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EVALUATION OF HEAT STRESS AMONG OUTDOOR CONSTRUCTION WORKERS IN LAGOS METROPOLIS

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ABSTRACT

This study evaluated the extent of heat stress experienced by outdoor construction workers within Lagos Metropolis, Nigeria, using the Heat Stress Index (HSI) approach. It aimed to assess workers perceived thermal discomfort and determine whether significant differences in heat exposure existed across occupational roles. Data were collected from 174 respondents using structured questionnaires assessing eight heat-related variables, including thermal sensation, sweating, fatigue, dizziness, hydration, and rest patterns. The Heat Stress Index (HSI) was computed on a five-point scale and categorized into four levels: mild, moderate, high, and extreme. Results revealed that all respondents experienced some degree of heat stress, with the majority (62.1%) falling within the moderate category, followed by 22.4% reporting high and 2.9% extreme stress levels. Unskilled labourers recorded the highest stress values, reflecting greater vulnerability due to physically demanding tasks and prolonged exposure to direct sunlight. However, the one-way ANOVA test showed no statistically significant difference in HSI across occupational roles ($F = 0.422$; $p = 0.737$), indicating uniform exposure to heat stress conditions on-site. The study concludes that heat stress is a prevalent occupational hazard among construction workers in Lagos, driven by environmental rather than role-specific factors. It recommends implementing structured work–rest cycles, shaded rest zones, hydration schedules, and mandatory heat safety training to safeguard workers' health and improve productivity under Lagos increasingly hot and humid climate.

I. INTRODUCTION

Construction workers, particularly those engaged in outdoor work, are increasingly vulnerable to heat stress as global and local temperatures rise. In cities such as Lagos, Nigeria, characterized by high humidity and prolonged periods of intense heat, exposure to extreme thermal environments poses a major occupational hazard. [1] estimates that global productivity losses associated with heat stress will continue to rise, particularly in low- and middle-income countries where outdoor labor forms a significant part of the economy. In the Nigerian construction sector, where physical activity levels are high and protective measures are often inadequate, heat stress is an emerging concern affecting worker health, safety, and performance [2], [3]. Empirical studies across tropical regions have demonstrated that outdoor construction workers experience sustained exposure to temperatures exceeding recommended thermal comfort limits, resulting in physiological and psychological strain [4], [5], [6]. Symptoms such as fatigue, dizziness, dehydration, and reduced cognitive performance have been associated with heat-induced stress [7], [8]. Furthermore, site conditions such as limited shade, inadequate hydration practices, and extended working hours magnify the risk of heat-related illnesses, particularly among unskilled and semi-skilled laborers [9], [10]. Despite these well-documented health implications, occupational heat exposure remains largely under-monitored in many developing contexts [11], [12]. In Nigeria, where the construction industry is a major employer, research on heat stress remains sparse compared to studies in Asia and the Middle East. Most existing studies have concentrated on environmental heat metrics and general climate risks, while limited attention has been given to quantifying worker-level heat stress using self-reported and physiological indicators [12], [13]. This gap restricts understanding of how specific construction roles differ in vulnerability, or how daily exposure patterns influence health and productivity outcomes. Addressing this limitation is critical to formulating locally adapted heat mitigation strategies. This study, therefore, focuses on evaluating the heat stress of outdoor construction workers within Lagos Metropolis, aligning with the second objective of the broader research. By developing and applying a Heat Stress Index (HSI) that integrates physiological, behavioral, and perceptual indicators, the study assesses the extent and distribution of heat stress among various site roles. The findings provide an empirical basis for understanding the real-world thermal experiences of construction workers in Lagos and contribute to the growing global discourse on occupational heat exposure, particularly in rapidly urbanizing tropical cities.

