study, and this was partly due to lack of access to relevant information. Results presented in here showed that the majority of construction workers had no direct source of information on the potential safety risks of global warming and extreme work environments. Furthermore, results show the reluctance of most construction workers surveyed towards use of recommended adaptive strategies such as wearing PPEs at work, despite their routine exposure to extreme work environments. Such outcome underscores the need for contractors and other stakeholders to ensure adequate sensitisation and close supervision of the construction workforce to facilitate adoption of safety practices related to work under extreme heat conditions.

It is essential that outdoor workers maintain body fluids while working under extreme heat to optimise productivity. Results from the study reveal that 57.3% of the respondents' raised

concerns regarding the non-availability of palatable water sources on site. This outcome further impacts their level of fluid intake and promotes the development of heat-related illnesses, just as 64.6% of the respondents reported having experienced morbidity associated with heat exposure in their work place. Earlier studies have revealed that other key factors that limit the need for fluid intake among construction workers include the lack of onsite toilet facilities as well as lack of cold-water drinking source on site [78,79]. Dehydration associated with extreme heat exposure results in reduced work capacity, accelerated fatigue with body fluid loss of between 1–2% body weight [78], and cognitive performance [80,81] leading to compromise of worksite existing safety measures and long-term risk of developing CKDnt [12,13,82]. These important findings associated with workplace heat exposure and associated health risks should be considered in shaping workplace adaptation and heat management policies across the construction sector [73,82], as heat related diseases are likely to be on the increase due to widespread prevalence of increased heat at work environments [71], and limited provision of shed and safety at workplaces [83].

In instances where workers' health is impaired as a result of heat induced stress and the absence of policies to abate such measure, the consequence is more likely to reduce their productivity with further potential impact on the nation's economy due to loss of earnings especially in cases of chronic illnesses. Hence, the need for construction organizations to prioritize safety programs for their workers through the adoption of sustainable adaptive strategies that include the development of an early warning systems related to heat stress at work, availability of palatable drinking water, use of PPE, adequate work-rest schedules, periodic seminars, and up-to-date courses on health and safety practices. Such approaches will strengthen and improve awareness levels and bring in the provision of health and safety policies at all organizational levels targeting climate change adaptive strategies. In furtherance, there should also be a conscious synergy between government, construction organizations and worker unions towards the development and implementation of these initiatives to help safe guard the safety and health of the workers in this industry.

Conclusion

The climate change effects on the distinct geographical dynamics of Nigeria poses significant health and safety challenges to outdoor workers often exposed to such extreme heat and harsh work conditions. While relative efforts have been made in advanced geographical climates around the globe to curb such challenges through the development of early warning systems, there has been little or no such efforts in most developing countries like Nigeria. To promote the goal of SDG 3 (Promotion of healthy living and well-being of employees) and SDG 8 (Decent work and economic growth), the involved stakeholders should pay attention to the plight of construction workers in Nigeria for better workplace management around the effect of extreme heat on their productivity as part of workplace culture and policy-making. This would enable achieving safety targets for organisations, and enhance the drive towards attaining decent work while enhancing workers productivity.

Supporting information

S1 Data. Dataset.
(SAV)

Author Contributions

Conceptualization: Haruna Musa Moda, Yahaya Ibrahim Makarfi.

Data curation: Ravi Rangarajan, Yahaya Ibrahim Makarfi.

Formal analysis: Haruna Musa Moda, Joy Maina.

Funding acquisition: Haruna Musa Moda.

Investigation: Haruna Musa Moda, Mahmud Bello Zailani.

Methodology: Ravi Rangarajan, Joy Maina.

Project administration: Haruna Musa Moda.

Software: Mahmud Bello Zailani.

Supervision: Mu'awiya Abubakar, Yahaya Ibrahim Makarfi.

Validation: Mahmud Bello Zailani, Ravi Rangarajan, Pauline Hickey, Mu'awiya Abubakar, Joy Maina.

Visualization: Ravi Rangarajan, Pauline Hickey, Mu'awiya Abubakar, Joy Maina.

Writing – original draft: Haruna Musa Moda, Yahaya Ibrahim Makarfi.

Writing – review & editing: Mahmud Bello Zailani, Ravi Rangarajan, Pauline Hickey, Mu'awiya Abubakar, Joy Maina, Yahaya Ibrahim Makarfi.

