UNIVERSITY OF CAPE COAST

HEAT EXPOSURES ASSOCIATED WITH HEAT STRESS AND AMBULATORY HYPERTENSION AMONG FISH SMOKERS IN COASTAL AREAS OF GHANA

EMMANUEL ANKOMAH-APPIAH

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BY

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Thesis submitted to the Department of Health, Physical Education and Recreation of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Doctor of Philosophy Degree in Health Promotion (Environmental and Occupational Health Promotion)

February 2024

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……………………………… Date: ………………………

Name: Emmanuel Ankomah-Appiah

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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Name: Dr. Thomas Hormenu

ABSTRACT

Occupational health is a critical aspect of workplace safety and productivity, encompassing the physical, mental, and social well-being of workers. In high-temperature working environments, such as those found in fish-smoking operations, the importance of maintaining occupational health is paramount. High temperatures pose significant health risks, including heat stress, dehydration, and heat-related illnesses, which can severely impact workers' health and efficiency. The study aimed to investigate the influence of workplace heat exposure on heat stress and ambulatory hypertension among fish smokers in the coastal areas of Ghana. Guided by six research questions, the study employed an exploratory cross-sectional design using a sample of 2,018 fish smokers. Participants were conveniently selected from Keta, Tema New Town, Teshie, Awutu Senya, Moree, Elmina, and Shama. Data was collected using adapted questionnaires and anthropometric measurements, while data analysis utilised the Kruskal-Wallis H test, bivariate analysis, and a hierarchical binary logistic regression. The findings revealed a high prevalence of heat stress, at 87.6%, and a significant rate of ambulatory hypertension at 59.0% within this population. Additionally, fish smokers who work in the afternoon exhibited significantly higher levels of heat stress compared to those who work in the morning and evening, while those working 3-5 days and 5-7 days per week experienced frequent and severe ambulatory hypertension. The study also highlighted that age, education level, alcohol and caffeine consumption, time of day, water intake, personal protective equipment usage, and working under shade influence the prevalence of heat stress among these coastal fish smokers in Ghana. Consequently, there is an urgent need to address these socio-demographic and work-related factors and enforce labour protection and safety standards within the fish-smoking industry in Ghana.

KEYWORDS

Ambulatory hypertension

Occupational health and Safety of the Fish smoker

Socio-demographic and work-related factors

Workplace heat stress

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DEDICATION

To my mum, Madam Beatrice Ankomah-Appiah

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LIST OF ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienist
AMHPT	Ambulatory Hypertension
AOR	Adjusted Odd Ratio
API	Air Pollution Index
BMI	Body Mass Index
BP	Blood Pressure
CET	Corrective Effective Temperature
CODA	Coastal Development Authority
COPD	Chronic Obstructive Pulmonary Disease
CSIR	Center for Scientific and Industrial Research
DV	Dependent Variable
EEZ	Economic Exclusive Zone
ETR	Effective Temperature Radiation
FSSD	Fisheries Scientific Survey Division
GDP	Gross Domestic Product
HRI	Heat Related-Illness
ILO	International Labour Organisation
IRB	Institutional Review Board
ISO	International Organization for Standardization
IV	Independent Variable
mmHg	Millimeter Mercury
MOFAD	Ministry of Fisheries and Aquaculture Development
NAFAG	National Fisheries Association of Ghana
NAFPA	National Fish Processors and Traders Association
NCDs	Non-communicable diseases

NIOSH	National Institute for Occupational Safety and Health
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
PSI	Physiological Strain Index
SPSS	Statistical Package for Social Science
TD	Dry Bulb Air Temperature
TG	Globe Temperature
TNWB	Natural Wet bulb Temperature
TWB	Wet Bulb Temperature
TWL	Thermal Work Limit
U.S.	United States
UCC	University of Cape Coast
USG	Urine Specific Gravity
WBGT	Wet Bulb Globe Temperature
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

Background to the Study

Millions of workers in the informal sectors suffer from illness, injuries, and even death due to workplace heat exposure (De Sario et al., 2023). Hence, the World Health Organization (WHO) and the International Labour Organisation (ILO) are advocating for a safe, healthy, and decent working environment for all workers against health exposure. Heat exposure in the workplace can lead to various health problems, such as heat stress, heat stroke, dehydration, and other heat-related illnesses. These conditions can be particularly dangerous for workers who are not adequately protected or informed about the risks people face (WHO,2015; ILO, 2018).

Globally, work-related illnesses and accidents account for a significant proportion of the overall population's morbidity. In many industries and occupations, workers are exposed to various health and safety risks which may lead to injuries, illnesses, or long-term health issues (Page & Sheppard, 2016; Adei, Agyemang-Duah, & Mensah, 2021). This may be occurring because workers account for more than half of the global population and they contribute significantly to modern societies' economic and social worth (Siegrist, 2016). Therefore, paying particular attention to the occupational health and safety (OHS) needs of workers to safeguard their safety, health, and well-being is crucial in contemporary society. Moreover, protecting workers is a human rights issue that creates decent work and eventually safe work (WHO, 2015). Since safety in the workplace is a global issue, several countries have measures and legislation that guarantee the safety of their workforce (Jacklitsch et al., 2016). The argument is that workers from various industries are faced with a plethora of work-related hazards, injuries, and illnesses (Fagan & Hodgson, 2017; Morris, Gonzales, Hodgson, & Tustin, 2019). For instance, the food processing industry presents a vast range of health and safety implications for their workers due to heat exposure.

Heat exposure is a rising concern in workplaces globally because climate change is exacerbating the effects of heat exposure on workers—a situation that creates public health concerns (Kjellstrom, Lemke, & Otto, 2017). For instance, working in a hot, dry environment can cause stress leading to impaired performance, heat-related illnesses, and eventually, death (Levy & Roelofs, 2019). Heat stress occurs when a combination of exposure to ambient heat and the build-up of heat from the body through physical exertion exceeds the human body's ability to dissipate heat (Asamoah, Kjellstrom, & Östergren, 2018), causing heat-related illness. Heat-related occupational illness, injuries, and reduced productivity occur in situations in which the total heat load (environmental plus metabolic heat) exceeds the body's capacity to maintain normal bodily functions (ACGIH, 2017). This condition results in a malfunction of the human thermoregulatory system under extreme conditions leading to physiological reactions or illnesses such as heat stroke, heat exhaustion (Martinez-Nicolas et al., 2015), cramps, skin eruptions, chronic dehydration, kidney disease, and hypertension (Cheshire, 2016; De Sario et al., 2023).

Heat stress is the subject of ongoing research on work environments where workers are often exposed to high air temperatures, radiant heat sources, high humidity, direct body contact with hot objects, or strenuous physical activity (Acharya, Boggess, & Zhang, 2018; Gao, Kuklane, Östergren, & Kjellstrom, 2018). Exposure to higher ambient heat has also been linked to an increased risk of traumatic injuries among workers (De Sario et al., 2023). Environmental factors such as ambient temperature, wind, humidity, ventilation, and direct exposure to the sun influence the heat load on some occupations, especially outdoor industries such as agriculture, mining, road building, fisheries, and forestry (Nyarubeli, Tungu, Moen, & Bråtveit, 2019). Thus, heat stress and ambulatory blood pressure could occur, with negative impacts, on workers. For example, in 2016, there were about 125 million more people who experienced heat waves than there were in 2000 .In Europe, 70,000 people died in 2003 as a result of the June-August heat event, compared to 56,000 deaths in 2010 due to a 44-day heatwave in the Russian Federation (WHO, 2018).

Evidence indicates that about 7 million people died from air pollution-related diseases in 2012, making it the single largest risk to environmental health globally (WHO, 2015). Unfortunately, climate change is expected to cause an additional 250,000 deaths from malaria, diarrhoea, heat, stress, and malnutrition between 2030 and 2050 (World Health Organization [WHO], 2022). These complications, from heat exposure, are evident in different sectors globally. For instance, the United States (US) Bureau of Labor Statistics (2019) stated that 252 persons died on the job as a result of ambient heat exposure between 2011 and 2017, affecting many worker groups. Also, workers in fishing and hunting had a fatal injury rate of 145.0 per 100,000 full-time employees (US Bureau of Labor Statistics, 2019). Moreover, a systematic review showed that the effects of heat stress on health and productivity are increasing in low- and middle-income countries (Afshari, Moradi, Angali, & Shirali, 2019). Thus, about 94 kitchen workers in northern India were subjected to an average workplace temperature of 38 ^{0}C with 67% humidity which led to high urinary specific gravity, and 85% albumin-to-creatinine ratio > 30 mg/dl5 (Varghese et al., 2019).

Furthermore, a study of 312 women workers in southern India's agricultural field of brickmaking and steelmaking revealed that 71% of the workers had exposure above the recommended limit (defined by WBGT), which resulted in urine specific gravity > 1.020, excessive sweating and thirst during work shifts (Morabito et al., 2020). Similarly, a cross-sectional study of bakeries in Lebanon and Shahroud Cities in Iran showed heated environments and heat stress-related health ailments (Afshari et al., 2019; Habib, El-Haddad, Halwani, Elzein, & Hojeij, 2021). From Sri Lanka, Jayasekara et al. (2019) also found among agricultural workers that 85.4% were exposed to heat stress conditions, which was associated with kidney disease among the workers. The high prevalence of exposure to occupational heat stress is no different in the African context. Evidence showed that developing countries in sub-Saharan Africa (SSA) are also grappling with an increasing burden of non-communicable diseases (NCDs), which are driven by urbanisation and increasing temperatures leading to conditions like high blood pressure (Marquez, 2013; Mudie et al., 2019). Unfortunately, up to 50% of hypertension cases go undiagnosed, and only a small minority of those on treatment achieve the treatment target (van der Merwe, 2020).

Risks related to working in hot conditions in Zimbabwe revealed that over 80% of workers in small-scale industries like cooks and farmers work in abnormally high thermal conditions (Ngwenya et al., 2018). Additionally, Sepadi & Nkosi (2022) reported that a good number of small-scale workers in the informal sector in South Africa were exposed to extreme thermal conditions due to the nature of their occupation. This was earlier reported by Yengoh & Ardö (2020) that 75% of small-scale farmers in Kenya and Tanzania were at risk of several health conditions due to occupational heat stress, climate change, and other work-related activities. Moreover, the work of Frimpong et al. (2017) in Ghana found that close to 60% of mine workers suffer some form of work-related heat stress. Frimpong et al. (2017) further revealed that mining workers were at risk of severe heat stress because of the nature of their occupation. Additionally, Nunfam et al. (2019) emphasised that exposure to heat stress does not only have medical implications, but also results in productive capacity loss, anxiety, slow pace of work, and inadequate social well-being of workers. Thus, exposure to excessive heat has far-reaching physiological effects for all humans, often worsening existing conditions, and leading to premature death and disability (Al-Bouwarthan, Quinn, Kriebel, & Wegman, 2019). The extent and nature of the health effects of heat depend on the time, intensity, and duration of the temperature event, the degree of acclimatisation, and the adaptability to the heat by the local population (Al-Bouwarthan et al., 2019).

The food processing industry, specifically the fish processing industry, presents several work-related hazards (Barrow et al., 2022). Significant hazards can be found in fish smoking in developing nations, including Ghana (Adei, Braimah, & Mensah, 2019). For instance, long-term exposure to the heat of wood fire can cause burns and eye injuries with an attendant decrease in eyesight (Barrow et al., 2022). Moreover, traditional smoking produces high amounts of polycyclic aromatic hydrocarbons (PAHs) which are carcinogenic (Michael, Cai, Akwasi, & Adele, 2019). In addition, smoke from fish processing can impair the respiratory and immune response, increase dehydration, and aggravate heat stress, and other physiological conditions such as blood pressure, putting such workers at higher risk for infectious lung diseases and other heat-related illnesses (Adei et al., 2019; Venugopal, Latha, & Shanmugam, 2020). Therefore, measures such as heat stress assessment and ambulatory blood pressure monitoring among fishmongers are needed. For instance, ambulatory blood pressure monitoring can detect masked hypertension, reduce the risk of stroke, heart disease, and organ damage caused by hypertension, and assess a patient’s response to long-acting antihypertensive medications (Yu et al., 2020).

Such measurements may help rule out whitecoat hypertension and prevent workers from receiving unnecessary prescriptions.

Ambulatory hypertension is an elevated blood pressure level due to movement (Santos et al., 2016). Such a person is not already diagnosed with hypertension. Ambulatory hypertension is common among individuals who work in a fast-paced environment such as farmers (Frimpong et al., 2017), mining operators (Meshi et al., 2018), and fish smokers (Tene & Armah, 2020). This condition could also be due to work-related stress (Boucher et al., 2017; Trudel et al., 2020), which can result in severe health conditions such as chronic kidney disease, cardiovascular conditions, and stroke (Glaser et al., 2016). In a variety of occupations, work stress has been linked as an independent risk of the aetiology of coronary heart disease and the risk of elevated blood pressure (Venugopal, Latha, & Shanmugam, 2020). Unfortunately, high occupational stress is thought to be a contributing factor to 21% to 32% of occupational-induced hypertension prevalence (Wang,Q. et al., 2017).

The nature of high blood pressure due to work has been reported in studies globally. For instance, Huang, Lu, X. & Wang, (2024) study in China stated that approximately 45% of employees in the formal and informal sectors of the economy were at risk of developing hypertension due to the nature of their occupation. Also, studies conducted in Italy showed that the prevalence of work-related hypertension ranges from 25% to 43% among businessmen (Cerasa et al., 2020; Fatima, Rothmore, Giles, Varghese, & Bi, 2021). Moreover, it is evident from the USA that hypertension among healthcare workers is rising, and that, about 50% of the workers are likely to develop work stress-related hypertension (Munakata, 2018).

Hypertension due to job and occupational stress has also been reported in studies conducted in developing countries. Owolabi et al. (2012) found that about 26% of healthcare professionals in the Oyo State of Nigeria were at risk of developing hypertension as a result of occupational stress. Bosu (2016) also argued that about 23% of workers in West Africa have elevated blood pressure due to the stress and demanding nature of their occupation. These studies are further backed by a recent finding from Bokaba, Modjadji, and Mokwena (2021) who observed that the risk of high blood pressure among workers of both formal and informal sectors in Africa is on the rise and that it has various adverse consequences. From Ghana, Sanuade et al. (2018) revealed that the prevalence of hypertension due to work stress was 13.0% and this is likely to rise over the years. Again, Bosu (2016) also stated that work stress contributes to 29% of hypertension cases among workers in Ghana. These studies reiterate the health implications of occupational stress and other work-related factors and their implications on hypertension.

