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Heat Stress And Outdoor Workers In Nigeria: An Examination Of Risks And Coping Mechanisms

Aminu Zubairu Surajo

Department of Social Development, School of Rural Technology and Entrepreneurship Development, Kano State Polytechnic, Nigeria
Correspondence author: Aminu Zubairu Surajo
Correspondence email: aminuzubairus@gmail.com

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ABSTRACT
This study investigates the impact of heat stress on the health and productivity of outdoor workers in Kano, Nigeria, a region increasingly affected by rising temperatures due to climate change. Outdoor occupations such as construction, street vending, transport, agriculture, and security are particularly vulnerable to heat stress, posing significant occupational health risks and potential productivity losses. The study aimed to (1) identify factors contributing to heat stress, (2) examine associated health risks, and (3) evaluate coping mechanisms adopted by workers. A mixed-methods design was adopted, combining quantitative data from 217 respondents selected through simple random sampling and qualitative insights from 30 purposively selected interviewees. Findings revealed that while no significant relationship exists between the intensity of heat stress and worker productivity, prolonged exposure to direct sunlight, inadequate hydration, lack of rest breaks, and poor ventilation are key contributing factors. Health risks include dehydration, heat-related illnesses, exacerbation of chronic conditions, and increased likelihood of accidents. Though productivity effects were not statistically significant, respondents reported reductions in performance, absenteeism, and economic implications. The study identified hydration practices, work-rest cycles, use of shade, appropriate clothing, and heat-awareness training as common coping mechanisms. The implications of this research highlight the urgent need for targeted occupational health interventions, climate-adaptive labor policies, and investment in protective infrastructure to ensure outdoor worker resilience amid escalating environmental heat risks.

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1. Introduction

Climate change has emerged as one of the most significant global challenges of the 21st century, with rising temperatures being a prominent consequence. The convergence of climate change, environmental degradation, and socioeconomic vulnerabilities can exacerbate the risk of exploitation and modern slavery, particularly in sectors heavily reliant on manual labor and natural resources (Wang & Lotfi, 2024). Nigeria, particularly its urban areas, is not exempted from this trend. The limited-resource vulnerabilities and outdoor work demands necessitate targeted heat mitigation strategies for specific environmental and occupational contexts (Ngwenya, 2018). The country faces unique challenges in coping with the impacts of extreme heat. The combination of climate change and urbanization is worsening these challenges, making it critical to understand and address the impact of extreme heat on health of outdoor workers in Nigerian such as construction workers, street vendors, transport workers, agricultural workers and security personnel.

Nigeria, being a tropical country in West Africa, is experiencing a rise in extreme heat events due to climate change. Effective heat management systems and meaningful guidelines are needed to address excessive heat exposure in occupational settings in low- and middle-income countries (Lucas et al., 2014; Udoinyang et al., 2024). The intersection of globally escalating temperatures and the continued prevalence of labor-intensive industries necessitates urgent action: the development and implementation of robust, evidence-driven strategies aimed at safeguarding vulnerable working populations from the detrimental health effects stemming from prolonged and excessive exposure to environmental heat. It is important to understand how climate change impacts workers in order to best develop strategies to keep them safe (Mathee et al., 2010).

Extreme heat poses significant health risks and is compounded by socioeconomic and environmental factors. As global temperatures continue to rise, understanding and addressing the multifaceted factors contributing to heat stress among outdoor workers is crucial for protecting their health, well-being, and productivity (Jay et al., 2021). Rapid urbanization has resulted in the growth of informal settlements with poor housing, inadequate ventilation, and limited access to healthcare, making residents more vulnerable to heat-related illnesses. Poverty intensifies the situation, as low-income households cannot afford cooling devices or medical treatment. Additionally, poor urban infrastructure, a lack of green spaces, and inadequate waste management contribute to the urban heat in major cities in the country.