References

1. Malka A, Krosnick JA, Langer G. The association of knowledge with concern about global warming: Trusted information sources shape public thinking. Risk Analysis: An International Journal. 2009; 29(5): 633–647. https://doi.org/10.1111/j.1539-6924.2009.01220.x PMID: 19302280
2. IPCC. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation—A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press; 2012.
3. Moda HM, Filho WL, Minhas A. Impacts of climate change on outdoor workers and their safety: some research priorities. International Journal of Environmental Research and Public Health, 2019; 16(18): 3458. https://doi.org/10.3390/ijerph16183458 PMID: 31533360
4. International Labour Organization (ILO). Climate Change and Labour: Impacts of heat in the Workplace. 2016 [Cited 2023 March 28]. Available from: https://www.ilo.org/wcmsp5/groups/public/—ed_emp/—gjp/documents/publication/wcms_476194.pdf.
5. Raimi MO, Odubo TV, Omidiji AO. Creating the Healthiest Nation: Climate Change and Environmental Health Impacts in Nigeria: A Narrative Review. Sustainability in Environment, 2021; 6(1): 61. https://doi.org/10.22158/se.v6n1p61
6. Osei-Asibey D, Ayarkwa J, Acheampong A, Adinyira E, North P. Impacts of accidents and hazards on the Ghanaian construction industry. International Journal of Construction Management, 2021; 23(4): 708–717. https://doi.org/10.1080/15623599.2021.1920161
7. Ansah EW, Ankomah-Appiah E, Amoadu M, Sarfo JO. Climate change, health and safety of workers in developing economies: A scoping review. The Journal of Climate Change and Health, 2021; 3: 100034. https://doi.org/10.1016/j.joclim.2021.100034
8. Habibi P, Moradi G, Dehghan H, Moradi A, Heydarai A. The impacts of climate change on occupational heat strain in outdoor workers: A systematic review. Urban Climate, 2021; 36: 100770.f. https://doi.org/10.1016/j.uclim.2021.100770
9. Thomas F, Sabel CE, Morton K, Hoscock R, Depledge MH. Extended impacts of climate change on health and wellbeing. Environmental Science and Policy, 2014; 44: 271–278. https://doi.org/10.1016/j.envsci.2014.08.011
10. Moda HM, Alshahrani A. Assessment of Outdoor Workers Perception Working in Extreme Hot Climate. In: Filho LW, Manolas E, editors. Handbook of Climate Change Communication: Vol. 3. Climate Change Management. Springer; 2018. pp. 183–195.
11. Kiefer M, Rodríguez-Guzmán J, Watson J, Wendel de Joode B, Mergler D, Soares da Silva A. Worker health and safety and climate change in the Americas: issues and research needs. Revista Panamericana de Salud Pública, 2016; 40(3): 192–197. PMID: 27991978

12. Chapman E, Haby MM, Illanes E, Sanchez-Viamonte J, Elias V, Reveiz L. Risk factors for chronic kidney disease of non-traditional causes: a systematic review. Revista Panamericana de Salud Pública, 2019; 43. https://doi.org/10.26633/RPSP.2019.35 PMID: 31093259

13. Wesseling C, Glaser J, Rodríguez-Guzmán J, Weiss I, Lucas R, Peraza S, et al. Revista chronic kidney disease of non-traditional origin in Mesoamerica: a disease primarily driven by occupational heat stress. Panamericana de Salud Pública, 2020; 44. https://doi.org/10.26633/RPSP.2020.15 PMID: 31998376

14. Omoruyi EP, Kunle OA. Effects of climate change on health risks in Nigeria. Asian Journal of Business and Management Sciences, 2012; 1(1): 2047–2528.

15. World Health Organization (WHO). Climate Change Fact sheet 2023 October 12 [Cited 2024 March 28] Available from: https://www.who.int/news-room/fact-sheets/detail/climate-change-andhealth#:~:text=Climate%20change%20is%20impacting%20health,diseases%2C%20and%20mental%20health%20issues.

16. United Nations. Transforming our World: The 2030 Agenda for sustainable development. 2015: 12–14. [Cited 2024 March 28] Available from: https://sdgs.un.org/2030agenda.