Studies have indicated the consequences of job demands among food processors, specifically fish smokers (Sun, Wu, & Gong, 2019). To put this theory to the test, several studies have been conducted to show that environmental exposures such as heat stress, working conditions, and climate change predict depression, stress, and weariness among workers in the food processing sector, notably fish smokers (Tawatsupa et al., 2010; Stults-Kolehmainen & Sinha, 2014; Cianconi et al., 2020). These findings indicate how these factors are associated with health outcomes, as well as the health and safety of fish smokers. Therefore, examining environmental exposures such as heat stress and ambulatory hypertension due to work-related among fish smokers becomes important and urgent.

Statement of the Problem

The exigency for strengthening the health and safety measures for labourers is a subject of considerable concern in both international (Chirico & Taino, 2018; Kajiki et al., 2020) and national discourses (Mustapha, Aigbavboa, & Thwala, 2018). The body of OHS research, particularly within the Ghanaian context, predominantly centres on sectors such as manufacturing (Eyiah, Kheni, & Quartey, 2019; Osei Tutu & Anfu, 2019), mineral extraction (Amponsah-Tawiah & Mensah, 2016; Aram, Saalidong, Appiah, & Utip, 2021), construction (Eyiah et al., 2019), agriculture (Asamani, 2020), healthcare (Asamani, 2020; Frimpong, Odonkor, Kuranchie, & Nunfam, 2020), and the operation of fuel stations (Ansah, Mintah, & Ogah, 2018). Within these examinations, a gap emerges; scant research has been directed towards the health and safety concerns of fish smokers in Ghana, despite the critical role such a workforce plays in the local economy. The inherent occupational risks associated with the fish industry, notably for those engaged in smoking processes, present significant potential for adverse impacts on the physical well-being and safety of these workers.

A limited set of inquiries has been directed towards the exploration of occupational injuries within Ghana's informal sector (Adei et al., 2021). Yet, these studies scarcely extend to the specific hazards of heat stress and ambulatory hypertension among fish smokers—a worker group that endures consistent exposure to high thermal work environments that may precipitate health and safety repercussions (Habibi, Moradi, Moradi, & Heydari, 2021). Previous research endeavours, including those by Adei et al. (2021) and Habib et al. (2021), while assessing occupational hazards among fish processors and bakers, and evaluating their health and safety practices and coping strategies, have neglected to consider the influence of heat stress. Notably, these investigations have utilised subjective survey methods, potentially overlooking the empirical rigours that objective measurements such as the Wet Bulb Globe Temperature (WBGT) index and ambulatory blood pressure monitoring could contribute to the assessment of hypertension as a function of occupational exposure to heat.

While extant literature documents the frequency of injuries among fisherfolk across various geographic and economic contexts, from Kenya (Ngaruiya, Ogendi, & Mokua, 2019) to Europe (Woodhead, Abernethy, Szaboova, & Turner, 2018) and other West African locales (Olapade, Kpundeh, Quinn, & Nyuma, 2021), only a handful have focused on the fish processing workforce, including fish smokers (Adei et al., 2019; Olapade et al., 2021). Despite the documented injuries in the industry, there is limited investigation into the direct relationship between occupational heat stress and hypertension among fish smokers. This oversight is critical as numerous scholars have posited the correlation between stressful work environments such as fish processing and the emergence of hypertension and other chronic health conditions (Magnavita, Capitanelli, Garbarino, & Pira, 2018; Afshari et al., 2019; Jayasekara et al., 2019; Thompson et al., 2019). Regrettably, the literature remains deficient in addressing the confluence of work-induced heat exposure, physiological stress responses, and individual worker characteristics such as age, hydration levels, and the predilection for hypertension among Ghanaian fish smokers.

Internationally, the relationship between occupational heat stress and health maladies like hypertension has been scrutinised, with findings pointing to a substantial link (Zamanian et al., 2017; Umar & Egbu, 2020). This association has been substantiated in various occupational contexts from construction workers in Turkey to mine labourers in India (Ramdhan, Indriani & Puspita, 2018). However, conflicting evidence emerges from agricultural sectors, such as in Southern Argentina, where heat stress is associated with dehydration and fatigue, but not significantly with hypertension (Glaser et al., 2016; Poggio et al., 2016). Such disparities necessitate an in-depth investigation to elucidate the specific impact of heat stress on hypertension among workers in the fish processing industry.

The present analysis underscores a pronounced research deficiency in understanding the occupational health hazards of heat stress and its implications for hypertension among fish smokers in Ghana. This gap is notably pronounced when considering the broader spectrum of occupational health studies within the nation. Therefore, this study intends to investigate the potential relationships between occupational heat exposure and the incidence of ambulatory hypertension among fish smokers.

Purpose of the Study

The purpose of this study is to investigate the relationship between occupational heat exposure and the incidence of ambulatory hypertension among fish smokers in Ghana. This research aims to address the critical gap in understanding the specific occupational health risks faced by this workforce, using objective measurements such as the Wet Bulb Globe Temperature (WBGT) index and ambulatory blood pressure monitoring. Based on this purpose, six objectives are formulated to guide the study. These are to: (1) explore the level of workplace heat exposure and ambulatory hypertension, (2) examine differences in heat stress scores based on work shift periods, (3) examine the differences in ambulatory hypertension scores based on working days per week, (4) explore how socio-demographic and work-related factors associate with heat stress (5) examine how socio-demographic and work-related factors associate with ambulatory hypertension, and (6) explore the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers along the coastal cities in Ghana.

Research Questions

Aligning with the purpose and objectives, the following research questions guided the study:

1. What are the levels of heat exposure and ambulatory hypertension among fish smokers in the coastal areas of Ghana?
2. What are the differences in heat stress scores at different work shift periods among fish smokers in the coastal areas of Ghana?
3. What are the differences in ambulatory hypertension scores based on working days per week among fish smokers in the coastal areas in Ghana?
4. What worker socio-demographic variables and work-related factors are associated with the occurrence of heat stress among fish smokers in the coastal areas of Ghana?
5. What worker socio-demographic variables and work-related factors are associated with the occurrence of ambulatory hypertension among fish smokers in the coastal areas of Ghana?
6. What is the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers in the coastal areas of Ghana?

Significance of the Study

The findings of this study give an alternative understanding of the level of occupational heat exposure and associated heat stress on ambulatory hypertension among fish smokers residing along the coast of Ghana. The findings may influence how to design specific OHS interventions and expand the body of knowledge aimed at ensuring the health and safety practices of fishmongers. The study is also useful for addressing climatic and occupational health concerns by utilising field data, which is typically absent in studies on heat stress. Furthermore, the findings may influence advocacy on the benefits and essence of comprehensive national fisheries (OHS) policies to protect these fish smokers. Moreover, evidence from this research can be used as a monitoring and diagnostic tool for the assessment of the working conditions among Ghanaian fish smokers.

Delimitation

This study was delimited to the use of a survey interview questionnaire which facilitated the acquisition of self-reported data. The study also made use of physical measurement tools such as a sphygmomanometer to measure blood pressure, thermometers for ambient temperature assessment, weight scales, stadiometers for height measurement, and heat stress monitoring meters to objectively quantify the heat stress experienced by the participants. The research was focused on examining the exposure to heat stress and its impact on ambulatory hypertension among fish smokers in selected Ghanaian coastal cities through a cross-sectional descriptive design. Data analysis was confined to the use of descriptive statistics and multivariate binary logistic regression. The study's geographic scope was limited to specific coastal cities including Keta, Tema New Town, Teshie, Awutu Senya, Moree, Elmina, and Shama.

Limitations

The results of this study should be interpreted with caution, as participants cannot be considered fully representative of all Ghanaian fish smokers. The sample, derived from a convenience selection of fish smokers in coastal cities or towns such as Keta, Tema New Town, Teshie, Awutu Senya, Moree, Elmina, and Shama, may not encompass the full diversity or characteristics of the wider population of fish smokers in Ghana. Therefore, generalising the findings on heat stress and ambulatory hypertension from this study to the entire national context may not be accurate.

Additionally, a limitation of this research is the use of purposive sampling, which restricts the generalisability of the findings. Participants were chosen based on specific criteria instead of randomly, which may introduce bias and increase the chance of researcher subjectivity, potentially affecting both the results and their interpretation.

Definition of Terms

Ambulatory Hypertension (AMHPT): This is a relatively new technique for assessing a person's blood pressure (O'Brien, Parati, & Stergiou, 2013; van der Merwe, 2020).

Ambulatory Blood Pressure: Blood pressure during routine daily activity (Martinez-Nicolas et al., 2015).

Fish smoker: Someone who processes fish and seafood with heat from burnable material (Dovlo, Amador, K. & Nkrumah, 2016).

Heat-related illnesses: They occur when body heat is generated during physical work.

Heat Stress: The net heat load to which a worker is exposed, from the combined contributions of metabolic heat, environmental factors, and clothing worn resulting in an increase in heat storage in the body (Jacklitsch et al., 2016).

Heat Strain: The physiological response to the heat load (external or internal) experienced by a person in which the body attempts to increase heat loss to the environment to maintain a stable body temperature (Jacklitsch et al., 2016).

Heat Stroke: An acute medical emergency caused by exposure to extreme heat from an excessive rise in body temperature above 41.1°C (106°F) and failure of the temperature-regulating mechanism. Injury occurs to the central nervous system characterised by a sudden and sustained loss of consciousness preceded by vertigo, nausea, headache, cerebral dysfunction, bizarre behaviour, and excessive body temperature (Parsons, 2019).

Hypertension: A condition in which the blood vessels have persistently raised pressure. In adults, BP is abnormally high when the resting, supine arterial systolic pressure is equal to or greater than 140mmHg and the diastolic pressure is equal to or greater than 85mmHg (Ameli-Renani et al., 2014).

Metabolism: Transformation of chemical energy into free energy that is used to perform work and produce heat in the human body (Parsons, 2019).

Occupational safety: All aspects of physical, mental, and social health and safety in a workplace (World Health Organization [WHO], 2017).

Occupational heat stress: The net load to which a worker is exposed, from the combined contributions of metabolic heat, environmental factors, and clothing worn which results in an increase in heat storage in the body (NIOSH, 2017).

Total Heat Load: The total heat exposure of an environment plus metabolic heat (Parsons, 2019).

Wet Bulb Globe Temperature (WBGT): A measure of environmental temperature in dry air temperature, humidity, and radiant energy (i.e., usually, direct sunlight being absorbed by clothing), used to calculate a thermal load on a person (Jacklitsch et al., 2016).

Organisation of the Study

There are five chapters in this study. The first chapter contained the background to the study, statement of the problem, purpose of the study, research questions, significance of the study, delimitation, limitations, and definition of terms. The second chapter focused on a review of related literature. It summarised the work of other authors related to occupational heat stress and ambulatory hypertension in employees. The chapter also provided a theoretical, conceptual, and empirical examination of workplace safety predictors of heat stress and ambulatory hypertension. Chapter three presented the research methods, study design, study area, population, sampling procedure, instrument for data collection instrument, data collecting procedures, and data processing and analysis. chapter four presented the results and the discussion. Finally, chapter five focused on the summary, main findings, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

The purposes of this study are to: (1) explore the level of workplace heat exposure and ambulatory hypertension, (2) examine differences in heat stress scores based on work shift periods, (3) examine the differences in ambulatory hypertension scores based on working days per week, (4) explore how socio-demographic and work-related factors associate with heat stress (5) examine how socio-demographic and work-related factors associate with ambulatory hypertension, and (6) explore the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers along the coastal cities in Ghana. This chapter presented a review of related literature that guided the study. This review's literature was sourced from a variety of search engines and databases, including Google Scholar, PubMed, Scopus, and JSTOR. This was done to collect relevant papers, journals, and publications on heat stress and ambulatory hypertension among fish smokers in Ghana's coastal regions. To achieve these goals, a variety of materials were studied, including books, databases, articles, journals, magazines, and newspapers, and the resulting literature was classified and organised into the following sub-headings:

1. Fish Smoking
2. Heat Exposure
3. Physiological and Occupational Perspectives of Human Heat Stress
4. Socio-demographic and Work-related Factors Influencing Heat Stress and Ambulatory Hypertension
5. Impact of Heat Exposure in the Workplace
6. Heat Exposure Disorders, Interventions, Heat Stress and Climate Change

7. Heat Stress and Productivity Loss
8. The Wet Bulb Globe Temperature (WBGT) Index
9. Theoretical Framework
10. Conceptual Framework
11. Summary

Fish Smoking

Ghana has a large fish industry where mostly fish harvest is smoked (Johnson & Yamoah, 2018). Practically, all fish harvested in the country can be smoked, and 75% of marine and freshwater catch is smoked (Alhassan, Boateng, & Ndaigo, 2013). However, Ghana's fish smoking industry is unregulated and primarily has hygiene challenges. The most common ovens are energy inefficient and smokery, creating dangers for the environment and the oven users who are mostly women and children (Dovlo, Amador, K. & Nkrumah, 2016), because of the high temperatures and the smoke from such ovens.

Furthermore, fish processing peripheral and core temperatures differ between hot and cold smoking types. In the northern parts of Ghana, the prevalent method of preserving fish is through cold smoking, which effectively prevents premature cooking or drying of the fish. The temperature of the smoke is carefully regulated to ensure it does not exceed 28°C. Depending on the smoking oven installation and product, the treatment might last from a few hours to many days. Due to the high-water content of cold smoking, rigorous hygienic standards and quality control are required. The smoked fish is then vacuum-packed, refrigerated, or frozen, however, it has a limited shelf life (Johnson & Yamoah, 2018). Thus, to increase the shelf life and preserve fish, hot smoking is commonly used especially in developing countries (Gordon, Pulis, & Owusu-Adjei, 2011). This technique imparts a smoky flavour to the fish and is favoured for its ability to produce dependable commodities. During hot smoking, temperatures typically range from 60 to 120^{o}C (Adei et al., 2019). The duration of hot smoking can vary significantly, with some processes taking up to two days.

The water content of the final smoked fish product is influenced by both the specific product being processed and the type of fish used. Moreover, the kind of fish, its thickness, and the method of slicing determine the ultimate use and storage duration of the smoked fish. There are different variations of hot smoking techniques. One approach is “soft smoking”, which lasts one to two hours and results in a moist and malleable product. This method provides a relatively short shelf life of 1 to 3 days for the processed fish. In contrast, “hard smoking” lasts 10 to 18 hours, and it is followed by “light smoking” (Johnson & Yamoah, 2018). Additionally, it is worth noting that fish can also be cooked during the smoking process, with temperatures exceeding 80^{o}C (Amaravathi, Parimalam, Premalatha, Hemalatha, & Ganguli, 2016). The choice of smoking method and duration plays a crucial role in determining the texture, flavour, and shelf life of the final smoked fish product.