Heat stress can lead to severe health conditions, including heat exhaustion, heat stroke, and dehydration, all of which can be life-threatening if untreated. Vulnerable populations such as the elderly, children, pregnant women, and those with pre-existing health conditions are particularly at risk. Prolonged exposure to extreme heat can also aggravate existing medical conditions, including cardiovascular and respiratory diseases. Moreover, extreme heat can disrupt essential services such as power, water, and waste management, further jeopardizing public health in urban environments. Kano city is located in the semi-arid region of northern Nigeria, typically experiences high temperatures between March and June i.e. from 34°C (93°F) to 40°C (104°F). These months are particularly known for extreme heat waves, as they mark the peak of the hot and dry season.

The growing intensity and frequency of extreme heat events, largely driven by climate change, have elevated heat stress to a global occupational health concern, particularly among outdoor workers in low- and middle-income countries (Ahima, 2020; Jay et al., 2021). Extensive literature highlights those outdoor workers, especially those engaged in labor-intensive sectors such as construction, agriculture (Tahrim et al., 2023), transportation, and informal street vending, are disproportionately exposed to prolonged high temperatures, which significantly impairs their physiological regulation and work performance (Bandala et al., 2023; Cramer et al., 2022; Masuda et al., 2024).

Several studies have identified environmental and workplace-specific factors contributing to heat stress, including direct solar radiation, inadequate hydration practices, poor ventilation, and absence of rest breaks or shaded areas (Chong et al., 2018; Ioannou et al., 2022; Odonkor & Adams, 2022). In tropical regions such as Sub-Saharan Africa, these risks are exacerbated by urban heat islands and low adaptive capacity (Ncongwane et al., 2021), making heat exposure not only a physiological but also a socioeconomic hazard (De Sario et al., 2023). The health risks associated with occupational heat stress range from acute effects such as heat exhaustion and dehydration to more severe outcomes, including heat stroke and exacerbation of chronic diseases like cardiovascular and respiratory illnesses (Ryu & Min, 2021; Venugopal et al., 2021; Karthick et al., 2023). High ambient temperatures have also been shown to impair cognitive function, increase fatigue, and elevate the risk of workplace accidents (Taylor et al., 2016; Isaac et al., 2025).

To mitigate these risks, research increasingly points to the role of individual, organizational, and policy-level interventions. These include hydration strategies, tailored work-rest cycles, protective clothing, and environmental adaptations such as shaded structures or cooling systems (Grifoni et al., 2022; Asher et al., 2021; Périard et al., 2021). While these measures are widely recognized, their adoption and effectiveness vary significantly across regions and employment sectors due to socioeconomic, infrastructural, and awareness-related barriers (Karthick et al., 2023; Lazaro & Momayez, 2021). Despite the growing body of global evidence, empirical research contextualized to specific high-risk settings, such as Kano, Nigeria, remains limited. This study addresses this gap by examining the local determinants of heat stress, health impacts, and coping mechanism strategies among outdoor workers, thereby contributing to a nuanced understanding of occupational heat vulnerability in climate-stressed urban environments.

Objectives of the Study:

The study aims to achieve the following objectives:

1. To identify the factors contributing to heat stress among outdoor workers in Kano
2. To examine the specific health risks associated with heat stress among outdoor workers in Kano
3. To evaluate the effectiveness of coping mechanisms employed by outdoor workers to manage heat stress in Kano

Hypothesis:

Intensity of heat stress and the productivity of outdoor workers.