17. Ndizera H, Muzee H. A critical review of Agenda 2063: Business as usual? African Journal of Political Science and International Relations, 2018; 12(8): 142–154. https://doi.org/10.5897/AJPSIR2018.1114

18. Nwozor A, Okidu O, Adedire S. Agenda 2063 and the Feasibility of Sustainable Development in Africa: Any Silver Bullet? Journal of Black Studies, 2021; 52(7): 688–715. https://doi.org/10.1177/00219347211021099

19. Toole TM, Gambatese J. The trajectories of prevention through design in construction. Journal of Safety Research, 2008:39(2): 225–230. https://doi.org/10.1016/j.jsr.2008.02.026 PMID: 18454974

20. Ahamad MA, Arifin K, Abas A, Mahfudz M, Cyio MB, Khairil M, et al. Systematic Literature Review on Variables Impacting Organization's Zero Accident Vision in Occupational Safety and Health Perspectives. Sustainability, 2022; 14(13): 7523. https://doi.org/10.3390/su14137523

21. Pandit B, Albert A, Patil Y, Al-Bayati AJ. Impact of safety climate on hazard recognition and safety risk perception. Safety Science, 2019; 113: 44–53. https://doi.org/10.1016/j.ssci.2018.11.020

22. Idoro GI. Health And Safety Management Efforts as Correlates of Performance in The Nigerian Construction Industry. Journal of Civil Engineering and Management, 2008; 14(4): 277–285. https://doi.org/10.3846/1392-3730.2008.14.27

23. Afolabi F, Beer P de, Haafkens J. Can occupational safety and health problems be prevented or not? Exploring the perception of informal automobile artisans in Nigeria. Safety Science, 2021;11(1). https://doi.org/10.1016/j.ssci.2020.105097

24. Moda HM, Ofodile N, Zailani BM, Abubakar M, Ibrahin YM. Management support as a critical success factor (CSF) for changing worker's safety attitude: a case of the Nigerian construction industry. International Journal of Construction Management, 2022; 23(15): 2551–2557. https://doi.org/10.1080/15623599.2022.2077084

25. Zailani BM, Abubakar M, Ibrahim YM. The role of safety attitude in changing safety behaviour and hazard recognition capability of construction workers. In: Procs. West Africa Built Environment Research (WABER) Conference, 2021: 1001–1011.

26. Maina, JJ. Adamu, DI. Key Performance Indicators for Project Success: Perspectives of Architectural Practitioners in Nigeria. In: Ogwuelka AC, editors. Procs of the 6th Research Conference of the Nigerian Institute of Quantity Surveyors (RECON 6), 2022: 126–139.

27. Abubakar M, Ibrahim YM, Bala K, Ibrahim AD, Abdullahi M, Identifying the Factors Influencing Hazard Recognition Capability of Construction Workers. Construction Research Congress 2020: 268–278. https://doi.org/10.1061/9780784482872.030

28. United Nations Common Country Analysis 2022 –Nigeria. 2022 February. [Cited 2024 March 28] Available from: https://www.unodc.org/conig/uploads/documents/Common_Country_Analysis_2022_Nigeria.pdf.

29. Shiru MS, Shahid S, Alias N, Chung E-S. Trend analysis of droughts during crop growing seasons of Nigeria. Sustainability, 2018; 10(3): 871. https://doi.org/10.3390/su10030871

30. Sylla MB, Elguindi N, Giorgi F, Wisser D. Projected robust shift of climate zones over West Africa in response to anthropogenic climate change for the late 21st century. Climatic Change, 2021; 134(1): 241–253. https://doi.org/10.1007/s10584-015-1522-z

31. Shiru MS, Shahid S, Dewan A, Chung ES, Alias N, Ahmed K, et al. Projection of meteorological droughts in Nigeria during growing seasons under climate change scenarios. Nature Scientific Reports, 2020; 10(1): 1–18. https://doi.org/10.1038/s41598-020-67146-8 PMID: 32572138

32. Cervigni R, Valentini R, Santini M. Toward Climate-resilient Development in Nigeria. Directions in Development: Countries and Regions. World Bank, Washington, DC. 2013. https://doi.org/10.1596/978-0-8213-9923-1

33. Abiodun BJ, Lawal KA, Salami AT, Abtan AA. Potential influences of global warming on future climate and extreme events in Nigeria. Regional Environmental Change, 2013; 13(3): 477–491. https://doi.org/10.1007/s10113-012-0381-7

34. Eludoyin OM, Adelekan IO, Webster R, Eludoyin AO. Air temperature, relative humidity, climate regionalization and thermal comfort of Nigeria. International Journal of Climatology, 2014; 34(6): 2000–2018. https://doi.org/10.1002/JOC.3817

35. Madu IA, Nwankwo CF. Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria. Geo Journal, 2021; 86(6): 2691–2707. https://doi.org/10.1007/S10708-020-10223-2

36. Ebele N, Emodi NV. Climate change and its impact in Nigerian economy. Journal of Scientific Research and Reports, 2016; 1(13): 1–13. https://doi.org/10.9734/JSRR/2016/25162