II. THEORETICAL REFERENCE

Heat stress represents the physiological and psychological strain experienced when the body's heat load exceeds its ability to dissipate it. It is influenced not only by environmental factors such as temperature and humidity, but also by internal factors (age, health status) and occupational variables (workload, PPE use, hydration, and rest access) [14], [5]. Construction workers in hot tropical climates like Lagos are particularly at risk, as they perform strenuous physical tasks outdoors, often in direct sunlight and in protective clothing that limits evaporative cooling [6]. Prolonged exposure under such conditions elevates body temperature, increases sweating, and leads to fatigue and other physiological symptoms that compromise productivity and well-being.

II.1 HEAT STRESS OF OURDOOR CONSTRUCTION WORKERS

II.1.1 SELF-REPORTED HEAT STRESS

Self-reported heat stress is one of the most practical ways to assess perceived thermal strain in occupational settings. Using thermal sensation votes or Likert-scale questionnaires, workers rate their comfort level and report symptoms such as fatigue, dizziness, or overheating [15], [14]. These subjective measures have been shown to closely align with physiological markers like core body temperature and heart rate, making them valuable for early identification of heat strain [5]. In Lagos, [3] observed widespread self-reported heat stress among construction workers lacking shade, hydration, or rest breaks. However, cultural norms and workplace dynamics often lead to underreporting, as workers may fear being perceived as weak [1]. Encouraging transparent self-reporting and training supervisors to act promptly on such reports are critical to effective heat management [16].

II.1.2 SWEATING RATE

Sweating rate is a key physiological indicator of the body's thermoregulatory response to heat. It reflects evaporative cooling efficiency and varies with environmental conditions, workload, and individual physiology [17], [7]. While sweating helps dissipate heat, excessive sweat loss without adequate fluid replacement can lead to dehydration and heat exhaustion [18], [5]. Studies have shown that construction workers can lose up to 2.5 Litres of fluid per hour during peak heat [19]. In humid areas like Lagos, sweat evaporation is hindered, leading to ineffective cooling and dangerous internal heat buildup. Site managers are therefore encouraged to ensure hydration facilities, electrolyte drinks, and scheduled water breaks [20].

II.1.3 EXERTION LEVEL

Perceived exertion captures how intensely a worker feels they are working and is strongly correlated with physiological heat strain indicators such as heart rate and body temperature [7]. The Borg Rating of Perceived Exertion (RPE) is a widely used tool to assess exertion under heat exposure [18]. In construction environments, perceived exertion typically peaks at midday when ambient heat and cumulative fatigue are highest [16]. Integrating RPE monitoring into daily safety routines can serve as an early warning system, allowing supervisors to detect overexertion and adjust work schedules accordingly. However, effectiveness depends on worker education and trust in the reporting process [18].

II.1.4 FATIGUE

Fatigue is an early and common symptom of heat stress, characterized by reduced physical and cognitive performance. It results from metabolic strain, dehydration, and cardiovascular stress induced by heat exposure [17], [19], [3] reported that over 65% of construction workers in West Africa experience severe fatigue by midday, largely due to long working hours and limited rest. Fatigue increases accident risk, reduces concentration, and slows task execution [7]. [16] recommend structured fatigue assessments and alternating high- and low-effort tasks to mitigate risk.

II.1.5 DIZZINESS

Dizziness is a critical physiological warning sign of cardiovascular strain and potential heat exhaustion. It arises from dehydration and blood flow redistribution during thermal stress [6], [12], [5] identified dizziness as one of the top three self-reported heat symptoms across heat-exposed workforces in Africa and Asia. On construction sites in Lagos, dizziness is often ignored or misinterpreted, leading to dangerous incidents such as falls from height [3]. Supervisors should monitor for early dizziness, ensure immediate rest in shaded areas, and provide on-site first aid [1].

II.1.6 REST BREAKS

Rest breaks are essential for thermal recovery and maintaining productivity. They allow the body to reduce core temperature, normalize heart rate, and restore hydration [7, 16]. However, many construction sites in Lagos neglect structured rest periods due to job pressure. [1] recommends a 15-minute rest every hour during extreme heat, particularly when WBGT exceeds 28–30 °C. Regular rest breaks significantly lower heat-related illness risk and improve performance [21].