It is however imperative to acknowledge that, inefficient and smoky ovens used in the smoking process generate high temperatures, subjecting the workers, especially women and children, to prolonged periods of heat exposure. This can have adverse effects on their health, including heat-related illnesses such as heat exhaustion and heat stroke. This concept of heat exposure is therefore explored in the subsequent discussion.

Heat Exposure

Workers who are exposed to hot and humid conditions, including the outdoors, factories, and hot kitchens, are at a higher risk for heat illness

(Frimpong et al., 2020; Nunfam & Afrifa-Yamoah, 2021). Workers conducting heavy tasks or wearing bulky safety apparel and equipment are also at risk. Some workers may face a higher risk than others though, particularly if individuals have not developed a tolerance to elevated temperatures (Yeargin, Hirschhorn, & Grundstein, 2020). Thus, heat-associated illnesses affect workers who are frequently exposed to hot and humid surroundings, such as factories and hot restaurants (Flouris et al., 2018; Nerbass et al., 2017). This is because the body typically has a temperature of 37^{0}C, with the core temperature ranging from 97 to 99 degrees Fahrenheit (98.6ºC). It requires an ambient temperature of roughly 82°F (28°C) to maintain without the assistance of heating or cooling systems. Sweating alone may not keep the body cool in such a high-heat environment (Dillane & Balanay, 2020). Unfortunately, without appropriate heat body regulation, increased body heat can lead to heat cramps, heat stroke, and tiredness (Leiva & Church, 2023).

Physiological and Occupational Perspectives of Human Heat Stress

Every person may respond to thermal surroundings differently and many individuals have been disabled, hurt, or killed as a result of heat stress (Parsons, 2019; Tustin, Lamson, Jacklitsch, Thomas, & Arbury, 2018). Therefore, studies have been conducted into how people react to heat, to avoid or reduce heat-related illnesses and deaths. Established knowledge of heat stress enables effective assessment and prediction of thermal strain in humans using standardised methods (Parsons, 2019).

Understanding heat stress and its consequences is crucial due to its association with high temperatures. Heat stress is influenced by four environmental variables: air temperature, radiant temperature, air velocity, and humidity, along with two individual factors: clothing and metabolic rate

(Nerbass et al., 2017; Tustin et al., 2018). Heat is derived from the energy that is spread throughout space, ranging from areas of no energy when everything remains motionless, to varied quantities of energy which cause everything to move or change state i.e., from liquid to gas (Parsons, 2019). Therefore, a comprehensive examination of these factors is essential when assessing the impact of heat stress on individuals.

Generally, the more energy contained within an object, the faster its constituent particles move. It would thus, take an insulated human body roughly 51 minutes to achieve 38°C and 102 minutes to reach 39°C, calculating "safe" exposure periods using body temperature (Roduner & Krüger, 2022; Wissler, 2018). The preceding ideas apply if the individual is not insulated by "clothes", yet the environment is sufficiently hot that no heat may escape (i.e., insulted by the environment). A few situations may even enhance the body's heat content, while others, as is "normal", enable heat to pass from the body to the environment (Verberk et al., 2021). This may be done in more typical conditions such as when a person is sitting, standing, or doing something energetic and there is not much risk of heat transmission from the body to the surroundings (Parsons, 2019).

Using this technology, all heat channels to and from the body may be monitored and measured. Depending on how much heat is absorbed and exhaled from the body, the body temperature increases or decreases at different periods. It is important to remember that thermodynamic laws apply to everything, including humans, and because energy cannot be created or destroyed (Roduner & Krüger, 2022), the transfer of heat can only be accounted for when the temperature in the body is higher than the temperature of the surrounding environment. A high concentration of vapour such as that created by perspiration evaporation near a person's warm skin can move to lower concentrations of vapour such as those found at lower temperatures and humidity levels (Wissler, 2018).

In addition to individual physiological characteristics, certain socio-demographic and occupational factors can modulate a person's susceptibility to heat-related illness. For example, outdoor workers face greater occupational heat stress risks than office employees working in air-conditioned indoor settings. Age, fitness level, acclimatisation state, and underlying health conditions also impact thermal regulation abilities. Careful consideration of both environmental and personal contextual factors is needed to accurately assess heat stress risks for various populations and adequately protect worker safety and public health.

Socio-demographic and Work-related Factors Influencing Heat Stress and Ambulatory Hypertension

Exploring how heat stress is linked to ambulatory hypertension is crucial, especially for worker health in hot environments (Heather Mpemwangi, 2021). Ambulatory hypertension means blood pressure is high during day-to-day activities, which is often found with a device that monitors blood pressure throughout the day. This condition can worsen when a person experiences heat stress, which is a risk for those working in places with high temperatures (Fan et al., 2023). A worker experiences heat stress when the body is so warm that it struggles to keep its temperature stable. The first reaction of the body under heat stress is to widen blood vessels to cool down, which might make blood pressure drop for a short time.

However, as the body loses water through sweat and tries to keep water inside, blood pressure might go up. When it gets too hot, the heart has to work harder to help cool the body down. This can affect the heart rate and blood pressure (Heather Mpemwangi, 2021). These conditions can be worrying for people who already have high blood pressure because it can rise even more during heat stress. Being in the heat for too long can also make the body produce stress hormones and make blood vessels narrow again, which can push blood pressure even higher. This can start a cycle where heat causes stress, and that stress makes high blood pressure worse, and it keeps going around creating a very health-threatening condition for the worker.

Under heat stress, the kidneys' job of controlling how much water is in the body and blood pressure becomes even more important. The heat can cause the body to hold onto salt and water, which increases the amount of blood in the vessels and raises blood pressure. This can make it harder to manage blood pressure for those with ambulatory hypertension when it is hot.

The way heat stress and ambulatory hypertension interact is complicated and can seriously affect the health of people working in the heat environment. This shows why it is important to keep an eye on and manage blood pressure, especially for people more likely to have hypertension.

Heat stress can also occur when the body's natural cooling system cannot handle the temperature (Leiva & Church, 2023). This can happen from being in high heat or doing hard physical work in hot weather (De Sario et al., 2023). People in certain jobs are more likely prone to heat stress, which can impact their heart health and lead to ambulatory hypertension (Fan et al., 2023). Heat can lead to losing too much water, making the blood thicker and harder to pump, increasing the heart's workload and blood pressure (Stotz et al., 2014). Heat can also trigger stress hormones and make the nervous system more active, both of which can raise blood pressure. Individuals with high blood pressure may experience elevated levels when exposed to high temperatures (Akerman et al., 2021).

In Ghana, several studies have explored the link between heat stress, hypertension, and the health of workers. For example, a study conducted at a cardiac clinic in Kumasi found that ambulatory blood pressure monitoring (ABPM) significantly improved the management and control of hypertension among patients, reducing misdiagnosis and allowing for targeted treatment (van der Merwe, 2020). Additionally, they highlighted the barriers to occupational heat stress adaptation among mining workers in Ghana, noting the importance of water intake, wearing appropriate clothing, and taking regular breaks to mitigate the effects of heat stress (Nunfam et al., 2019).

The prevalence of hypertension among Ghanaians is significant, with studies showing high rates of awareness, treatment, and control issues. For instance, a study in urban poor communities in Accra found that 28.3% of the population had hypertension, but awareness and treatment levels were low, particularly among men (Awuah et al., 2014). Another study assessing the prevalence and management of hypertension in various Ghanaian populations reported that hypertension awareness and treatment were higher among urban dwellers, but blood pressure control remained a challenge (Singh et al., 2024).

However, the interaction between heat stress and ambulatory hypertension is complex, with significant implications for worker health in hot environments. Effective management strategies, including regular monitoring, appropriate adaptation measures, and targeted treatment interventions, are crucial to mitigate these risks and protect the well-being of workers. Since socio-demographic and work-related factors significantly influence the complex interaction between heat stress and ambulatory hypertension. It is therefore necessary to address these factors for the preservation of the health and well-being of individuals working in hot environments.

Work environment

Various elements affect the risks of heat stress and ambulatory hypertension of workers like fish smokers. Temperature, moisture in the air, direct heat from the sun or equipment, and the movement of the air can individually or in combination alter how much heat stress a worker feels (Jacklitsch et al., 2016). Individuals with high blood pressure or heart conditions, as well as those who take medications such as diuretics, are particularly sensitive to the effects of heat (Leyk, 2019; Monakali et al., 2018). When a person is active, the body creates heat internally. This heat needs to be passed to the environment to prevent a dangerous increase in body temperature. However, working in a hot environment can make it harder to get rid of this excess heat, which increases the impact of heat stress the body feels.

In Thailand, Phanprasit et al. (2021) reported that heat stress symptoms were present in around 18% of workers who worked in controlled environments, but this number rose to 43% in places where they worked in hot environments. This underscores the importance of proper workplace conditions to manage heat stress. The National Institute for Occupational Safety and Health (NIOSH) has suggested several design strategies for workplaces in hot conditions (NIOSH, 2017). These include engineering solutions and implementing a heat alert program (Schulte et al., 2023). In Japan, a study by Ueno et al. (2018) on construction workers highlighted those measures to prevent heat stress, such as the use of electric fans, making cool water and ice available, and scheduling regular breaks, which were effective in lowering heat stress among the workforce. These findings point to the significant role proper workplace design and preventive measures play in safeguarding workers from the health risks associated with heat stress, including high blood pressure, particularly in physically demanding jobs like fish smoking.

In Ghana, fish smokers are exposed to significant health risks due to the high levels of particulate matter (PM2.5) and volatile organic compounds (VOCs) produced from biomass fuel used in smoking fish. A study in the Western Region of Ghana found that fish smokers experienced high exposure to these pollutants, leading to symptoms such as eye infections, coughs, and headaches (Obeng et al., 2023). The study highlighted that indoor environment where fish smoking occurs had the highest concentrations of PM2.5, which significantly impacts the health of workers. Furthermore, a study on the impact of adopting improved fish smoking technology (the Chorkor smoker) in Ghana revealed improvements in economic activities and health status. Women who adopted the improved technology reported fewer eye problems and headaches due to reduced exposure to smoke and heat (Pemberton-Pigott et al., 2016).

Another study in the Ga District of Ghana found a high prevalence of hypertension among rural residents, with significant associations between hypertension and factors such as age, obesity, and urban dwelling (Brenyah et al., 2024). This study underscores the importance of addressing hypertension and its risk factors through public health measures and lifestyle interventions.

Thus, proper workplace conditions and preventive measures are crucial in managing heat stress and its associated health risks, including ambulatory hypertension, especially in physically demanding jobs like fish smoking. Adopting improved technologies and implementing effective health and safety strategies can significantly reduce these risks and improve the well-being of workers. In addition to these measures, acclimatisation is also an important factor to consider for workers in hot environments. Acclimatisation involves allowing the body to adapt to the heat over time, which can help reduce the risk of heat-related illnesses. This process typically takes about 5 to 7 days of gradual exposure to the hot environment, allowing the body to adjust and become more efficient at managing heat stress

Acclimatisation

Chronic humans' exposure to hot environments can lead to physiological adaptations to the heat, including a faster and more robust sweating response—this process is known as acclimatization. As described by Parsons (2019), acclimatisation leads to an increase in blood volume, a reduction in core body temperature, and a lower concentration of sodium chloride in sweat and urine. These changes help the body to cope more effectively with heat, keeping the internal body temperature and heart rate at safer levels during heat stress (Jacklitsch et al., 2016). However, a failure to acclimatise can result in serious health issues, including heatstroke, heat syncope, heat exhaustion, and heat cramps (Parsons, 2019).

Hesketh et al. (2020) have pointed out that workers who are not physiologically adapted to high ambient temperatures and increased levels of exertion in their workplaces experience a greater degree of heat-related stress. The research by Hesketh et al. (2020) used length of time to indicate acclimatisation. It was noted that workers within their first week of employment suffered a higher rate of heat-related illnesses (14%) compared to other health-related issues (3.3%). This suggests that new workers are more vulnerable to heat stress due to a lack of acclimatisation. Additionally, regardless of employment duration, a sudden spike in daily maximum temperature—specifically, an increase of 10°F or 5.5°C may correlate with a 42% increase in heat-related illnesses. This emphasizes that even for acclimatised workers, extreme temperature fluctuations remain a significant risk factor for affecting their health.

Considering the importance of acclimatisation in mitigating heat stress risks, it becomes imperative to explore its relationship with work activity and physical load. Understanding how acclimatisation intersects with the demands of specific job tasks can provide further insights into effective strategies for safeguarding workers in hot environments.

Work activity or physical load

The human body constantly produces heat as part of its normal metabolic processes, even at rest, to maintain a stable body temperature. The body must release the excess heat into the environment to avoid overheating. One strategy to help manage internal heat production is modifying the intensity of physical labour and scheduling regular rest breaks. Research by Messeri et al. (2019) in a manufacturing context demonstrated that workers who were allocated longer rest periods and lighter workloads experienced a noticeable drop in core body temperature to a healthy state throughout their shifts. Their findings suggests that such interventions can significantly reduce the risk of heat-related health issues for individuals working in environments with high temperatures.

However, managing heat stress is not solely about adjusting workloads or rest periods. Messeri et al. (2019 broaden the scope of heat stress management to include hydration and acclimatisation. Accordingly, workers who stay well-hydrated and acclimate to warm environments tend to handle heat stress better than those who do not take these factors into account or seriously. Therefore, an integrated approach to managing heat stress is crucial, where hydration and gradual exposure to heat complement modifications in work patterns.

Combining the insights from these studies indicates that tackling heat stress in the workplace requires a comprehensive strategy. Adjusting work intensity and breaks, as suggested by Messeri et al. (2019), forms part of this approach. However, as Afshari et al. (2019) highlighted, ensuring proper hydration and facilitating acclimatization are equally important measures. Together, these studies offer directions on how to effectively reduce, and manage heat stress, pointing towards a holistic approach that considers various interrelated factors.

Furthermore, it is essential to consider the age of workers in this comprehensive strategy, as different age groups may respond differently to heat stress. Integrating age-specific considerations into the overall approach can enhance the effectiveness of heat stress management in diverse work environments.