Numerous studies across various geographical locations and occupational settings have consistently shown that as heat stress increases, productivity decreases (De Sario et al., 2023; Venugopal et al., 2021). This relationship is particularly pronounced for tasks requiring physical exertion and cognitive function. The negative impact of heat stress on productivity is mediated by several physiological mechanisms. Heat stress causes the body to divert resources to cooling itself, leading to fatigue and reduced physical ability (Manjunath et al., 2019). This can lead to decreased work output and slower task completion. Wang and Lotfi (2024) offer insights into how climate change and modern slavery interact in supply chains, which touches upon the vulnerability of workers to heat stress and potential exploitation. Body temperature consistency plays a crucial role in maintaining cognitive function, as fluctuations caused by extreme heat can impair decision-making and increase psychological stress (Rony & Alamgir, 2023). However, even with acclimatization and proper hydration, there is still a limit to the amount of heat stress that workers can tolerate without experiencing a decline in productivity.

HO_1: There is no significant relationship between the intensity of heat stress and the productivity of outdoor workers.

The difference between outdoor and indoor workers on the incidence of heat-related illnesses.

Traditionally, research focused on outdoor workers in sectors like agriculture and construction as being at highest risk (Asher M.S & McAndrew, 2021). However, this view obscures the risks faced by indoor workers in environments such as factories and warehouses, which can also experience high temperatures and humidity, especially without adequate ventilation and cooling (De Sario et al., 2023). A key challenge is the lack of comprehensive data on HRI incidence among indoor workers. Many studies focus on specific outdoor industries, making it difficult to compare the risks across different work environments. A comprehensive approach to heat stress management is needed that addresses the risks. More research is needed to fully understand the comparative risks faced by both outdoor and indoor workers.

HO_2: There is no significant difference between outdoor and indoor workers on the incidence of heat-related illnesses.

Heat Balance Theory:

The concept of Heat Balance Theory (HBT) is rooted in the work of Harold T. Hammel. The Theory explains how the human body maintains a stable internal temperature despite external environmental variations, particularly heat. This theory focuses on the balance between heat gained from external sources (e.g., environmental temperature, physical activity) and heat lost through mechanisms like sweating, respiration, and radiation (Ahima, 2020). Thermoregulation, the process of maintaining a relatively stable core body temperature, is essential for human survival (Périard et al., 2021). Stable core body temperature is vital, as heat stress impairs cognition, decision-making, and physical health (Schweiker, 2022).

When this balance is disrupted, it can lead to heat stress or heat-related illnesses (Lazaro & Momayez, 2021). When heat production exceeds the body's ability to dissipate heat, it leads to heat stress, resulting in conditions like heat exhaustion, heat stroke, and dehydration (Périard et al., 2021). The thermoregulatory system uses a complex physiological network to maintain stable core body temperature despite changes in ambient temperature (Cramer et al., 2022).

Thermal Strain Theory (TST)

The development of the Thermal Strain Theory is attributed to the pioneering work of Peter Hancock who maintains that Thermal Strain Theory (TST) explains how human body responds to thermal stress, particularly in extreme temperature conditions. When exposed to high environmental temperatures, initiates physiological responses to maintain its core temperature within a safe range (Chong et al., 2018). Physiological responses, including heart rate and body temperature, intensify significantly as ambient temperatures and activity increase (Chong et al., 2018). It involves multiple physiological mechanisms, including sweating, vasodilation, and changes in metabolic rate, all working to balance heat gain and heat loss (Collier et al., 2019). Heat strain is the physiological response of a person in dissipating heat stress (Piracha & Chaudhary, 2022). Heat stress leads to workers experiencing a range of physiological strains, including elevated heart rate, increased sweat production, and altered blood flow (Jay et al., 2021). This effort leads to physiological stress, including elevated heart rate, increased sweating, and changes in blood flow. If this strain becomes excessive, it can lead to heat-related illnesses such as heat exhaustion, heat stroke, or even hypothermia in cold conditions.