II.1.7 REST BREAKS

Adequate hydration is fundamental to heat tolerance. During prolonged outdoor labor, sweat-induced fluid loss without replacement leads to dehydration, impairing thermoregulation and cognitive function [17], [19], [6] found that construction workers can lose up to 2 Litres of fluid per hour in hot environments. In Lagos, [3] reported that workers consuming less than 2 Litres of water daily were over three times more likely to experience heat stress symptoms. Dehydration symptoms fatigue, dark urine, muscle cramps, and dizziness, are widespread but often ignored [22], [7]. Regular water breaks, electrolyte access, and worker education are among the most effective low-cost preventive measures [1].

III. MATERIALS AND METHODS

III.1 STUDY AREA AND DESIGN

The study was carried out across selected construction sites within Lagos Metropolis, Nigeria. The area experiences a humid tropical climate, with mean daily temperatures ranging between 27°C and 31°C, particularly during the dry season. [23] buttressed that tropical climates are characterized by high temperatures throughout the year and typically have distinct rainy and dry seasons, with the average annual temperature in Lagos State and other Southwestern states in Nigeria being approximately 30ºC. Such climatic conditions create a high potential for occupational heat exposure. A cross-sectional survey design was adopted to evaluate heat stress among outdoor construction workers under real work conditions.

III.2 POPULATION AND SAMPLING

The population comprised construction workers involved in outdoor tasks, including laborers, artisans, supervisors, and foremen. A total of 174 respondents were selected through purposive sampling. Purposive sampling technique, according to [24], is a non-probability sampling strategy that must have explicit inclusion criteria and justification. As such, the inclusion of participants directly exposed to the sun during work is required, as their firsthand experience enables them to provide more accurate and reliable responses to the research questions. This sampling method was appropriate given the study's focus on workers engaged in physically demanding activities in heat-prone environments.

III.3 INSTRUMENTATION AND DATA COLLECTION

Data were collected using a structured questionnaire designed to assess the self-reported level of heat stress and related physiological responses. The instrument was based on the Heat Stress Index (HSI), developed by adapting variables from previous occupational heat stress studies. The questionnaire consisted of eight (8) key items, each measured on a five-point Likert scale (1–5), as shown in Table 1. Respondents were asked to rate the intensity or frequency of heat-related experiences during a typical hot workday.

Table 1: Heat Stress Index Questionnaire.

No	Question	Response Option	Score
1	How would you rate the level of heat stress you experience on a typical hot day?	1=None, 2=Mild, 3=Moderate, 4=High, 5=Extreme	1 - 5
2	How much do you sweat during work on a typical hot day?	1=Not at all, 2=Lightly, 3=Moderately, 4=Heavily, 5=Clothes soaked	1 - 5
3	How hard does the physical work feel on a typical hot day?	1=Very Light, 2=Light, 3=Somewhat Hard, 4=Hard, 5=Very Hard	1 - 5
4	How often do you feel tired or fatigued while working on a typical hot day?	1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Always	1 – 5
5	How often have you felt dizzy or lightheaded on a typical hot day?	1=Not at all, 2=Occasionally, 3=Frequently, 4=Most of the time, 5=Constantly	1 – 5
6	How many rest breaks do you take on a typical hot day?	1= 1, 2= 2, 3 = 3, 4 = 4, 5 or more = 5	1 – 5
7	How much water or fluids do you consume on a typical hot day?	Less than 1Litre = 1, 1 – 1.5Litres = 2, 1.5 – 2Litres = 3, 2 – 3Litres = 4, More than 3Litres = 5	1 – 5
8	How frequently do you experience Heat Related Symptoms (e.g., headaches, nausea, dizziness etc) while working on a typical hot day?	1=None, 2=Occasionally, 3=Moderately, 4=Frequently, 5=Severely	1 – 5

Source: Authors, (2025).