Age

Older workers may indeed be at greater risk for heat-related illnesses and, in severe cases, heat-related death (Xiang, Hansen, Pisaniello, & Bi, 2016). In a study investigating heat stress vulnerability across various age groups in Adelaide, Australia, Xiang et al. (2014) found that younger male workers, specifically those aged 24 and under, had a higher incidence rate ratio (IRR) for heat stress at 1.005 (95% CI 1.002–1.008), compared to the general male worker population with an IRR of 1.004 (95% CI 1.002–1.006). This data suggests a notable susceptibility to heat stress among the younger working demographic in that specific region. Moreover, from Washington in the United States, Hesketh et al. (2020) pointed out that the 25–34 age group was most at risk for heat-related illness claims, closely followed by the 18–24 and 35–44 age brackets. Intriguingly, the cumulative percentage of heat-related illness claims was approximately 75% for workers aged 18 to 44. Also, from Arizona, a study by

Petitti, Harlan, Chowell-Puente, and Ruddell (2013) on heat-related mortality within the construction and agricultural sectors indicated that older workers, those aged between 35–49 and 50–65, represented a significant share of the mortality cases, comprising 25.2% and 25.7%, respectively.

Despite these findings, there remains a striking deficiency in empirical data regarding the effects of heat stress across different age groups in developing countries. This lack of data points to a critical research gap, especially because of the heightened vulnerabilities that older workers may face due to factors, including workplace regulations, limited access to healthcare, and the physical demands of labour-intensive jobs. Thus, closing this gap is essential for creating appropriate and effective heat stress mitigation strategies tailored to the needs of all workers especially older workers in the developing world.

In Ghana, studies in Ghana have shown that heat stress significantly impacts smallholder farmers. For example, a study in Northern Ghana found that farmers who had lived longer in the area exhibited significant experiences of heat stress and climate change impacts, emphasizing the need for government-led interventions to assist farmers in coping with heat stress (Frimpong et al., 2020). This study underscores the importance of tailored strategies to manage heat stress, especially for those engaged in labour-intensive activities. Also, an evaluation of heat stress impacts and adaptations among smallholder farmers in the northern part of Ghana highlighted the varying impacts and coping strategies employed by farmers. The study revealed that current strategies are often ineffective in preventing heat-related morbidity and mortality, underscoring the need for comprehensive adaptation policies and support from the government (Frimpong et al., 2020).

More importantly, understanding the role of water intake in mitigating heat stress is crucial. Adequate hydration is a fundamental aspect of heat stress management, and research has shown that proper water intake can significantly contribute to reducing the risks associated with heat-related illnesses. Examining water intake practices, alongside age-specific considerations, can enhance the effectiveness of comprehensive heat stress mitigation strategies in diverse work environments.

Water intake

Hydration is important in managing heat stress, particularly when workers are exposed to high temperatures that induce significant sweating. Jacklitsch et al. (2016) point out the necessity of fluid intake, thus, to counteract the dehydration that can occur due to profuse sweating in heated environments. The balance of hydration is maintained by several factors, including the rate of sweat loss, water consumption, work conditions, the choice of clothing, and individual lifestyle habits like alcohol consumption (Nunfam et al., 2019).

For instance, a study by Afshari et al. (2019) found a link between thermal work limits and hydration status, as indicated by Urine Specific Gravity (USG) levels, among construction workers in Iran. Accordingly, workers who were exposed to direct sunlight showed significantly higher mean USG levels (1.026 ± 0.005), compared to their counterparts in non-exposed conditions, with a mean USG of 1.021 ± 0.005. These findings suggest that the sun-exposed workers were between mildly dehydrated to clinically dehydrated states (Montazer et al., 2013).

The efficiency of sweating as a cooling mechanism is also greatly reduced in humid environments. Under such conditions, the body may struggle to release heat through perspiration, which can undermine the cooling benefits of rehydration. Moreover, excessive water intake in such situations can lead to hyponatremia, a potentially dangerous condition where the concentration of sodium in the blood becomes abnormally low due to the dilutional effect of excessive water intake (Jacklitsch et al., 2016). Workers need to be educated about the importance of drinking water at regular intervals and monitoring for signs of dehydration. In addition, workplace policies should encourage appropriate hydration strategies tailored to the specific conditions, including the provision of electrolyte-replacing fluids, when necessary, particularly in high-humidity conditions where the risk of hyponatremia may be increased. Therefore, managing hydration in hot work environments necessitates a careful and informed approach.

Rest

Taking breaks during work, especially working in hot environments is a critical strategy to mitigate the effects of heat stress on the worker. Xiang et al. (2016) employed Monte Carlo simulation to evaluate the relationship between physiological responses, behavioural adaptations, and environmental factors, including the WBGT and air pollution index (API). This model helped to pinpoint an optimal break schedule for rebar workers, which suggested a 15-minute rest after 120 minutes of continuous work in conditions where WBGT was approximately 28.9 ± 1.3 °C. The recommendation from this study is that work schedules need to be adjusted to include more frequent rest periods as a countermeasure against heat stress.

Physically demanding jobs exacerbate the challenge of heat stress, as these tasks do not only increase metabolic heat production within the body but also reduce the chances for workers to recover and cool down. Heat stress can compel workers to take longer and more frequent rest breaks, which has a significant impact on labour productivity. In Australia, for instance, Zander, Mathew, and Garnett (2018) quantified the annual financial impact of reduced labour productivity due to heat stress at over 7 billion Australian Dollars—a substantial economic burden.

The environment in which workers rest also influences their ability to recover from heat stress. Jay et al. (2019) found that the type of cooling provided during rest periods—whether through fans or air conditioning—can significantly affect thermal comfort and subsequent work performance. This study demonstrated that providing airflow with fans at ambient room temperatures of 27 to 30^{0}C can maintain comfort for individuals at rest and improve cumulative work by 11% compared to those using air conditioning. This suggests that the cooling strategy during rest periods can be fine-tuned to optimize recovery and productivity. However, the effectiveness of cooling devices such as fans can vary depending on factors like age and the health status of the worker. For the elderly, fans may not be the best cooling strategy in extreme heat, particularly at high humidity levels. Thus, Gagnon and Crandall (2017) observed that in older adults, exposed to temperatures around 42 °C (107 °F), using fans increases heart rate and core temperature, contrary to the cooling effect that is expected.

Overall, these studies emphasise the importance of structured rest breaks and appropriate cooling methods as part of a comprehensive approach to managing heat stress in the workplace. Therefore, tailoring these strategies to the specific needs and vulnerabilities of different worker populations is crucial for ensuring worker safety and maintaining productivity in hot working conditions. Considering the importance of rest breaks, the role of shade as an additional protective measure against heat stress cannot be overlooked. Providing shaded areas for workers during breaks contributes significantly to their ability to recover and enhances the overall effectiveness of heat stress management strategies

Shade

Water-rest-shade programmes are recognised as effective strategies for mitigating the effects of heat exposure and preventing heat-related illnesses, including kidney dysfunction on the worker. As Crowe (2014) and Nerbass et al. (2017) have indicated, these programmes are critical in maintaining workers' health and safety. Thus, ensuring adequate hydration, providing opportunities for rest, and offering access to shaded or cool environments help maintain normal physiological functioning and reduce the risk of heat-related health issues. Shade and cooling areas are fundamental components of these programmes. Luo et al. (2014) emphasise the importance of access to cooler environments to prevent core body temperature from reaching dangerous levels. This can be particularly important for outdoor workers or those in settings without climate control. Air-conditioned spaces are ideal for rapid cooling, but in their absence, shaded areas with air movement, such as those with fans, can also be effective, and could also promote productivity.

Working in hot conditions without adequate heat mitigation strategies can lead to a significant drop in worker output. For example, Morabito et al. (2020) have shown in their studies across the Mediterranean, Guangzhou, and Florence that productivity can be markedly improved when work is conducted in shaded conditions. This is because shade does not only reduce the thermal stress on the workers' bodies, but it also helps to avoid the cognitive decline associated with heat exposure, allowing workers to maintain focus and efficiency.

These findings collectively demonstrate the value of implementing water-rest-shade programmes as part of OHS practices, particularly in regions where high temperatures are a regular occurrence. By doing so, employers can ensure that their workforce remains healthy, safe, and productive even in challenging thermal conditions. In addition to water-rest-shade programs, the choice of clothing becomes a crucial consideration in managing heat stress among workers.

Clothing

Protective clothing, including PPE, plays a critical role in the safety and health of workers, particularly in industries where employees are exposed to hazardous physical conditions. However, the design and material of these clothes and equipment can significantly influence heat stress and overall comfort, which in turn impacts worker performance and health.

Yi and Chan (2013) emphasise that in hot and humid conditions, like those often found in Hong Kong, specialised clothing are indispensable, such as cooling vests, to reduce the risk of heat stress. Such anti-heat stress clothing is designed to help maintain body temperature and reduce the amount of sweat produced, which is essential for comfort and preventing heat-related illnesses. On the other hand, Jiao (2019) found that even low-intensity work performed over several days while wearing protective clothing did not improve the physiological response of workers. This could indicate that while such clothing may provide a short-term benefit, the body does not necessarily adapt over time to become more tolerant to the heat stress caused by the clothing. Garzón-Villalba et al. (2019) and Weyant et al. (2022) highlight that the weight of clothing, especially when it comes to protective gear, can impede task efficiency. The additional effort required to move and work while wearing such heavy or restrictive clothing can lead to increased metabolic heat production, which further exacerbates heat stress in the worker.

Jacklitsch et al.'s (2016) study shows that protective clothing can increase physical exertion and metabolic heat production, which are critical factors in occupational heat stress. This highlights the need for careful consideration of the type and nature of PPE provided to workers, especially those working in hot environments.

Also, Weyant et al. (2022) emphasise the importance of clothing that can adapt to environmental conditions, such as adjustable insulation, which can mitigate thermal stress during heatwaves. Such clothing modifications can be pivotal in maintaining worker comfort, safety, and productivity. Thus, while protective clothing and PPE are essential for worker safety, their design and material need to be carefully considered to manage heat stress effectively. In addition, innovative solutions like cooling vests, breathable fabrics, and adjustable insulation can significantly improve worker comfort and safety in hot environments. Implementing these measures requires a balance between providing necessary protection and ensuring that the clothing does not contribute to additional health risks due to heat stress.

Moreover, the impact of protective clothing on heat stress may vary with the number of years a person has been working in a particular industry or under specific conditions. Considering the duration of exposure and experience of workers becomes essential in tailoring strategies to manage heat stress effectively throughout their careers.

Years of working

When the attention is turned to the fish processing industries in developing countries, a narrative seems to tell rather a grim tale of workplace neglect. Researchers like Ansah et al. (2021) have brought to light that in many of these informal work settings, there's a single-minded pursuit of product quality and efficiency, where the human cost often fades into the background. It is a scenario where the shimmer of freshly processed fish belies the stark conditions faced by those who toil to bring these goods to market.

The narrative is not just about the sweat of labour but also the very air that workers breathe. Studies such as those by Olapade et al. (2021) illustrate environments dense with heat and smoke, that also lack the breeze of proper ventilation. It is in these stifling confines that workers spend long hours, and with each passing minute, the toll on their health silently mounts, with multifaceted risks. The relentless embrace of heat, as Yang et al. (2023) noted, is more than a matter of discomfort—it is a health hazard with the potential for long-term consequences. The tenure of one's employment, as discussed is not just a testament to their experience, but also a marker of prolonged exposure to a risky workspace (Dahlman-Höglund & Andersson, 2020).

Likewise, age is more than a number (Bokaba et al., 2021); it is a factor that weighs heavily on a worker's ability to withstand the rigours of their job. Older workers may find the wrap of heat and smoke heavier to bear, with their health more easily compromised. Training or the lack thereof is a thread that runs through these workplace challenges. Stoecklin-Marois et al. (2013) emphasise that knowledge is a form of armour against the onslaught of occupational hazards. Without adequate knowledge, workers are left vulnerable, unarmed against the perils that pervade their workstations.

Further exploration into the impact of heat exposure on workers in fish processing industries underscores the urgent need to address the challenges they face daily. From the physical strain to the environmental conditions, understanding and mitigating the effects of heat exposure are essential steps toward creating safer and more sustainable workplaces.

Impact of Heat Exposure on the Worker

The evidence pointing to the detrimental effects of heat on workers in various industries is indeed compelling. Sectors such as construction, agriculture, warehousing, manufacturing, landscaping, and mining are particularly vulnerable, given that these industries often require physical labour in hot conditions and mostly outdoor. As noted by Zander et al. (2018), definitive steps must be taken to safeguard the well-being of individuals employed in these areas. Applebaum et al. (2016) emphasise the importance of this awareness for maintaining a safe work environment.

The body's response to intense heat and humidity is a complex physiological process. When the body is unable to dissipate heat effectively, its internal temperature rises, potentially leading to a spectrum of heat-related illnesses, from mild conditions like heat rash and heat cramps to more severe forms such as heat exhaustion and heatstroke, the latter of which can be fatal (Zander et al. (2018)). To manage these risks, a multipronged approach is essential. Engineering controls, such as air conditioning, ventilation systems, and the provision of shade can play a significant role in reducing workplace temperatures.

Work practice controls are equally important. These include scheduling work for cooler parts of the day, rotating job functions among workers, ensuring access to water, and mandating regular rest breaks in cool environments. Moreover, developing and implementing a heat stress management programme can provide a structured approach to mitigate these risks. Such programmes often encompass training workers to recognise heat stress symptoms, providing guidelines for acclimatisation, and establishing emergency procedures for heat-related illnesses.

In Ghana, studies have documented the significant impact of heat exposure on workers in various sectors, particularly mining. Research has shown that Ghanaian mining workers are highly vulnerable to heat exposure, which poses significant health, safety, and productivity risks. These risks are exacerbated by climate change effects, physical labour, extended shifts, and the need to wear protective clothing that restricts evaporative cooling. Evaluations have highlighted the importance of adequate adaptation policies and heat exposure management to reduce heat stress risk and improve the productivity and social health of mining workers (Frimpong et al., 2020).

Frimpong et al. (2017) emphasised the variations in workers' awareness and use of occupational heat stress prevention and control measures across different types of mining activities. This underscores the need for targeted occupational heat stress prevention activities and a concerted effort to promote workers' adaptive capacity (Frimpong et al., 2017). Additionally, studies have found that heat exposure can significantly affect the health, safety, productivity, psychological behaviour, and social well-being of mining workers. These findings highlight the necessity for empirical evidence to guide the formulation of heat exposure management policies (Nunfam et al., 2019).