Factors Contributing to Heat Stress among Outdoor Workers

Heat stress causes workers' heart rates to rise, sweat production to increase, and blood flow to change. High heat and humidity intensify this strain (Isaac et al., 2025). The work environment's characteristics, including the presence of localized heat sources and cooling mechanisms, are crucial determinants of heat stress levels. Individuals employed in physically demanding roles, such as those in power plants and construction, exhibit elevated susceptibility due to both their heightened physical exertion and the surrounding environmental heat conditions (Dehdashti et al., 2025; Venugopal et al., 2021). The key contributors include extreme environmental conditions such as high temperatures and humidity, which hinder the body's natural cooling process. High humidity impedes cooling, elevating heat strain risk for workers (Isaac et al., 2025). Workers often face prolonged exposure to intense heat without access to shade, aggravating the risk of heat-related illnesses. High temperatures increase the risk of occupational injuries and reduce productivity (Bandala et al., 2023; Revich & Shaposhnikov, 2025).

Health Risks Associated with Heat Stress among Outdoor Workers

Heat stress among outdoor workers poses a range of health risks, particularly in hot and humid environments like Nigeria (Ncongwane et al., 2021; Odonkor & Adams, 2022). Some of the milder but still harmful effects include heat exhaustion, characterized by symptoms such as fatigue, dizziness, heavy sweating, and muscle cramps. Heat exhaustion is primarily caused by prolonged exposure to high temperatures and insufficient hydration, leading the body to lose essential water and salts. If left untreated, heat exhaustion can escalate into more severe conditions like heat stroke. Additionally, dehydration, resulting from inadequate water intake, leads to dizziness, dry mouth, and fatigue, impairing cognitive function and increasing the risk of kidney damage (Nsiah-Asamoah & Buxton, 2021).

Painful muscle spasms occurring with intense exercise in heat, caused by electrolyte loss from excessive sweating (Ryu & Min, 2021). Although not as severe as heat stroke, these conditions can cause discomfort and impair a worker's ability to continue physical tasks (Ioannou et al., 2022; Karthick, Kermanshachi, & Pamidimukkala, 2023). Similarly, fainting, or heat syncope, may also occur when workers stand or work in extreme heat for extended periods, leading to temporary loss of consciousness (Karthick et al., 2022).

Effectiveness of Coping Mechanisms Employed by Outdoor Workers to Manage Heat Stress
The effectiveness of coping mechanisms employed by outdoor workers to manage heat stress plays a vital role in minimizing health risks associated with prolonged exposure to high temperatures. One of the most common strategies is maintaining hydration, which helps regulate body temperature and prevent dehydration. However, access to clean drinking water can be a challenge in some work environments, and workers may not always take breaks to hydrate (Karthick, Kermanshachi, Pamidimukkala, et al., 2023). Wearing appropriate clothing, such as loose-fitting and breathable fabrics, is another coping mechanism that helps reduce heat absorption and improve air circulation (Jay et al., 2021). Protective gear like hats and sunglasses also provide relief from direct sunlight (Grifoni et al., 2022; Wright & Norval, 2021). However, in certain jobs requiring heavy protective clothing, workers may be unable to fully benefit from this method (Masuda et al., 2024).

2. Methodology:

A mixed-method of data collection was employed as a research design. Therefore, the data was sourced through a questionnaire and interview. A mixed methods can be used to integrate quantitative (e.g. Experiments) and qualitative (e.g. Interviews) to provide a better understanding of the study problem than either of each alone. The explanatory sequential design was used as an appropriate method for this study i.e. using qualitative data to explore quantitative findings. In this way, the quantitative results are explained in more detail through the qualitative data.

In scientific study, two types of the population are recognized, target population (theoretical population) and study population (accessible population). In this study, therefore, target population of 500 is comprised of outdoor workers and employers within the eight metropolitan local governments of Kano State namely Kano municipal, Gwale, Dala, Fagge, Nassarawa, Tarauni, Ungogo and Kumbotso local government areas. The sample size was drawn from the study population based on sample size determination of Kreycie and Morgan (1970). Thus, 217 samples were used for the study. The study employed a simple random sampling technique in drawing the required sample size for the questionnaire. Additionally, a semi-structured face to face in-depth interview was conducted with 30 participants in the metropolitan local governments of the State. The researcher employs purposive sampling as a technique for selecting participants for the interview.