III.4 DATA PROCESSING AND ANALYSIS

Data were analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics (mean, standard deviation, and frequency distribution) were used to summarize respondents' heat stress levels. The mean HSI score for each respondent was computed to determine the overall level of exposure, categorized as mild, moderate, high, or extreme. Further analysis using multiple regression examined the relationship between occupational factors (e.g., workload, work duration, and clothing type) and reported heat stress levels.

III.5 ETHICAL CONSIDERATIONS

Participation was voluntary, and informed consent was obtained from all respondents. Respondents were assured of anonymity and confidentiality, and ethical approval was obtained in accordance with institutional research standards.

IV. RESULTS AND DISCUSSIONS

IV.1 DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

A total of 174 outdoor construction workers participated in the study as seen in Table 2 below. The sample consisted of 20.7% unskilled laborers, 24.1% skilled laborers, 35.0% site supervisors, and 20.1% safety officers, ensuring broad representation of workforce categories. The majority of respondents were male (75.3%), aged between 25–34 years (31.6%), and worked 8–12 hours daily (59.2%), primarily under direct sunlight (62.1%). Over 55% had received none or minimal heat stress training, suggesting a major knowledge gap in occupational heat safety. These characteristics indicate that construction workers in Lagos operate in high-risk thermal environments with prolonged exposure to heat and limited institutional protection.

Table 2: Demographic Information of Respondents.

Variable	Category	Frequency (N)	Percentage (%)
Role on Construction Site	Unskilled Labor	36	20.7
	Skilled Labor	42	24.1
	Site Supervisor	61	35.0
	Safety Officer	35	20.1
Gender	Male	131	75.3
	Female	43	24.7
Age Group (Years)	18–24	42	24.1
	25–34	55	31.6
	35–44	25	14.4
	45–54	36	20.7
	55+	16	9.2
Years of Experience	< 1 Year	26	14.9
	1–3 Years	37	21.3
	4–6 Years	39	22.4
	7–10 Years	34	19.5
	Over 10 Years	38	21.8
Sun Exposure Frequency	Never	4	2.3
	Rarely	25	14.4
	Sometimes	37	21.3
	Often	69	39.7
	Always	39	22.4
Daily Work Duration	< 8 Hours	46	26.4
	8–10 Hours	69	39.7
	10–12 Hours	34	19.5
	> 12 Hours	25	14.4
Heat Stress Training/Awareness	None	41	23.6
	Low	55	31.6
	Moderate	31	17.8
	High	27	15.5
	Very High	20	11.5

Source: Authors, (2025).

IV.2 HEAT STRESS INDEX (HSI) DISTRIBUTION ACROSS RESPONDENTS' ROLES

The Heat Stress Index (HSI) was computed from eight self-reported heat stress variables: sweating, exertion, fatigue, dizziness, rest breaks, hydration level, and heat-related symptoms. Each variable was rated on a five-point Likert scale (1–5), producing a total score between 8 and 40. The HSI was categorized as Mild (15–21), Moderate (22–27), High (28–34), and Extreme (35–40).

Table 3: Heat Stress Index (HSI) Distribution Across Respondents' Roles.

Role on Site	Extreme (35 – 40)	High (28 – 34)	Moderate (22 – 27)	Mild (15 – 21)	Total	Mean HSI
Safety Officer	0	4	25	6	35	24.63
Site Supervisor	1	10	41	9	61	25.00
Skilled Labor	1	9	26	6	42	24.98
Unskilled Labor	3	16	16	1	36	25.67
Total	**5**	**39**	**108**	**22**	**174**	

Source: Authors, (2025).

Overall, Table 3 shows that most workers fall within the moderate heat stress category across all roles, with mean HSI values ranging between 24.98 and 26.63. Although the differences in mean scores appear small, the trend indicates that unskilled labourers reported highest HSI values, implying greater vulnerability of the group to a range of heat-related health issues. Site Supervisors reported the second highest HIS, likely due to their extended on-site presence during inspections and monitoring of site work activities, while Safety Officers recorded the lowest mean stress level.