The impact of heat stress on smallholder farmers in Ghana has also been significant. For example, a study on farmers in Bawku East, Northern Ghana, assessed environmental heat exposure and its effects on farmers' health and productivity. The findings revealed that farmers experienced severe heat stress, particularly during the middle of the day in the rainy season, leading to serious health risks and threatening the sustainability of manual farming practices (Frimpong et al., 2017).

Another study assessing the impact of heat stress on farmers in Ghana highlighted the severe consequences of extreme heat exposure, such as increased incidences of heat-related illnesses, reduced productivity, and long-term health impacts on workers' well-being (Weyant et al., 2022). The relationship between high temperatures and labour-intensive work demands a thorough grasp of heat stress, including its physiological mechanisms and effective control measures. Understanding these complexities enables businesses to protect worker health, ensure safety compliance, and maintain productivity in challenging thermal environments.

The mechanism of heat transfer in the human body

Heat stress remains a prominent public health concern, particularly due to the increasing frequency of extreme temperature events that have had devastating impacts worldwide (Parsons, 2019). The human body, a complex organism, relies on multiple mechanisms to regulate its internal temperature and ensure survival in varying thermal conditions (Leyk, 2019). The primary process of heat dissipation in cooler climates is through radiation, where heat flows from the warmer body to the cooler surrounding air, akin to how heat emanates from a fireplace (McGregor & Vanos, 2018). Radiation is effective when the external temperature is below the body's internal temperature; however, its efficiency wanes as the ambient temperature ascends to or surpasses that of the body, rendering it a less viable cooling mechanism (Parsons, 2019).

Evaporation plays a vital role as well. The body excretes sweat onto the skin, and as this moisture evaporates, it absorbs heat from the body, producing a cooling effect (Leyk, 2019). This evaporative cooling accounts for a large share of heat loss during vigorous physical activity, but its effectiveness is compromised in high-humidity environments (Parsons, 2019). High humidity impedes the evaporation rate, leading to a reduced cooling effect and an increased risk of heat-related illnesses (Morabito et al., 2020). Convection is yet another process through which the body can shed excess heat, with the movement of air or water across the skin facilitating heat transfer (Jacklitsch et al. 2016). In still environments, this process is less effective, but it can be significantly enhanced with the aid of wind or fans creating airflow over the skin.

Given the pronounced impact of high temperatures and humidity on these thermoregulatory processes, it is critical to understand how the body produces and relinquishes heat. In environments where the natural mechanisms are overwhelmed, it becomes necessary to artificially bolster these processes through engineering controls like air conditioning, the use of cooling garments, adequate hydration, and modifying work practices to avoid the peak heat periods of the day. Understanding these physiological underpinnings of heat stress is indispensable for the development of effective heat management strategies. Such strategies are essential not only for mitigating the immediate risks associated with heat exposure but also for adapting to the broader challenges posed by a changing climate with increasingly extreme temperature events.

In Ghana, studies by Eyiah et al. (2019) and Asamani, (2020) have documented the significant impact of heat exposure on workers in various sectors, particularly mining. Amponsah-Tawiah & Mensah (2016) has shown that Ghanaian mining workers are highly vulnerable to heat exposure, which poses significant health, safety, and productivity risks. These risks are exacerbated by climate change effects, physical labour, extended shifts, and the need to wear protective clothing that restricts evaporative cooling. Evaluations have highlighted the importance of adequate adaptation policies and heat exposure management to reduce heat stress risk and improve the productivity and social health of mining workers (Nunfam et al., 2019).

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Further, another research effort focused on the health-seeking behaviours of electronic waste workers in Ghana. It noted that these workers, who are often exposed to extreme heat and hazardous materials, frequently suffer from various health issues such as respiratory problems, physical injuries, and heat-related illnesses. The study underscored the importance of effective health policies and access to healthcare services to mitigate these risks (Asamani,2020). Moreover, a study on healthcare providers and ancillary staff in Ghana identified significant occupational health hazards due to heat exposure and inadequate sanitary facilities.

The relationship between high temperatures and labour-intensive work necessitates a comprehensive understanding of heat stress and a commitment to implementing effective controls to manage it. This approach not only ensures regulatory compliance but also promotes workforce health, safety, and productivity. Elucidating the physiological processes of heat transfer and thermoregulation in the human body can help develop targeted interventions to enhance occupational safety and well-being in thermally challenging environments.

Regulating body temperature and comfort

The human body’s ability to adapt to heat stress is a testament to its remarkable resilience and the sophistication of its thermoregulatory systems. Both behavioural and physiological strategies play crucial roles in maintaining a stable internal environment, especially as temperatures rise globally (Weng et al., 2020). At the core of the body’s physiological response to heat is the body's sensory network, specifically the nerve endings in the skin that detect heat intensity, alerting the body system of thermal discomfort (Wissler, 2018). The central processing system, particularly the hypothalamus, integrates this sensory input to coordinate a range of responses aimed at cooling the body, such as vasodilation and sweating (Weng et al., 2020).

Vasodilation is one of the body's primary responses to excessive heat. By widening blood vessels, it facilitates increased blood flow to the skin’s surface, enhancing heat loss through radiation and convection (McGregor & Vanos, 2018). When this is not enough, the body activates sweat glands, leveraging the cooling power of evaporative heat loss to regulate internal temperature (Baker, 2019).

The empirical evidence underscores the efficiency of these physiological mechanisms, which operate continuously and unconsciously, ensuring our bodies can function even in the face of thermal challenges (Morris et al., 2019). These responses are complemented by behavioural thermoregulation, where individuals consciously modify their environment or behaviour to maintain thermal comfort. Actions like seeking shade, adjusting clothing, and using fans are part of this adaptive response (Frimpong et al., 2020; Krishnamurthy et al.,

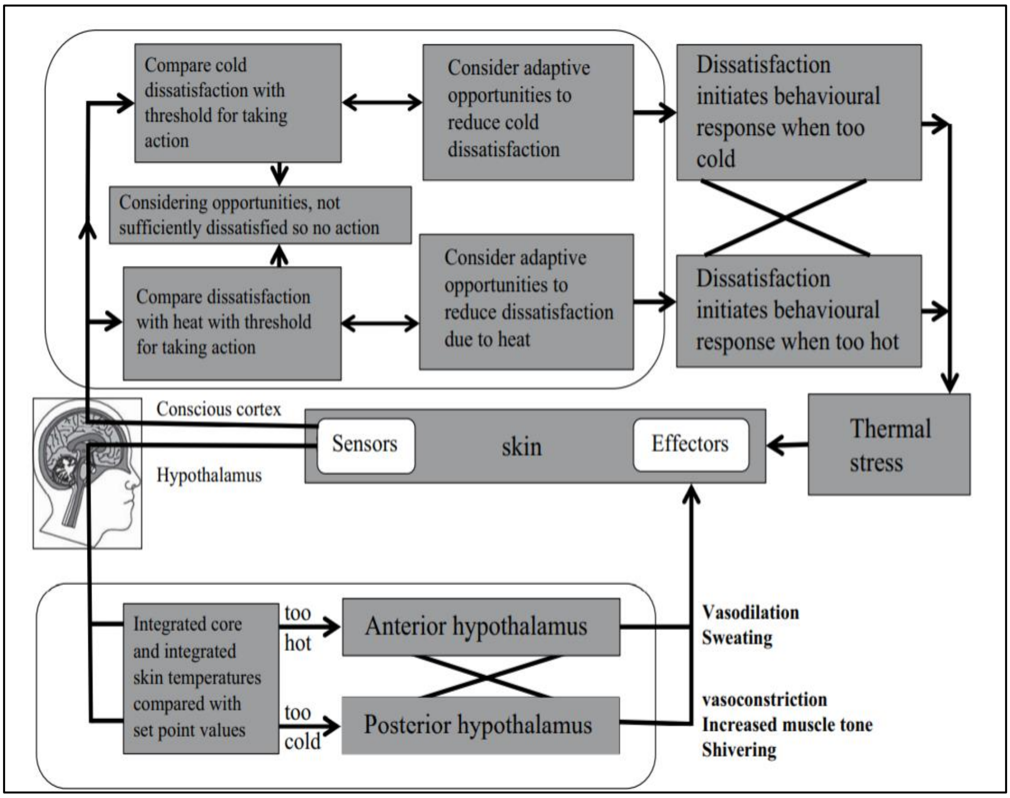

Figure 1: Diagram of Human Thermoregulation (Parsons, 2019).

2017). Meanwhile, the physiological responses continue to work in the background. Vasodilation and perspiration, for example, are automatic processes that occur without conscious thought, tirelessly adjusting in response to our body's heat load (Page & Sheppard, 2016).

The brain controls active and passive biochemical thermoregulation. Skin, fat, muscle, bone, and organs are examples (Weng et al., 2020). The thermal qualities of passive system components will affect their ability to maintain a stable temperature. The controlling system "attempts" to keep the body's temperature at 37°C by removing metabolic heat and absorbing heat from the environment (Wissler, 2018). Consequently, the controlling system has a detection and transmission system, an integration and processing system, and a system for influencing the physiological response of the body like vasodilation and sweating. The regulated variable directly affects the core body temperature (Parsons, 2019).

The interplay between behavioural and physiological thermoregulatory strategies is a powerful alliance, enabling humans to survive and thrive in diverse and often challenging thermal environments. The studies on these processes enhance our understanding of human biology and inform public health strategies, workplace policies, and individual behaviours to mitigate the adverse effects of heat stress.

Understanding the complexities of human thermoregulation sheds light on the mechanisms that come into play when the body faces excessive heat. However, prolonged exposure or extreme conditions can lead to heat stress or exhaustion, presenting significant health risks. Exploring the manifestations, preventive measures, and interventions for heat-related illnesses becomes crucial in safeguarding individuals who may experience challenges in maintaining effective thermoregulation under such conditions.

Heat Stress or Exhaustion

Heat exhaustion, also called heat stress, is the body's reaction to excessive water and salt loss during work or exercise in a hot climate (Tustin et al., 2018). Elderly and high blood pressure patients are more prone to heat exhaustion that may manifest in headache, nausea, dizziness, weakness, irritability, thirst, excessive perspiration, raised body temperature, and reduced urine production (Glaser et al., 2016; Habibi et al., 2021). Persons with heat exhaustion must be moved to a shade or air-conditioned area, such as an office, construction trailer, or break room (Ueno et al., 2018). Such groups of workers should be given beverages to drink, and any extra clothes, such as hard helmets and safety vests, as well as work boots and socks, should be removed (Sato et al., 2021).

Empirical studies in Ghana further elucidate the prevalence and impact of heat exhaustion in the region. Gowda et al. (2023) found that outdoor workers in Accra experienced high incidences of heat exhaustion during peak summer months, with symptoms aligning with those identified by global research. Adei et al. (2021) observed that market vendors in Kumasi were significantly affected, reporting frequent cases of dizziness, weakness, and excessive perspiration. Moreover, Frimpong et al. (2017) highlighted that farmer in the Northern Region faced increased health risks due to prolonged exposure to high temperatures, with a marked increase in heat-related illnesses during the dry season.

While heat exhaustion is a serious concern, it can escalate to an even more severe condition known as heatstroke. Understanding the distinctions, symptoms, and immediate interventions for heatstroke becomes imperative in ensuring the well-being of individuals exposed to extreme heat conditions.

Heat stroke

Heat stroke is a life-threatening medical emergency (Jiao, 2017). It happens when the body's ability to regulate temperature is compromised the temperature of the body rapidly rises, the sweating mechanism fails, and the body is unable to cool itself (Jacklitsch et al., 2016). The body’s temperature can quickly rise to 106 degrees Fahrenheit or higher if heat stroke develops, and this can result in death or permanent disability if emergency care is not provided quickly (Habib et al., 2021). Heat stroke symptoms include disorientation, mental impairment, and slurred speech are all signs of heat stroke. As a result of heat stroke, a person may also lose consciousness and have seizures.

Adding to this understanding, some empirical studies in Ghana provide additional insights into the occurrence and impact of heat stroke in the region.

For example, Eyiah et al. (2019) found that construction workers in Accra are particularly vulnerable to heat stroke, especially during the dry season when temperatures soar. Similarly, Adei et al. (2019) observed that street vendors in Kumasi frequently suffer from heat-related illnesses, with heat stroke being one of the most severe conditions reported. Furthermore, research by, Frimpong et al. (2017) highlighted that agricultural workers in the Northern Region are at a high risk of heat stroke due to prolonged exposure to extreme temperatures, exacerbated by the lack of adequate cooling mechanisms and hydration.

To fully grasp the severity of heat-related illnesses, it is essential to understand conditions like heat syncope. Heat syncope is characterized by sudden dizziness or fainting that occurs when blood pressure drops due to excessive heat exposure. Exploring the distinct features, causes, and preventive measures for heat syncope becomes crucial in comprehensively addressing the spectrum of health risks associated with excessive heat exposure.

Heat syncope

Heat syncope is fainting while standing in heat (Leyk, 2019). When blood pools in dilated skin and lower body veins, those who have not adjusted to their new environment are most at risk. Patients should be reclined, and temperatures should be reduced to increase recovery time. Heat syncope can be avoided through acclimatisation, sweat-wicking clothing, and physical activity. Exploring the spectrum of heat-related illnesses brings attention to conditions like heat cramps. Understanding the causes, symptoms, and appropriate interventions for heat cramps becomes essential in ensuring a comprehensive approach to managing the health risks associated with heat exposure (Parsons, 2019).

Empirical studies in Ghana provide further insight into the prevalence and impact of heat syncope. A study by Weyant et al. (2022) found that outdoor workers in Accra experienced high incidences of heat syncope, especially during the hot season, with many cases linked to inadequate acclimatisation. Similarly, Adei et al. (2019) reported that market vendors in Kumasi were frequently affected by heat syncope due to prolonged exposure to high temperatures and limited access to cooling areas. Preventive measures for heat syncope include acclimatisation, wearing sweat-wicking clothing, and engaging in physical activity. Heat cramps, characterized by muscle spasms due to heavy sweating and significant electrolyte loss, were also observed among Ghanaian workers, particularly those engaged in manual labour (Eyiah et al., 2019).

Heat cramps

Heat-related illnesses encompass a range of conditions, each with distinct causes, symptoms, and interventions. Heat cramps, for example, are caused by a sudden and significant reduction of salt and water in working muscles, leading to discomfort in the arms, legs, and abdomen (Parsons, 2019). In hot climates, excessive sweating and water consumption can result in dehydration and salt loss (Leyk, 2019). The underlying physiological irregularities include salt loss through sweat, increased water intake, and water entering muscles, causing spasms (Cunha et al., 2020). Oral or intravenous salted liquids can provide quick relief, and new workers can avoid dehydration by consuming enough salt in their meals (Nerbass et al., 2017). Heat cramps rarely affect acclimatized individuals, though hyponatremia can result from excessive water intake.