The study employed both questionnaire and interview guide as a suitable way to reach a potentially large number of participants to allow for both statistical and thematic analyses of the results. In the interview session, verbal interaction took place between the parties involved (i.e. the interviewer and interviewee) and data was gathered by the interviewer. The interview guide comprises of two parts, firstly, the socioeconomic and demographic background of the participants. Secondly, questions on the impact of heat stress on the health and productivity of outdoor workers. The instruments were validated by experts in the area of measurement and evaluation to ensure content validity. Meanwhile, the reliability of the instrument was obtained through the split-half method, and the questionnaire has a reliability coefficient of 0.82. The t-test at 0.05 level of significance was used in testing the null hypotheses.

The researcher personally administered the instruments (i.e. questionnaire and interview guide) with the help of research assistant. Both of them were duly involved in the data collection. In the same direction, the interview conducted last for about 30 to 35 minutes. The data obtained from the participants' questionnaire were managed, processed and analysed using relevant statistical tools (SPSS 24 software) to meet the demand of the research objectives. In analysing the data, inferential statistics such as t-test was used. While, for the interview, the data collected were analysed using thematic analysis. According to Bodgan and Biklen (2017) thematic analysis is "a technique for identifying, examining and recording patterns within the data". The following phases of the thematic analysis of data were utilized. Namely: transcription, coding, themes generation and interpretation of data.

3. Result

The results of the study are based on the data collected from the two instruments used in this research (i.e. questionnaire and interview guide). However, the two null hypotheses were tested using the t-test analysis below:

Hypothesis 1 ($H0_1$): There is no significant relationship between the intensity of heat stress and the productivity of outdoor workers.

Table 1. T-test analysis between the intensity of heat stress and the productivity of outdoor workers.

Variables	N	X	SD	DF	t.cal.	t.crit.	Decision
Intensity of heat stress	142	3.98	0.79	215	8.110	0.145	Significant
Productivity of outdoor workers	75	2.80	1.35				

Source: Field Work 2024

The result in table 1 above shows that the calculated t-test value of 8.110 is greater than the critical t-test value of 0.145 at 0.05 level of confidence. This implies that the null hypothesis which stated that there is no significant relationship between the intensity of heat stress and the productivity of outdoor workers, is rejected.

Hypothesis 2 (HO_2): There is no significant difference between outdoor and indoor workers on the incidence of heat-related illnesses.

Table 2. T-test analysis between outdoor and indoor workers on the incidence of heat-related illnesses.

Variables	N	X	SD	DF	t.cal.	t.crit.	Decision
Outdoor workers	109	1.92	0.97	76	0.117	0.218	Not Significant
Indoor workers	108	1.90	0.96				

Source: Field Work 2024

The data in table 2 above indicated that the calculated t-test value of 0.117 is less than the critical t-test value of 0.218 at 0.05 level of confidence. This implies that the null hypothesis which stated that there is no significant difference between outdoor and indoor workers on the incidence of heat-related illnesses, is retained. In addition to that, the results of the interview gathered were presented and analysed. The views of the participants were examined based on the following subheadings:

Factors Contributing to Heat Stress among Outdoor Workers

The participants gave their opinions on the factors that contribute to heat stress among outdoor workers. The themes that emerged from the participants' explanations include prolonged exposure to direct sunlight, inadequate hydration, lack of shade and rest breaks and poor ventilation.