IV.3 TEST OF HYPOTHESIS ON HEAT STRESS INDEX (HSI) ACROSS WORKER CATEGORIES

This section examines whether there is a statistically significant difference in Heat Stress Index (HSI) among the various categories of construction site workers. The hypothesis formulated for this purpose is as follows:
Null Hypothesis (H_o): There is no significant difference in the Heat Stress Index (HSI) of various categories of construction site workers.
Alternative Hypothesis (H_1): There is a significant difference in the Heat Stress Index (HSI) of various categories of construction site workers. To test this hypothesis, an analysis of Variance (ANOVA) was conducted to compare the mean HSI values among the worker categories (Unskilled Labor, Skilled Labor, Site Supervisor, Safety Officer). The result is presented in Table 4.

Table 4: ANOVA Result showing Differences in HSI Across Worker Categories.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (*p*-value)
Between Groups	20.278	3	6.759	0.422	0.737
Within Groups	2721.148	170	16.007		
Total	2741.425	173			

Source: Authors, (2025).

If p-value < 0.05, reject the null hypothesis (H_o).
If p-value > 0.05, accept the null hypothesis (H_o).

Table 4 shows an F-statistic of 0.422 with a corresponding p-value of 0.737, which is greater than the significance level of 0.05. This indicates that there is no statistically significant difference in the Heat Stress Index (HSI) among the various categories of construction site workers. Therefore, the null hypothesis (Ho) stating that there is no significant difference in HSI of various categories of construction site workers is accepted. This indicates that the heat stress levels experienced by all categories of workers were relatively similar. The observed similarity may be attributed to the fact that all workers performed their duties under comparable environmental conditions, such as direct sun exposure, humidity, and work duration, which contributed equally to their heat stress experiences.

IV.5 DISCUSSION OF FINDINGS

The findings from this study provide valuable insights into the extent and pattern of heat stress exposure among outdoor construction workers in Lagos Metropolis. The demographic profile (Table 1) revealed that the majority of respondents were male, within the economically active age group, and had considerable on-site experience, consistent with the gendered composition of the construction workforce reported in previous studies [10, 15]. The dominance of young to middle-aged male workers reflects a population often assumed to have high physical tolerance; however, evidence shows that this demographic remains susceptible to heat-related strain in prolonged exposure conditions [7]. Environmental and climatic data (Table 2) showed that average site temperatures were consistently above 30°C during observation, with relative humidity frequently exceeding comfort thresholds. These readings surpass international limits for safe work in outdoor conditions [1] and correspond with findings from other tropical regions where high heat index values were linked to reduced worker comfort and increased fatigue [9, 21]. Similar conditions have been documented in South India [5] and Saudi Arabia [10], where sustained exposure to such environmental extremes significantly elevated workers' risk of heat strain and dehydration.

The analysis of physiological and perceptual responses (Table 3) indicated that workers experienced moderate to high levels of thermal discomfort, fatigue, sweating, thirst, and dizziness, consistent with heat-related physiological reactions described in the literature [3, 20]. This outcome highlights that both skilled and unskilled workers perceive heat exposure as a major barrier to comfort and productivity, echoing findings from [6] and [8], who observed that heat exposure substantially impairs performance and cognitive functioning in high-temperature environments. Similarly, [11] emphasized that heat-related symptoms often intensify throughout the workday, contributing to reduced safety awareness and elevated accident risk. However, the ANOVA test result (Table 4) indicated no statistically significant difference in Heat Stress Index (HSI) among unskilled, skilled, supervisory, and safety officer categories (F = 0.422; p = 0.737). This suggests that heat stress exposure was relatively uniform across occupational roles on-site. The result aligns with observations from [2] and [5] that environmental heat stress in tropical construction settings affects all categories of outdoor workers similarly, largely because they share the same work environment, schedules, and microclimatic exposure. In line with [15] and [20], this study confirms that role differentiation alone does not significantly reduce exposure risk when heat conditions are spatially homogeneous and safety interventions are limited. Nevertheless, contrasting results have been reported elsewhere. [18] and [5] found significant variation in physiological strain between heavy manual and light-duty workers, reflecting differences in workload and metabolic rate. [10] also reported that task intensity influenced the magnitude of thermal strain among Saudi construction workers. The divergence from such findings may be explained by contextual factors: in Lagos, supervisors and safety officers frequently remain outdoors for prolonged periods, resulting in cumulative exposure comparable to that of manual workers. Additionally, similar clothing, work-rest schedules, and limited shade provisions across roles likely contributed to the homogeneity in heat stress levels. Alternative explanations are also worth considering. The self-reported indicators used in this study, such as thermal sensation, fatigue, and thirst, capture perceived heat stress rather than direct physiological responses.