Empirical studies in Ghana highlight the prevalence and management of heat cramps in various populations. For instance, Frimpong et al. (2017) found that agricultural workers in the Northern Region frequently experienced heat cramps during peak harvesting season due to inadequate salt intake and excessive water consumption. Similarly, Eyiah et al. (2019) reported that construction workers in Accra often suffered from heat cramps due to prolonged exposure to high temperatures and insufficient electrolyte replenishment.

Rhabdomyolysis, another severe heat-related condition, involves the release of injured muscle cell contents into the bloodstream due to heat, physical stress, or trauma, which can harm organs (NIOSH, 2017). Studies in Ghana, such as Nunfam et al. (2019, have shown that miners in the Western Region are particularly susceptible to rhabdomyolysis due to the physical demands of their work combined with high environmental temperatures. The research emphasises the need for regular breaks, proper hydration, and monitoring of physical exertion levels to prevent this condition.

Prickly heat, or miliaria, characterised by small, itchy red rashes caused by blocked sweat ducts, is another concern. Studies in Ghana, such as Adei et al. (2019) , have documented the prevalence of prickly heat among children and outdoor workers in urban areas. The research highlights the importance of wearing loose-fitting, breathable clothing and maintaining proper hygiene to prevent the condition.

Understanding and managing these conditions comprehensively enhances our approach to mitigating heat-related health risks. The collective findings from Ghanaian empirical literature emphasise the critical need for effective strategies, including acclimatisation, proper clothing, hydration, and monitoring of physical exertion, particularly for vulnerable populations frequently exposed to hot environments.

Prickly heat

Prickly heat is characterised by itchy, red blisters (Krishnamurthy et al., 2017; Parsons, 2019). This is caused by a combination of perspiration retention and clogged sweat gland ducts. Infection prevention requires the use of mild drying lotions and the maintenance of clean skin whereas treatment requires the provision of cool sleeping quarters to allow the skin to dry between heat exposures (Mitchell et al., 2018).

Empirical studies in Ghana further illuminate the impact and management of prickly heat in the region. For instance Gowda et al. (2023) documented the high prevalence of prickly heat among children in Accra, attributing it to the combination of high temperatures and humidity, along with poor access to cooling facilities. Another study by Adei et al. (2019) found that outdoor workers in Kumasi frequently suffered from prickly heat, particularly those in the informal sector who lacked proper hygiene facilities and cooling mechanisms.

To prevent and treat prickly heat, these studies recommend measures such as using mild drying lotions, ensuring good personal hygiene, and providing cool sleeping environments to allow the skin to dry between heat exposures. These recommendations align with global best practices and highlight the need for improved infrastructure and resources to manage heat-related conditions effectively in Ghana.

Anhidrotic heat exhaustion

In anhidrotic heat exhaustion, large parts of the skin do not sweat (DeGroot, Mok, & Hathaway, 2017). Currently, there is no effective therapy for anhidrotic skin (Parsons, 2019). Sweating tends to return gradually in colder climates. Preventative measures include treating heat rashes, avoiding sunburn, and intermittent cooling (Gauer & Meyers, 2019). In Ghana, extreme heat stress significantly impacts the health and productivity of various populations, particularly farmers and urban residents. Farmers in the north-eastern parts of Ghana face severe heat stress due to global climate change. They work in hot and humid conditions, with temperatures reaching up to 38°C during the rainy season and offering little relief even at night (Frimpong et al., 2017). Despite implementing various coping strategies, these measures are often insufficient to prevent heat-related health issues, indicating a need for government intervention to assist farmers (Frimpong et al., 2020).

Urban areas in Ghana, such as Accra and Kumasi, experience the urban heat island (UHI) effect, which exacerbates heat-related health risks. Research has shown significant increases in land surface temperatures over three decades, driven by urban expansion and the reduction of vegetated areas (Huang et al., 2024). Poor infrastructure and the urban heat island effect significantly hinder access to healthcare during extreme heat events, impacting both health facilities and residents (Weyant et al., 2022).

Concerning heat-related conditions, transient heat fatigue is another aspect to explore. Transient heat fatigue occurs when the body becomes overheated during physical activity, leading to symptoms such as weakness, headache, and syncope. Studies indicate that patients with spinal cord injuries, who often have anhidrotic areas, are particularly susceptible to heat fatigue due to impaired thermoregulation (Parsons, 2019). Effective management strategies for transient heat fatigue include ensuring adequate hydration, taking regular breaks in cool environments, and using cooling devices.

Transient heat fatigue

Heat exhaustion impairs sensorimotor, mental, and vigilance (DeGroot et al., 2017; Parsons, 2019). Unacclimatised and unskilled employees suffer the most. Physical abnormalities cause discomfort and strain. Avoiding boredom, acclimatisation, and heat work training may help reduce it (Gauer & Meyers, 2019). In the proceeding subsection, the researcher discusses chronic heat fatigue.

Chronic heat fatigue

Chronic heat exhaustion causes poor performance, social norms (Afulani et al., 2021), and difficulty in focusing (Sahu, Sett, & Kjellstrom, 2013). Employees from temperate climes who fail to assimilate socially and organisationally are in danger of long-term employment in tropical latitudes (Habibi et al., 2021). Psychological distress takes precedence over any physical symptoms. In the most extreme cases, medical and psychological treatment is necessary with the hope that symptoms will quickly subside once the worker-patient returns home. Avoid symptoms by learning about local customs, weather, and habits (Crowe, 2014).

Proper acclimatisation, cultural awareness, and preventive measures are crucial for mitigating these effects, particularly for workers from temperate climates adapting to tropical environments. Exploring the associated hazards of heat stress is crucial in understanding the multifaceted risks that individuals face in hot working environments.

Associated Hazards of Heat Stress

Heat stress can cause fogged safety glasses, sweaty palms, and dizziness (Syron, Lucas, Bovbjerg, Case, & Kincl, 2018). Mental alertness (Page & Sheppard, 2016) and physical competency may decline as the temperature goes up with increased discomfort promoting anger, irritability, and other negative emotions (Hayes et al., 2018) that can spark safety incidents, including the rise in blood pressure. Beyond immediate impacts to worker health and safety, heat stress may inflict longer-term damage as well. Persistently elevated core body temperatures and cardiovascular strain in hot conditions are thought to contribute to the development of ambulatory hypertension (AMHPT).

Ambulatory hypertension (AMHPT)

High temperatures and humidity stimulate the pumping of more blood to the skin. This causes the heart to pump twice as much blood per minute as it normally would (Yu et al., 2020). The greatest threats are posed by temperatures above 70 degrees Fahrenheit and humidity levels above 70%. High humidity levels suggest that there is a great deal of moisture in the air. This condition can affect many workers, including the young, and elderly (Staessen et al., 2019).

The elderly, the obese, and those with previous heart, lung, or kidney illnesses are more susceptible to the adverse effects of high humidity. Heat and perspiration can contribute to dehydration and a decrease in blood volume. This could make it difficult for the body to cool down, putting additional strain on the heart (Heather Mpemwangi, 2021). Consequently, untreated worker-patients with high blood pressure have a greater heart risk of contracting ambulatory hypertension. Ambulatory Blood Pressure Monitoring (ABPM) is blood pressure measured as the worker moves around, living their normal daily life, using a sphygmomanometer. Ambulatory blood pressure monitoring can detect disguised hypertension, minimise stroke, heart disease, and organ damage, measure a patient’s response to long-acting antihypertensive drugs, rule out white-coat hypertension, and prevent unnecessary prescriptions (Staessen et al., 2019; Yu et al., 2020).

Hypertension is generally diagnosed if the average blood pressure exceeds one of the following values: 24-hour average: above 135/80 mmHg, average for "Awake" hours: 140/90 mmHg, and average for "Asleep" hours: 124 mmHg/75 mmHg (Martinez-Nicolas et al., 2015). Given the physiological toll of heat, appropriate measures must be taken to protect workers from related health threats. The implementation of evidence-based interventions can help reduce risks of conditions like ambulatory hypertension emerging from recurring occupational heat strain.

Interventions for Heat Stress and Ambulatory Hypertension

Several interventions aim to mitigate the adverse effects of heat stress and ambulatory hypertension on individuals' health and well-being. These situations often involve a combination of preventive measures, lifestyle changes, and medical treatments.

Engineering control

Sweating more helps people adapt to hot temperatures (Page & Sheppard, 2016), and the behavioural ways of adjusting are attempting to remove clothes, drink cold liquids, fanning oneself, resting under a shade or a cool place, and/or slowing down (Luo et al., 2014; Zander et al., 2018). Proper design of tools, equipment, and machinery can reduce heat-related hazards. Cooling the workplace and mechanising tasks are the best engineering controls for preventing HRIs (Krishnamurthy et al., 2017).

Engineering controls can also reduce heat stress and ambulatory hypertension exposure. Air-conditioned crane cabs, break rooms, and ventilation (Habib et al., 2021), cooling fans, local exhaust ventilation (Jiao, 2019), reflective shields to redirect radiant heat (Parsons, 2018), insulation of hot surfaces, elimination of steam leaks (Afshari et al., 2019), cooled seats or benches for rest breaks (Wang,S. et al., 2017), use of machines or levers and use of misting fans (Kjellstrom et al., 2014) are all ways of mitigating heat stress and ambulatory hypertension on the worker.

Beyond engineering solutions, administrative controls provide another important approach for mitigating heat stress and related health risks in occupational settings. Regular breaks, modified work schedules and medical monitoring can all aid heat management through administrative means.

Administrative control

To reduce the risk of heat-related hazards, a standard work practice control consisting of risk assessment, standard operating procedures, and work instructions can be applied (US Occupational Health Safety Academy, 2021). First, workers can consider doing intense activities when humidity and heat are low, or carry out physically demanding tasks later in the day. Secondly, physical activity needs to be limited to reduce individual effort, and or the number of people assigned to a task can be increased, or arrange for micro-breaks can be arranged to cool down workers, while water is readily made available (Krishnamurthy et al., 2017).

Heat stress levels must be reduced for safe work (US Occupational Health Safety Academy, 2021). For this reason, employees who are not used to working in extreme heat areas should have work schedules and activities adapted (Krishnamurthy et al., 2017), schedule shorter shifts for newly hired, unacclimatised employees, and gradually increase shift length (Tustin et al., 2018). Physical demands can be reduced by organising tasks (Fatima, Rothmore, Giles, Varghese, & Bi, 2021) and job rotation among workers to aid rest cycles (Methner & Eisenberg, 2018). These can help limit exertion and heat exposure.

Moreover, water and dietary fluids intake such as consuming a suitable amount of water or fluids containing electrolytes (Sorensen et al., 2020) and abstinence from drinking hot beverages during lunch and afternoon breaks should remain one of the administrative controls in managing heat stress and ambulatory blood pressure. Employers should have an emergency plan that details what to do if a worker exhibits heat illness symptoms and a guarantee of medical assistance if needed (US Occupational Health Safety Academy, 2021). Finally, one should prepare for early warning signs of heat-related illness to offer information and first aid (Habib et al., 2021) and physiological monitoring of worker health and hygiene in hot conditions.

Policy and safe work procedures

Workplace policies and safe work procedures can play a crucial role in reducing the risk of heat-related illnesses. Employers need to ensure the health and safety of employees at work. Workplace policies and safe work procedures can reduce heat-related illness (HRI), for which employers are required to reduce working hours and work intensity during hot days (35°C/95°F outside and 33°C/91.4°F inside) (Hassan et al., 2020).

To illustrate, employers need to halt outdoor operations if temperatures reach 40°C/104°F. Hesketh et al. (2020) recommend wearing short-sleeved shirts while performing thermal spray operations with exposure to hexavalent chromium fumes, "nature breaks" and weather-related "comfort breaks" for workers and identify feasible and acceptable methods for reducing heat stress in the workplace.

Personal protective equipment (PPE)

Personal Protective Equipment (PPE) safeguard personnel from various job-related risks (Rother et al., 2020). However, it is important to recognize that

PPE, while providing protection, can also pose challenges, especially in hot weather conditions. One such challenge is the reduction in the wearer's ability to perspire effectively due to the limited breathability of some PPE materials. Lundgren et al. (2013) have highlighted that wearing PPE in hot weather, particularly when combined with strenuous work, can increase the risk of heat exhaustion. The findings of Lundgren et al. emphasise the importance of addressing heat stress concerns when PPE is worn in elevated temperatures.

Furthermore, excess heat can accumulate in PPE-protected clothing, particularly if individuals do not remove or exchange their PPE to allow it to dry (Nunfam et al., 2019). This accumulation of heat can further contribute to the risk of heat-related illnesses. To mitigate these risks, various technical and administrative measures have been suggested. Reflective clothing, face shields that reflect infrared light, and cooling neck coverings have been recommended to reduce the risk of heat stress (Habib et al., 2021; Zander et al., 2018).

In extremely hot weather, wearing thermally conditioned clothing has emerged as a viable solution. Options such as vests with vortex tubes connected to compressed air or jackets with reusable ice packs or phase change cooling packs have been explored (De Angelis, Saro, & Truant, 2017). Empirical evidence supports the efficacy of these innovative cooling solutions in mitigating heat stress in challenging environments. Furthermore, it is crucial to raise awareness among workers about the risks associated with PPE use (Jacklitsch et al., 2016; NIOSH, 2017). Empirical research and practical guidelines emphasise the importance of educating workers on the potential hazards of the use of PPE and appropriate measures to prevent heat-related illnesses when using PPE in hot weather conditions.

However, forward-looking efforts must account for predictions that climate change will exacerbate existing heat stress risks to outdoor workers.

Rising global temperatures associated with climate change are expected to increase both the frequency and severity of dangerous heat exposure events.

Climate change and Heat stress

The prediction is that the current global warming rate will naturally lead to more people experiencing heat stress (Gao et al., 2018) and other non-communicable diseases (Levy & Roelofs, 2019). Global warming may cause more volatile weather including extreme weather events. Several studies have examined the effects of global warming worldwide, and all concur that health and productivity will be severely impacted in developing countries and agricultural economies (Asamoah et al., 2018; Flouris et al., 2018; Kjellstrom, Freyberg, Lemke, Otto, & Briggs, 2018; Levi et al., 2018). For example, Ghana's average temperature rose 1°C per decade (1960–2000) and it is expected to rise 1.0–3.0 °C in 2060 and 1.5–5.2 °C in the 2090s (Siabi et al., 2023).