37. Sojobi AO, Balogun II, Salami AW. Climate change in Lagos state, Nigeria: what really changed? Environmental Monitoring and Assessment, 2016; 188(10): 556. https://doi.org/10.1007/s10661-016-5549-z PMID: 27613292

38. Amanchukwu R, Amadi-Ali TG, Ololube NP. Climate change education in Nigeria: The role of curriculum review. Education, 2015; 5(3): 71–79. https://doi.org/10.5923/j.edu.20150503.01

39. Akande A, Costa A, Mateu J, Henriques R. Geospatial analysis of extreme weather events in Nigeria (1985–2015) using self-organizing maps. Advances in Meteorology, 2017; 8576150: 1–11. https://doi.org/10.1155/2017/8576150

40. Schulte PA, Chun HK. Climate change and occupational safety and health: Establishing a preliminary framework. Journal of Occupational and Environmental Hygiene, 2009; 6(9): 542–554. https://doi.org/10.1080/15459620903066008 PMID: 19551548

41. Kiefer M, Lincoln J, Schulte P, Jacklitsh B. Climate change and occupational health and safety. NIOSH Science Blog. Centre for Disease Control and Prevention. 2014. [Cited 2024 March 28] Available from: http://blogs.cdc.gov/niosh-science-blog/2014/09/22/climate-change.

42. Flouris AD, Mcginn R, Poirier MP, Louie JC, Ionnou LG, t al. Screening criteria for increased susceptibility to heat stress during work or leisure in hot environments in healthy individuals aged 31–70 years. Temperature, 2018; 5(1): 86–99. https://doi.org/10.1080/23328940.2017.1381800 PMID: 29687046

43. Raimi K, Maki A, Dana D. Framing of geoengineering affects support for climate change mitigation. Environmental Communication, 2019; 13(3): 300–319. https://doi.org/10.1080/17524032.2019.1575258

44. Ioannou LG, Foster J, Morris NB, Pill JF, Havenith G, Mekjavic IB, et al. Occupational heat strain in outdoor workers: A comprehensive review and meta-analysis. Temperature, 2022; 9(1): 67–102. https://doi.org/10.1080/23328940.2022.2030634 PMID: 35655665

45. Roy S, Mishra DP, Bhattacharjee RM, Agrawak H. Heat Stress in Underground Mines and its Control Measure: A Systematic Literature Review and Retrospective Analysis. Mining, Metallurgy and Exploration, 2022; 39: 357–383. https://doi.org/10.1007/s42461-021-00532-6

46. Foster J, Smallcombe JW, Hodder S, Jay O, Flouris AD, Nybo L, et al. Quantifying the impact of heat on human physical work capacity; part III: the impact of solar radiation varies with air temperature, humidity, and clothing coverage. International Journal of Biometeorology, 2022; 66(1): 175–188. https://doi.org/10.1007/s00484-021-02205-x PMID: 34709466

47. Gbode IE, Ogunjobi KO, Dudhia J, Ajayi VO, Liu C. Impacts of global warming on West African monsoon rainfall: Downscaling by pseudo global warming method. Atmospheric Research, 2021; 249: 105334. https://doi.org/10.1016/j.atmosres.2020.105334

48. Kaushik S, Dharpure JK, Joshi PK, Ramanathan AL, Singh T. Climate change drives glacier retreat in Bhaga basin located in Himachal Pradesh, India. Geocarto International, 2020; 35(11): 1179–1198. https://doi.org/10.1080/10106049.2018.1557260

49. Haider H. Climate change in Nigeria: impacts and responses. 2019. [Cited 2024 March 28] Available from: https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/14761.

50. Amoadu M, Ansah E, Sarfo JO, Hormrnu T. Impact of climate change and heat stress on workers health and productivity: A scoping review. The Journal of Climate Change and Health, 2023; 3: 100034. https://doi.org/10.1016/j.joclim.2023.100249

51. Duru PN, Emetumah FC. Evaluating the effects of information literacy on climate change awareness among students in Imo State University. Archives of Current Research International, 2016; 4(3): 1–10. https://doi.org/10.9734/ACRI/2016/27186

52. Ajaero ID, Anorue LI. Newspaper framing and climate change mitigation in Nigeria and Ghana. African Population Studies, 2018; 32(2). https://doi.org/10.11564/32-2-1195

53. Otitoju M, Enete AA. Climate change adaptation: Uncovering constraints to the use of adaptation strategies among food crop farmers in South-west, Nigeria using principal component. Cogent Food and Agriculture, 2016; 2: 1178692. https://doi.org/10.1080/23311932.2016.1178692

54. Adogbo KJ, Ibrahim AD, Ibrahim YM. Development of a Framework for Attracting and Retaining Women in Construction Practice. Journal of Construction in Developing Countries, 2015; 20(1): 99–115.