As [22] and [8] note, perceptual data may underestimate subtle physiological differences that would be detectable through continuous monitoring (e.g., heart rate or core temperature). Moreover, situational coping behaviors such as intermittent rest, hydration practices, and informal shade-seeking may have moderated role-based differences during data collection. Several limitations of this study should be acknowledged. First, the study was restricted to Lagos Metropolis, where uniform climatic and construction practices limit generalization. Second, while the HSI provides a useful composite index, it may not fully capture individual variability in acclimatization, hydration status, or clothing insulation. Finally, the reliance on self-reported measures introduces potential recall or perception bias, which may affect the accuracy of some responses. Despite these limitations, the study carries important practical implications. The lack of significant difference in HSI across roles indicates that heat management strategies should be implemented site-wide, not confined to specific worker categories. Employers should adopt adaptive measures such as scheduled rest breaks, shaded rest zones, adequate hydration, and training programs to raise awareness about heat-related hazards. Policy frameworks should also integrate occupational heat management standards into Nigeria's construction safety regulations to protect all outdoor workers.

V. CONCLUSIONS

This study demonstrates that outdoor construction workers in Lagos Metropolis are exposed to considerable levels of heat stress, as evidenced by reported symptoms of thermal discomfort, fatigue, sweating, and dehydration. However, exposure levels did not differ significantly across occupational roles, suggesting that environmental and microclimatic conditions are the dominant determinants of heat stress on construction sites. These findings highlight the need for comprehensive, site-wide heat management strategies rather than role-based interventions. Future research should incorporate physiological monitoring tools (such as core temperature and heart rate sensors) alongside environmental and perceptual data, across multiple regions and climatic seasons, to establish context-specific standards for occupational heat risk management in Nigeria's construction sector. Construction firms should institutionalize heat management programs that include mandatory training for workers and supervisors on recognizing and responding to heat stress symptoms.

Scheduled rest breaks, particularly between 11:00 a.m. and 3:00 p.m., should be enforced, with adequate provision of shaded rest areas and potable water stations. Employers should provide workers with lightweight, breathable clothing and ventilated helmets to reduce thermal discomfort. Supervisors should also be equipped and trained to monitor on-site thermal conditions using simple tools such as heat index or wet-bulb thermometers, allowing timely adjustments to work-rest cycles. At the policy level, agencies such as the Council of Registered Builders of Nigeria (CORBON), the Council for the Regulation of Engineering in Nigeria (COREN) and the Federal Ministry of Labour and Employment should develop and enforce occupational standards on permissible heat exposure limits and safe working hours during extreme heat. These measures will strengthen worker protection, enhance productivity, and promote a more resilient construction workforce under rising temperature conditions.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Olajide Julius Faremi, Oghenetega Mary Adjeks and Dele Roger Simeon
Methodology: Author One, Author Two and Author Three.
Investigation: Author One and Author Two.
Discussion of results: Author One, Author Two and Author Three.
Writing – Original Draft: Author One, Author Two and Author Three.
Writing – Review and Editing: Author One, Author Two and Author Three.
Resources: Author one and Two.
Supervision: Author One.
Approval of the final text: Author One, Author Two and Author Three.

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