Trend and variability analysis showed that rainfall has been unpredictable but decreasing. Sea levels rose 2.1 mm per year from 1960–2000 and are expected to rise 5.8 cm and 16.5 cm by 2020 and 2050 (MESTI, 2013). Climate change is expected to increase the severity and frequency of heat-related illnesses in tropical developing countries like Ghana, which will exacerbate the effects of excessive work-related heat exposure. Heat stress in the workplace has been studied, but in the context of climate change, information is limited. "Heat island effect", physical labour, individual differences, and a poor national environment where technical improvements are often inapplicable will worsen heat stress in the current and future workplace (Lucas, Epstein, & Kjellstrom, 2014; Nunfam et al., 2019; Sahu et al., 2013).

Rising temperatures may reduce labour productivity, reducing global economic output and disproportionately affecting tropical poor countries.

Workers' health and safety, productivity, and social well-being are negatively impacted by long hours of physical exertion and increased workplace heat exposure due to climate change, particularly where prevention and control policies are inadequate (Ansah et al., 2021). Heat stress management is hindered by workers' differing concerns and awareness of the dangers posed by climate change and heat exhaustion. The effectiveness of climate change-related occupational heat stress management strategies depends on worker and supervisor awareness of the impacts, prevention, and control of heat stress. To reduce occupational heat stress associated with high temperatures and extreme weather, workers' experiences and concerns about heat-related morbidity guide the use of preventive and control measures. Workers' heat-related morbidity experiences and concerns are used to develop preventative and control measures to reduce the effects of climate change and high temperatures on occupational health.

Heat stress and Productivity loss

Heat stress has been shown to impact both physical and mental performance (Balmain, Sabapathy, Louis, & Morris, 2018). It affects cognitive performance in various ways depending on the task. In real-world scenarios, tasks are rarely straightforward, making it difficult to predict the exact impact of heat stress. Concerns may include teamwork, organisational problems, and other social issues (Messeri et al., 2019). External heat, additional heat sources at work, and internal heat production can cause clinical organ damage, as well as physiological and psychological effects in workers exposed to these conditions (Morabito et al., 2020).

In the Ghanaian context, heat stress significantly affects cognitive performance and health among mining workers. A study assessing the perceptions of climate change and occupational heat stress risks found that heavy physical workload combined with increasing workplace heat exposure due to climate change adversely impacts workers' health, safety, and productive capacity (Nunfam et al., 2019). Workers experienced heat-related morbidities, and the variation in morbidity experiences was significantly different across types of mining activity (Nunfam et al., 2019).

Empirical studies have demonstrated that moderate heat stress can significantly affect mental performance by reducing levels of arousal. Tasks demanding concentration and clear thinking are adversely affected, while memory tasks can improve slightly at moderate temperatures (Maula et al., 2016). The performance of both physical and mental tasks can also be adversely affected by heat and dehydration. Proper hydration can greatly reduce the adverse effects of heat stress (Parsons, 2019).

In international contexts, studies on elite athletes have shown that heat stress and dehydration can impair both physical and cognitive performance. For example, elite female field hockey players showed faster response times and improved accuracy on cognitive tasks in the heat, although hydration status did not affect cognitive performance significantly (Goods et al., 2024). Mental fatigue and heat stress can independently and jointly reduce endurance performance. However, a study found no negative effects of mild mental fatigue on endurance performance in the heat, suggesting that the brain's stress response may already be maximised by the hot environment (Van Cutsem et al., 2017).

To avoid heat exhaustion, workers often take more frequent and longer breaks, reducing labour productivity and individual and organisational economic output (Morabito et al., 2020). Effective management strategies include behavioural measures such as shift scheduling, proper hydration, and the use of cooling devices. These strategies are particularly crucial for outdoor workers who will face increasingly severe and prolonged heat stress due to climate change (Hudson & Day, 2019).

Validated tools are needed to assess occupational health and safety risks associated with heat stress. The wet bulb globe temperature (WBGT) index provides an objective measure of thermal conditions for evaluating heat stress hazards. This is further elaborated in the next subsection.

The Wet Bulb Globe Temperature (WBGT) Index

The WBGT index stands as one of the most widely accepted and utilized indices globally for assessing heat stress in various settings, including military, security, industrial, leisure, and sports activities (Brimicombe et al., 2023). A WBGT monitoring device measures critical environmental parameters, including temperature, humidity, wind speed, and solar radiation. These measurements are pivotal in understanding and mitigating heat stress risks associated with different activities (NIOSH, 2017; Yaglou & Minard, 1956).

The WBGT index serves as a simple, yet direct tool based on temperature parameters. Although other indices with comparable validity have been developed, the standardisation and international adoption of the WBGT have conferred significant practical experience and recognition upon it. This widespread usage, across diverse domains can be traced back to its origins in the early 1950s in the United States (Minard, Belding, & Kingston, 1957). During this period, a collaboration between a US Navy commander and a researcher from the Harvard School of Public Health led to the development of the WBGT system. Its primary purpose was to reduce heat-related casualties on military bases, marking a crucial milestone in the field of heat stress management (Minard, Belding, & Kingston, 1957).

WBGT is calculated by incorporating data from a black globe thermometer (TG) and air temperature (TA). However, over time, efforts have been made to refine and adapt this index for practical applications. For instance, Jiao (2019) introduced the concept of the wet bulb thermometer with integrated temperature (TNW). This innovation aimed to simplify the WBGT index by approximating the Corrected Effective Temperature (CET) value, which accounts for radiation. This new approach considered air temperature, radiant temperature, air velocity, and air humidity, mirroring the fundamental parameters influencing heat stress in humans.

Empirical research, such as the study by Jiao (2019), evaluated the practicality of this approach, which shows promise for assessing heat stress effectively. While the WBGT index was originally developed for outdoor activities, its utility has expanded to include both indoor and outdoor environments. This adaptability underscores its continued relevance as a tool for evaluating and mitigating heat stress, safeguarding the well-being and performance of individuals across various settings.

Initially, the simple WBGT measuring instrument was not precisely defined, but it has since been standardised, most recently in ISO 7243. A weighted average of sensor values provides $WBGT = 0.7 \times TNW + 0.3 \times TG$. Temperature, radiation, air velocity, and humidity are all factors that affect the sensors, but when the person and sensors are exposed to direct sunlight, the equation does not work. Where direct solar radiation is present, a second equation is used, which can be used both indoors and outdoors. That is $WBGT = 0.7 \times TNW + 0.2 \times TG + 0.1 \times TA$ (Asghari et al., 2020)

There have been incorrect variations and interpretations of the WBGT measuring instrument and formulas. A common example is the use of a black globe of a smaller diameter than 150mm. The effectiveness of the corrections will depend upon environmental conditions. High air velocity and radiation can cause significant errors in instruments that are not up to standard specifications, but still, air and negligible net radiation can result in insignificant errors. Globe temperature diameter is a common variation as the specified diameter of 150mm (6in.) is often inconvenient to use and transport. Smaller globes (25–125mm) are greatly affected by air velocity in a way that it is difficult to measure accurately and negates one of the originally stated advantages of using the WBGT index that air velocity is not required (Yaglou & Minard, 1956).

Yaglou and Minard (1956) reported using the cloth from the marine corps trainees' uniform to cover the black globe thermometer, simulating the effects of the colour of clothing (olive drab herringbone twill fabric) on (solar) radiation absorption. An earlier form of the WBGT equation for use in the sun was: $WBGT = 0.7\ TNW + 0.3\ (\alpha\ (TG - TA) + TA)$ where α is the solar absorptivity of clothing. For a black body or no solar radiation but maybe longer wavelength radiation (indoors), the equation is: $\alpha = 1.0$, $WBGT = 0.7\ TNW + 0.3\ TG$. For green clothing: α is around 0.67 in the sun (actually for olive drab uniform α is given as 0.74) so $WBGT = 0.7\ TNW + 0.2\ TG + 0.1\ TA$.

The natural wet-bulb temperature (TNW) has been standardised as the same measure to be used in both formulae, that is, in and out of solar radiation. However, Yaglou and Minard (1956) report the use of psychrometric (aspirated and thus not significantly affected by radiation) wet-bulb temperature (TWB) for the formulation, applicable to conditions with no direct solar radiation, and natural wet-bulb temperature (TNW) for conditions with direct solar radiation. ISO [2017] does not use psychrometric wet-bulb temperature and instead, standardises the use of natural wet-bulb temperature in all contexts and when exposed to whatever long or short wavelength radiation is present. At high air velocities, like those found in the outside wind, the natural wet-bulb temperature approaches the psychrometric wet-bulb temperature as the wind forces maximum evaporation (Chen & Chen, 2022).

Theoretical Framework

A theoretical framework serves as the intellectual foundation of a research study, providing a structured and conceptual framework for understanding and analysing a research problem. This study adopts the farmworker vulnerability to heat hazard framework.

Farmworker vulnerability to heat hazards framework

Given the complexity of the response of the human body to the exogenous factors that influence workplace heat, models are needed to promote the understanding of the vulnerability and physiologic response. A framework for explaining the elements affecting farmworkers' exposure to heat stress conceptualises the physiologic processes occurring in the body. In response to heat stress, sources, and moderating factors suggested a conceptual model connecting climate change and urban environment health (Mac & McCauley, 2017).

The model for farmworker vulnerability has been used in surveys (Fleischer et al., 2013), community and migrant health centres (Ngaruiya, Ogendi, & Mokua, 2019) and field-based continuous biomonitoring (Kpoclou et al., 2021) to explain heat exposure and physiologic responses (Mac & McCauley, 2017).

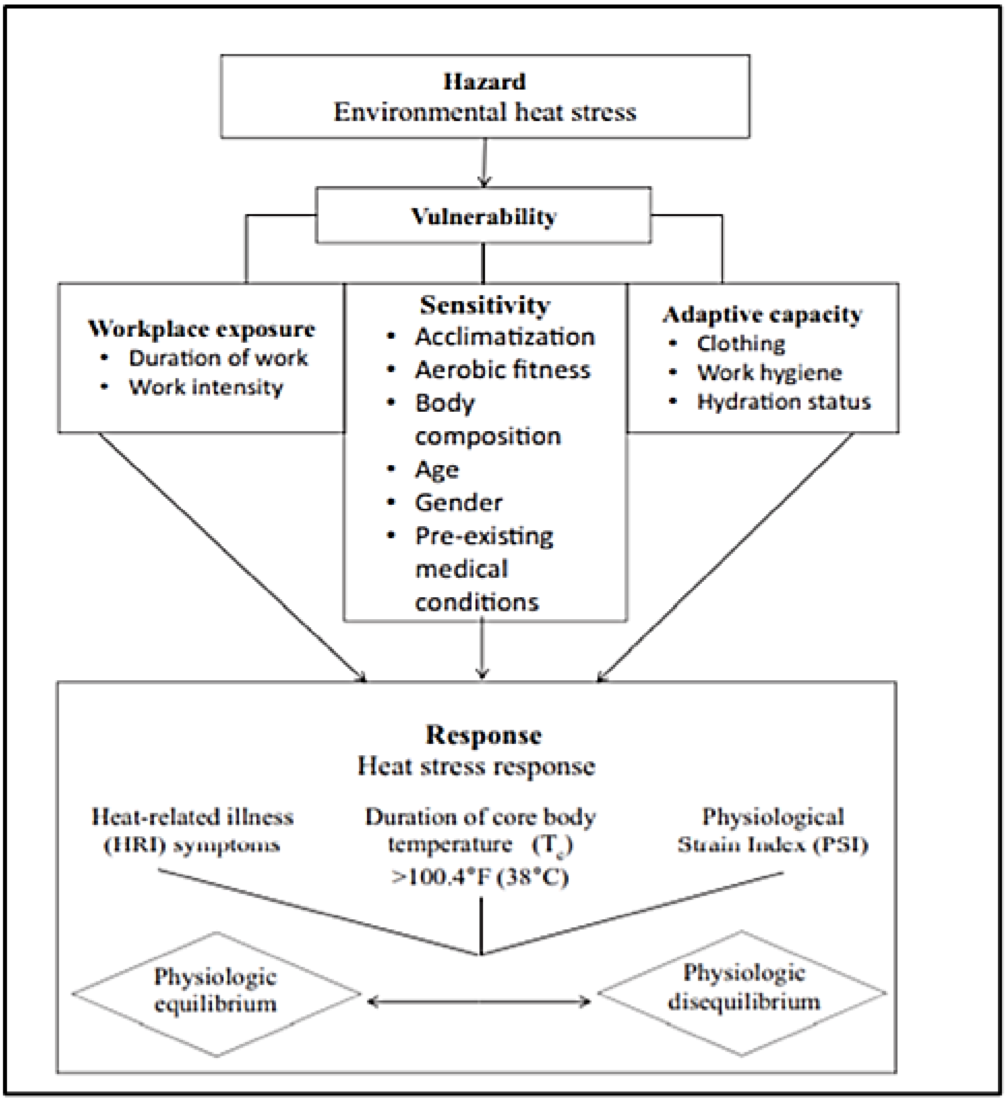

Figure 2: Farmworker Vulnerability to Heat Hazards Framework to Address Heat Exposure in the Workplace (Mac & McCauley, 2017)

Conceptual Base of the Study

The practice of fish smoking and processing are intrinsically linked to various factors, including workplace heat exposure leading to heat stress and ambulatory hypertension among the workers (Kpoclou et al., 2021; Ngaruiya, Ogendi, & Mokua, 2019). The impact of fish smoking on these variables can vary depending on the specific context and location in which the fish processing activities place. In Ghana, fish processing commonly involves the application of heat during smoking procedures. The heat generated within the work environment can exert a significant influence on the physiological status of fishmongers, promoting a rise in ambulatory blood pressure, thereby posing potential health hazards (Kusi, 2020). Heat stress, exacerbated by factors such as prolonged exposure, worker age, availability of shade, hydration levels, and adaptive behavioural responses to heat, may contribute to various adverse health outcomes, including ambulatory hypertension and other heat-related illnesses (NIOSH, 2017).

The current study's investigation into the relationship between individual heat exposure and workers' physiological responses in agricultural and food processing industries can improve understanding of heat adaptation and its health impacts. This knowledge can inform targeted interventions to reduce health risks in fish smoking and related activities, ensuring strategies are both suitable and effective for the specific needs of these workers.