55. Powell A, Sang KJC. Everyday Experiences of Sexism in Male-dominated Professions: A Bourdieusian Perspective. Sociology, 2015; 49(5): 919–936. https://doi.org/10.1177/0038038515573475

56. Rowlinson S, YunyanJia A, Li B, Chuanjinglu C. Management of climatic heat stress risk in construction: a review of practices, methodologies, and future research. Accident Analysis and Prevention, 2014; 66: 187–198. https://doi.org/10.1016/j.aap.2013.08.011 PMID: 24079394

57. Pamidimukkala A, Kermanshachi S. Development of strategies to improve health and safety of women in construction industry: A delphi method. Construction Research Congress 2022: Health and Safety, Workforce, and Education—Selected Papers from Construction Research Congress 2022, 2022a;4-D: 314–323. https://doi.org/10.1061/9780784483985.032

58. Trillo-Cabello A, Carrillo-Castrillo J. Perception of risk in construction. Exploring the factors that influence experts in occupational health and safety. Safety Science. 2021; 133: 104990. https://doi.org/10.1016/j.ssci.2020.104990

59. Pamidimukkala A, Kermanshachi S. Occupational Health and Safety Challenges in Construction Industry: A Gender-Based Analysis. Construction Research Congress 2022: Health and Safety, Workforce, and Education—Selected Papers from Construction Research Congress 2022, 2022b;4-D (1): 491–500. https://doi.org/10.1080/01446193.2013.828845

60. Gyekye S, Salminen S. Age and workers' perceptions of workplace safety: A comparative study. International Journal of Aging and Human Development, 2009; 68(2): 171–184. https://doi.org/10.2190/AG.68.2.d PMID: 19445348

61. Abubakar M, Zailani BM, Abdullahi M, et al. Potential of adopting a resilient safety culture toward improving the safety performance of construction organizations in Nigeria. Journal of Engineering, Design and Technology, 2022; 20(5): 1236–1256. https://doi.org/10.1108/JEDT-09-2020-0354

62. Kolo DN. Safety issues involving workers on building construction sites in Nigeria: An Abuja study. 2015. Available from: http://hdl.handle.net/11129/1724.

63. Spector JT, Bonauto DK, Sheppard L, Busch-Isaksen T, Calkins M, Adams D, et al. A case-crossover study of heat exposure and injury risk in outdoor agricultural workers. PLoS One, 2016; 11(10): p. e0164498. https://doi.org/10.1371/journal.pone.0164498 PMID: 27716794

64. Fatima SH, Rothmore P, Giles LC, Varghese BM, Bi P. Extreme heat and occupational injuries in different climate zones: A systematic review and meta-analysis of epidemiological evidence. Environment International, 2021; 148: 106384. https://doi.org/10.1016/j.envint.2021.106384 PMID: 33472088

65. Yoon JH, Lee WT, Yoon MJ, Lee W. Risk of Heat-Related Mortality, Disease, Accident, and Injury Among Korean Workers: A National Representative Study From 2002 to 2015. Geohealth, 2021; 5(12): p.e2021GH000516. https://doi.org/10.1029/2021GH000516 PMID: 34938932

66. Kjellstrom T, Kovats RS, Lloyd SJ, Holt T, Tol RSJ. The direct impact of climate change on regional labour productivity. Arch. Environ. Occup. Health, 2009; 64(4): 217–227. https://doi.org/10.1080/19338240903352776 PMID: 20007118

67. Nilsson M, Kjellstrom T. Climate change impacts on working people: how to develop prevention policies. Glob Health Action, 2010; 3: 5774. https://doi.org/10.3402/gha.v3i0.5774 PMID: 21140000

68. Gubernot DM, Anderson GB, Hunting KL. The Epidemiology of Occupational Heat-Related Morbidity and Mortality in the United States: A Review of the Literature and Assessment of Research Needs in a Changing Climate. Int J Biometeorol, 2014; 58: 1779–1788. https://doi.org/10.1007/s00484-013-0752-x PMID: 24326903

69. Ngwama JC. Framework for occupational health and safety in Nigeria: the implication for the trade union movement. Journal of Economics and Sustainable Development, 2016; 7(11): 98–109.