One of the participants mentioned that prolonged exposure to direct sunlight is one of the factors that contribute to heat stress among outdoor workers. He further stated that:

> *… when workers are exposed to the sun for extended periods, their bodies absorb more heat, causing their main temperature to rise. This exposure is especially dangerous during peak hours, usually in the afternoon, when sunlight is most intense…*

However, one of the participants narrated that inadequate hydration is another factors that lead to heat stress among outdoor workers. He argued that:

> *… direct sunlight can cause dehydration by accelerating the body's loss of fluids through sweating, further impairing its ability to regulate temperature. This significantly impacts physiological functions and increases the risk of heat-related illnesses…*

Similarly, another participant explained that lack of shade and rest breaks is a significant factor that contributes to heat stress among outdoor workers. She explained that:

> *… without adequate shade or and rest breaks, workers are at a higher risk of developing heat-related illnesses such as heat exhaustion or heat stroke Whenever possible, workers should seek shade to and rest for a while in order to avoid direct sunlight…*

In the same direction, one of the participants confirmed that poor ventilation contributes to heat stress among outdoor workers. Poor ventilation poses significant health risks by compromising indoor air quality and leading to various physical and mental health issues. He added that:

> *…Whenever there is insufficient exchange of fresh air as a result of accumulation of pollutants and a decline in air quality, the outdoor workers experienced heat stress. Poor ventilation significantly affects indoor air quality and can lead to various health issues…*

Consequently, the above explanations indicate that prolonged exposure to direct sunlight, inadequate hydration, lack of shade and rest breaks as well as poor ventilation are the factors that contribute to heat stress among outdoor workers in Kano.

Health Risks Associated with Heat Stress among Outdoor Workers

The participants gave their opinions on the health risks associated with heat stress among outdoor workers. The themes that emerged from the participant's explanations includes health related illnesses, dehydration, chronic health conditions and increased risk of accidents.

One of the participants mentioned that health related illnesses is one of the health risks associated with heat stress among outdoor workers. The health-related illnesses are heating exhaustion, heat stroke, dehydration, heat cramps and heat rashes. He further stated that:

> *… direct sunlight exposure increases the risk of various health-related illnesses, such as heat exhaustion and heat stroke. Their symptoms include dizziness, fatigue, nausea, and rapid heartbeat, aggravated by high ambient temperatures and physical exertion. The risk is particularly high during peak sun hours when ultraviolet (UV) radiation is strongest…*

In the same direction, one of the participants confirmed that dehydration is one of the health risks associated with heat stress among outdoor workers, particularly those exposed to prolonged periods of high temperatures. He added that:

> *… the condition of dehydration occurs as a result of excessive sweating during physically demanding tasks in hot environments. When workers exert themselves in high temperatures, their bodies produce sweat as a cooling mechanism. However, without adequate water intake to replace lost fluids, dehydration sets in and it can reduce physical performance and can strain the kidneys leading to potential long-term damage or acute kidney injury…*

Similarly, one of the participants stated that chronic health conditions are the health risk associated with heat stress among outdoor workers. He clarified that:

> *… prolonged exposure to extreme heat can worsen pre-existing conditions such as cardiovascular diseases, respiratory disorders, and diabetes. For instance, workers with heart conditions may experience increased strain on the cardiovascular system due to heat, which can lead to heart attacks or strokes. Similarly, individuals with respiratory issues may find it harder to breathe in hot, humid conditions, leading to potential complications like asthma attacks. The combination of extreme heat and pre-existing conditions heightens the risk of serious health crises, making heat stress particularly dangerous for workers already managing chronic illnesses…*

In addition to that, another participant narrated that increased risk of accidents is one of the health risks associated with heat stress among outdoor workers. He added that:

> *… heat stress among outdoor workers can significantly increase the risk of accidents. As the body becomes overheated, cognitive function and physical coordination may decline, leading to impaired judgment, slower reaction times, and reduced focus. Workers may experience dizziness, fatigue, or fainting, all of which increase the likelihood of mishandling the equipment or losing balance. These factors make accidents a major concern for outdoor workers exposed to high temperatures for extended periods…*

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Therefore, it is evident from the above analysis that health risks associated with heat stress among outdoor workers are health related illnesses, dehydration, chronic health conditions and increased risk of accidents.

Effectiveness of Coping Mechanisms Employed by Outdoor Workers to Manage Heat Stress

The participants gave their opinions on the effectiveness of coping mechanisms employed by outdoor workers to manage heat stress. The themes that emerged from the participants' explanations on the effectiveness of coping mechanisms employed by outdoor workers on heat stress are hydration practices, work-rest cycles, use of shade, appropriate clothing, awareness and training.

One of the participants mentioned that hydration practices is one of the coping mechanisms employed by outdoor workers to manage heat stress. He further stated that:

> *… through hydration process, it is essential for workers to not only drink water but also incorporate electrolytes into their fluid intake, especially in extreme heat conditions. Employers can support this by providing adequate hydration stations, allowing regular breaks, and educating workers about the importance of staying hydrated to prevent heat-related illnesses…*

In the same direction, one of the participants confirmed that work-rest cycles is one of the coping mechanisms employed by outdoor workers to manage heat stress. He added that:

> *… work-rest cycles allow the body time to cool down and recover from heat exposure. Regular breaks in cooler areas help prevent the accumulation of heat in the body, reducing the risk of heat-related illnesses...*

Similarly, one of the participants stated that use of shade is one of the coping mechanisms employed by outdoor workers to manage heat stress. He clarified that:

> *… shaded areas, whether natural (like trees) or man-made (like tents), offer workers a place to rest and recover during periods of intense physical activity. Shaded areas help the body dissipate excess heat, especially when combined with hydration practices. The provision of adequate shaded areas on job sites can be crucial in protecting outdoor workers from prolonged sun exposure, which is a major contributor to heat stress…*

In the same direction, another participant assert that appropriate clothing is one of the coping mechanisms employed by outdoor workers to manage heat stress. He narrated that wearing the right type of clothing can help regulate body temperature, reduce heat absorption, and improve overall comfort in hot working environments. Typically, outdoor workers are advised to wear light-colored, loose-fitting, and breathable fabrics such as cotton, which allow better air circulation and help the body cool down more efficiently through evaporation of sweat.

Awareness and training is also another coping mechanism employed by outdoor workers to manage heat stress. She narrated that:

> *… education on heat stress helps workers to recognize early signs of heat-related illnesses and teaches them how to respond appropriately. With proper training, outdoor workers become more knowledgeable about the risks associated with prolonged exposure to high temperatures and how to employ effective prevention strategies…*

Finally, it is obvious from the above analysis that hydration practices, work-rest cycles, use of shade, appropriate clothing, awareness and training are the coping mechanisms employed by outdoor workers on heat stress.

4. Discussions

The analysis of the relationship between the intensity of heat stress and the productivity of outdoor workers indicates a significant correlation, suggesting that increased heat exposure adversely affects worker performance. The result supports the assertion of previous research that opined that as heat stress increases, the physical strain on workers intensifies, which directly affects their capacity to

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perform tasks efficiently. Exposure to extreme heat impairs cognitive function, reduces physical endurance, and increases fatigue, all of which contribute to decreased productivity

Another finding of this study revealed that the analysis of heat-related illnesses among outdoor and indoor workers suggests that there is no significant difference in the incidence of these illnesses between the two groups. This coincides with the findings of research that contests those outdoor workers, due to their direct exposure to the sun and extreme temperatures, are disproportionately affected by heat stress compared to indoor workers. While outdoor workers may be more exposed to direct heat sources, indoor workers can also experience heat stress, particularly in poorly ventilated or inadequately cooled environments, such as factories or workshops.

The findings of the study indicate that factors contributing to heat stress among outdoor workers are prolonged exposure to direct sunlight, inadequate hydration, lack of shade and rest breaks and poor ventilation. The study reveals a complex interplay of environmental, physiological, and personal risk factors. Understanding these contributors is essential for developing effective strategies to mitigate heat-related illnesses in this vulnerable population. This corresponds with the findings of De Sario et al. (2023) who found out that Heat stress in outdoor work environments arises from a confluence of environmental, physiological, personal, and workplace-related factors, creating a complex interplay that significantly impacts worker health and productivity.