70. International Labour Office -Ministry of Labour, Qatar. Heat stress legislation in Qatar: A guide for employers. 2023. [Cited 2023 March 28]. Available from: https://www.ilo.org/beirut/countries/qatar/WCMS_794519/lang—en/index.htm.

71. International Labour Office–WCMS-711919. Working on a warmer planet: The impact of heat stress on labour productivity and decent work. 2019. [Cited 2023 March 28]. Available from: https://www.ilo.org/wcmsp5/groups/public/—dgreports/—dcomm/—publ/documents/publication/wcms_711919.pdf.

72. Lao J, Hansen A, Nitschke M, Hanson-Easey S, Pisaniello D. Working smart: An exploration of council workers' experiences and perceptions of heat in Adelaide, South Australia. Safety science, 2016; 82: 228–235. https://doi.org/10.1016/j.ssci.2015.09.026

73. Nunfam VF, Oosthuizen J, Adusei-Asante K, Van Etten EJ, Frimpong K. Perceptions of climate change and occupational heat stress risks and adaptation strategies of mining workers in Ghana. Science of the

Total Environment, 2019; 657: 365–378. https://doi.org/10.1016/j.scitotenv.2018.11.480 PMID: 30550901

74. Derakhshan S, Eisenman D, Basu R, Longcore T. Do Social Vulnerability Indices Correlate with Extreme Heat Health Outcomes?. The Journal of Climate Change and Health, 2023;100276. https://doi.org/10.1016/j.joclim.2023.100276

75. Rother HA, John J, Wright CY, Irlam J, Oosthuizen R, Garland RM. Perceptions of occupational heat, sun exposure, and health risk prevention: a qualitative study of forestry workers in South Africa. Atmosphere, 2018; 11(1): 37. https://doi.org/10.3390/atmos11010037

76. Yi W, Chan AP. Effects of heat stress on construction labor productivity in Hong Kong: a case study of rebar workers. International Journal of Environmental Research and Public Health, 2017; 14(9): 1055. https://doi.org/10.3390/ijerph14091055 PMID: 28895899

77. Kjellstrom T, Briggs D, Freyberg C, Lemke B, Otto M, Hyatt O. Heat, human performance, and occupational health: a key issue for the assessment of global climate change impacts. Annual Review of Public Health, 2016; 37: 97–112. https://doi.org/10.1146/annurev-publhealth-032315-021740 PMID: 26989826

78. Bates GP, Schneider J. Hydration status and physiological workload of UAE construction workers: A prospective longitudinal observational study. Journal of Occupational Medicine and Toxicology, 2008; 3 (1): 1–10. https://doi.org/10.1186/1745-6673-3-21 PMID: 18799015

79. Al-Bouwarthan M, Quinn MM, Kriebel D, Wegman DH. A field evaluation of construction workers' activity, hydration status, and heat strain in the extreme summer heat of Saudi Arabia. Annals of Work Exposures and Health, 2020; 64(5): 522–535. https://doi.org/10.1093/annweh/wxaa029 PMID: 32219304

80. McMorris T, Swain J, Smith M, Corbett J, Delves S, Sale C, et al. Heat stress, plasma concentrations of adrenaline, noradrenaline, 5-hydroxytryptamine and cortisol, mood state and cognitive performance. International Journal of Psychophysiology, 2006; 61(2): 204–215. https://doi.org/10.1016/j.ijpsycho.2005.10.002 PMID: 16309771

81. Taylor L, Watkins SL, Marshall H, Dascombe BJ, Foster J. The impact of different environmental conditions on cognitive function: a focused review. Frontiers in Physiology, 2016; 6: 372. https://doi.org/10.3389/fphys.2015.00372 PMID: 26779029

82. Venugopal V, Latha PK, Shanmugam R, Krishnamoorthy M, Srinivasan K, Perumal K, et al. Risk of kidney stone among workers exposed to high occupational heat stress-A case study from southern Indian steel industry. Science of The Total Environment, 2020; 722: 137619. https://doi.org/10.1016/j.scitotenv.2020.137619 PMID: 32197155

83. Krishnamurthy M, Ramalingam P, Perumal K, Kamalakannan LP, Chinnadurai J, Shanmugam R, et al. Occupational heat stress impacts on health and productivity in a steel industry in Southern India. Safety and health at work, 2017; 8(1): 99–104. https://doi.org/10.1016/j.shaw.2016.08.005 PMID: 28344848