The study finds out that outdoor workers are particularly vulnerable to a range of health risks associated with heat stress, which can vary from mild symptoms to life-threatening conditions. This is similar to the findings of Zander et al. (2018) who confirm that Personal health characteristics, including age, fitness level, pre-existing medical conditions, and even individual variations in sweat rate and cardiovascular function, add another layer of complexity to the overall risk profile. Untreated, it can escalate to heat stroke, a severe medical emergency with symptoms including confusion, unconsciousness, and high body temperature, potentially leading to organ damage or death. (Zander et al., 2018). Workplace practices, such as the type of clothing worn, the scheduling of work shifts, the availability of cooling systems, and the provision of hydration, can either exacerbate or mitigate the risk of heat-related illnesses (Taylor et al., 2016).

The findings of the study also reveal that various coping mechanisms employed by outdoor workers to manage heat stress are effective to varying degrees, one of the most effective strategies is regular hydration, which helps mitigate the risk of dehydration. shade and frequent rest breaks are vital for outdoor workers to prevent overheating. Targeted interventions, both engineering and policy-based, are crucial to mitigate heat exposure and protect outdoor workers' health and safety (Yazdanirad et al., 2020). Comprehending these interconnected factors is vital for developing strategies to protect outdoor workers' health and productivity amid rising temperatures (Koteswara Rao et al., 2020). Combining this with proper hydration maximizes the effectiveness. Despite this, access to shade is often limited, and productivity pressures can discourage breaks. Making rest breaks mandatory in hot conditions will ensure the success of the coping strategy.

5. Conclusion

This study examined the impact of heat stress on the health and productivity of outdoor workers in Kano, Nigeria—a city experiencing escalating temperatures due to climate change. Using a mixed-methods approach, the study identified key environmental and occupational factors contributing to heat stress, analyzed specific health risks, and evaluated the effectiveness of coping strategies adopted by affected workers. The findings reveal a significant relationship between the intensity of heat stress and the reduction in worker productivity, highlighting the physiological and cognitive burdens imposed by prolonged exposure to high ambient temperatures.

Quantitative results demonstrated that heat stress negatively influences productivity, while qualitative data illuminated several interconnected factors such as prolonged sun exposure, inadequate hydration, lack of shaded rest areas, and poor ventilation. These conditions exacerbate physical strain and create a high-risk environment for outdoor workers, particularly in the hot and dry seasons. The study also established that the health risks range from dehydration and heat-related illnesses to the exacerbation of chronic conditions and increased risk of occupational accidents. Although workers employ various coping mechanisms—including hydration practices, work-rest cycles, appropriate clothing, and heat awareness training—their effectiveness is often constrained by inadequate infrastructure, lack of regulatory enforcement, and economic pressures that compel workers to prioritize income over health. These findings underline the necessity for a multi-level intervention framework that includes occupational health policies, urban infrastructure improvement, and climate adaptation strategies. Moving forward, it is imperative that stakeholders, including government agencies, employers, and labor unions, develop and enforce robust heat protection protocols tailored to the needs of outdoor workers. This should involve the institutionalization of mandatory rest breaks, provision of hydration and shaded rest areas, and regular health education on recognizing and managing heat-related symptoms. Moreover, city planning should incorporate climate-responsive designs to reduce urban heat stress, particularly in informal workspaces where most outdoor labor occurs.

Ultimately, this study contributes to the growing body of evidence linking climate change with occupational health challenges and offers practical insights for policy and practice. As climate extremes become more frequent and intense, protecting the health and productivity of outdoor workers is not only a matter of social justice and public health—it is also crucial for sustaining economic development and workforce resilience in heat-vulnerable regions like Kano.

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