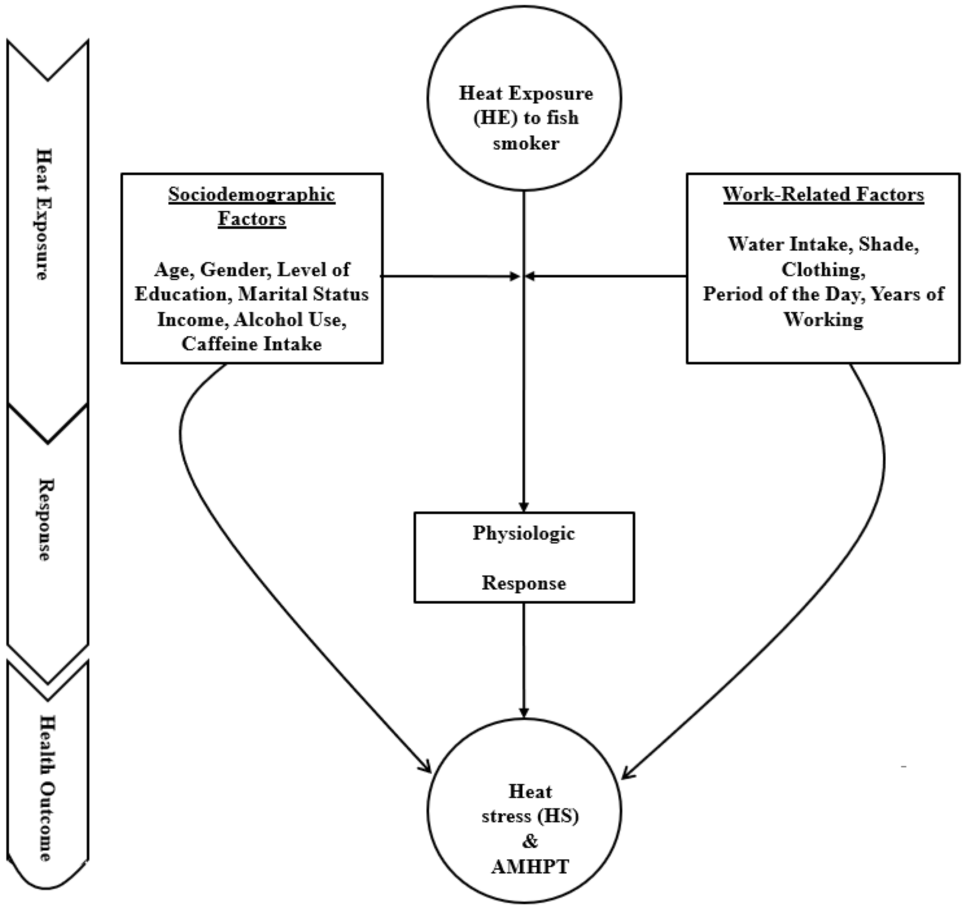

Figure 3: Conceptual Base of the Study

Summary

This chapter reviewed the extant literature related to the topic under study. From the literature review, the relationship between heat stress and ambulatory hypertension among fishmongers remains an understudied area, despite extensive research on heat stress in various occupations. This study aims to address this knowledge gap, exploring the interplay between these factors within the fish smoking industry. The findings have significant implications for occupational health and safety practices in this sector, potentially informing interventions to enhance worker welfare. International organisations like the ILO and WHO play crucial roles in guiding OHS activities, with conventions and policies underscoring the commitment of nations, including Ghana, to protect their workforce.

More importantly, research into workers' behavioural adaptations to heat stress has highlighted effective strategies such as regular hydration and planned rest breaks. Identifying and promoting such adaptations among fishmongers could lead to optimised work practices and improved resilience to heat stress and associated hypertension risks. This study's investigation into the relationship between heat stress and ambulatory hypertension among fishmongers promises valuable insights for occupational health in this industry and broader workplace safety concerns. By enhancing understanding of this complex relationship and its determinants, the research aims to inform evidence-based interventions that could benefit workers across various industries facing heat stress challenges.

CHAPTER THREE

RESEARCH METHODS

The previous chapter presented a comprehensive literature review to capture the state-of-art concerning the topic and purpose of this study. To recap, the purpose of this research is to investigate the relationship between occupational heat exposure and the incidence of ambulatory hypertension among fish smokers in Ghana. This chapter comprises the research design, study area, population, sampling procedures, data collection instruments, data collection procedure, and data processing and analysis.

Research Design

The ontological and epistemological positions of this study are supported by positivism. I believe that research should aim to explain and predict real events or facts. Therefore, examining the heat exposures associated with heat stress and ambulatory hypertension among fish smokers in coastal areas of Ghana helps explain how levels of work-related heat stress, differences in heat stress by work shift length, and ambulatory hypertension are impacting the workers based on number of working days and socio-demographic and other work-related factors.

Epistemologically, I believe that examining the socio-demographic and work-related factors associated with the incidence of heat stress and ambulatory hypertension among fish smokers can be directly investigated and measured using valid, reliable, and standardised measurements. In addition, I believe that research should be guided by theories that help to explain and predict constructs or variables of interest as in the current study. Finally, obtaining an adequate and representative sample of fish smokers using valid, reliable standard measures and robust statistical analytic tools helps extrapolate valid and reliable results, findings and conclusions of this study to fish smokers in coastal areas of Ghana.

Aligning with the positivist paradigm, this study adopted the exploratory cross-sectional design to examine heat exposures associated with heat stress and ambulatory hypertension among fish smokers in the coastal areas of Ghana. The exploratory cross-sectional design is an important descriptive research method that uses a representative sample to effectively collect large amounts of data from a target group such as fish smokers. Exploratory cross-sectional design entails the generation of inductively derived generalisations about the group, process, activity, or situation under study (Stebbins, 2001).

Furthermore, when studying a larger population to create a scope for future studies and explain research topics of interest in varying depths, an exploratory cross-sectional design is the best approach (Saunders, Lewis, & Thornhill, 2003). Moreover, many studies on personal heat exposure monitoring (Yi & Chan, 2013), agriculture (Asamani, 2020), bakery and epidemiology (Qin, Romero-Lankao, Hardoy, & Rosas-Huerta, 2015), climate change and health (Ansah et al., 2021; Kjellstrom et al., 2014; Morabito et al., 2020) and education (McNabb, 2020) used exploratory cross-sectional design across different cultures and segments of the population to study workplace health and associated factors.

The exploratory cross-sectional design offers some inherent advantages, including the ability to confirm or refute hypotheses, the cost-effectiveness of its execution, and the speed of completion. The data, which contained multiple factors at the time of data collection, can be used in future research projects. A variety of findings and results can be examined to generate new theories/studies or conduct in-depth research. A disadvantage of cross-sectional designs is the inability to study behaviour over time or establish cause-and-effect relations between and among variables (Ogah, 2013). A direct consequence of this approach is that the results can be flawed or biased if there is a conflict with the source of the data obtained. While acknowledging the limitations of the exploratory cross-sectional design, the study addressed some biases and strengthened inferences by using objective measures, and statistical controls, and discussing wider relevance and the need for further longitudinal research. It was based on these advantages and the statistical prowess of the design that justified its adoption for the study.

Study Area

The entire Gulf of Guinea spans an area of 238,500 Km^2 with a narrow continental shelf totalling approximately 24,300 Km^2. Ghana has a territorial sea of 12 nautical miles (nm), a contiguous zone of 24 nautical miles (nm), and an Exclusive Economic Zone (EEZ) of 200 nautical miles [nm] (United Nations, 1986). A 550-kilometre coastline stretching from Aflao in the east to Half Assini in the west within four regions of Ghana, with 189 fishing communities, plays an important role in the country's socio-economic development (Dovlo et al., 2016). Moreover, most fishing communities in Ghana enjoy stable social cohesion and steady economic development, both of which are leveraged by sustainable livelihoods derived from fisheries. The fisheries sector contributes significantly to Ghana's economy in terms of food security, employment, poverty alleviation, GDP, and foreign exchange revenues. The contribution of Ghana's fisheries sector is important, amounting to 4.5 per cent of the GDP, 12 per cent of the agricultural GDP, and 10 per cent of the labour force (Robadue, 2021).

There are four regions in Ghana mainly involved in fish processing: Western, Central, Greater Accra, and Volta Regions. According to the Fisheries

Commission (Cerath Development Organization, 2019; Dovlo et al., 2016), major fish smoking towns for these four coastal regions are; Aflao, Keta, Ketu South and Keta Districts in the Volta Region; Ada East, Ada West, Ningo-Prampram, Kpone-Katamanso, Tema, Ledzokuku Krowor, La-Dadekotopon, Accra and Ga South Districts in the Greater Accra Region; Awutu Senya, Effutu, Gomoa East, Gomoa West, Ekumfi, Mfantseman, Cape Coast, Abura-Asebu Kwamankese, Komenda-Edina-Eguafo-Abrem Districts in the Central Region, and Shama, Sekondi-Takoradi, Ahanta West, Nzema East, Ellembelle, Jomoro Districts in the Western Region.

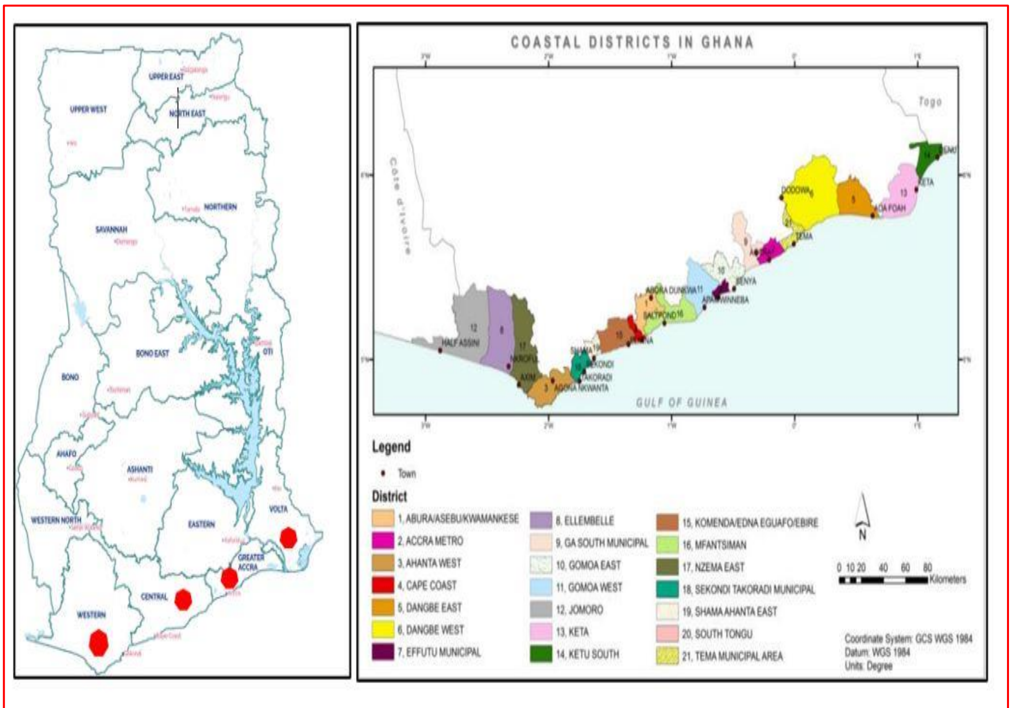

Figure 4: A Map Showing the Major Coastal District in Ghana (MOFAD, 2020).

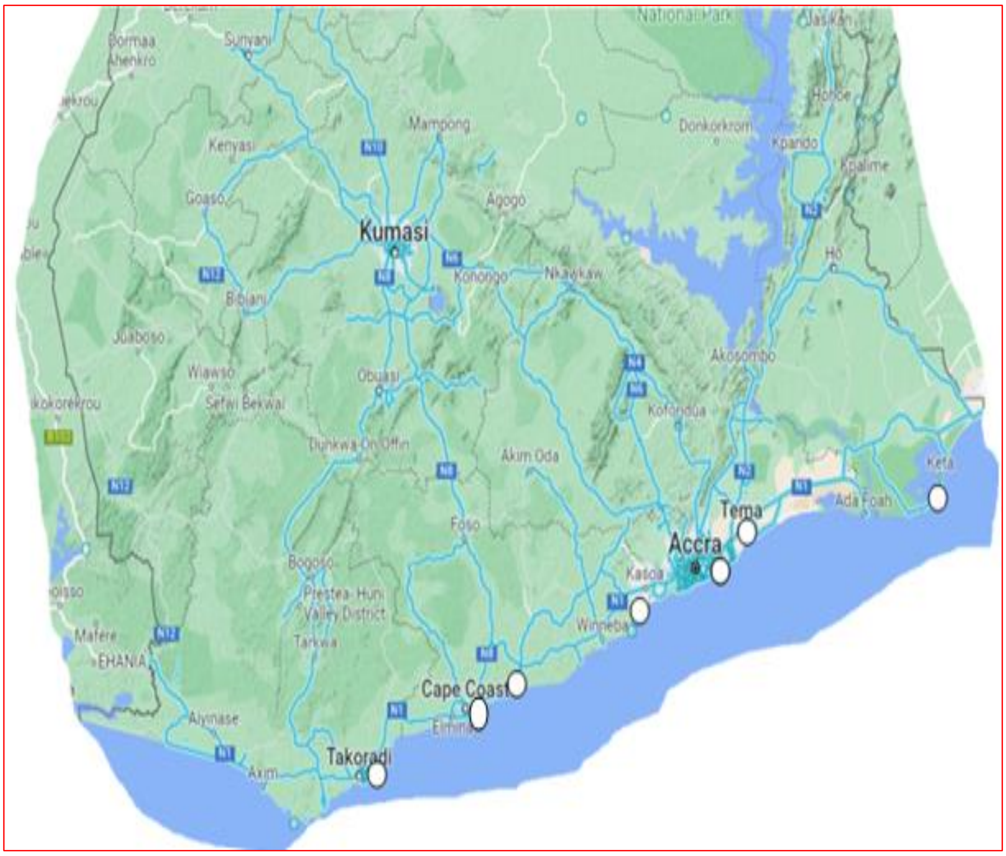

Figure 5: A Map Showing the Selected Coastal District for the Study (MOFAD, 2020).

Population

There are about 3,312 individuals involved in the business of smoking fish across the towns and communities included in this study. These fish-smoking traditional towns have the following fish-smoker population: Keta (400), Tema New Town (490), Teshie (483), Awutu Senya (466), Moree (472), Elmina (500), and Shama (501). The fish smokers are of diverse cultural backgrounds with 90% of them being young and from rural towns (Ofori-Danson, Asiedu, Amponsah, & Crawford, 2019).

Sampling Procedure

In this study, a total of 2,018 participants, representing 60.9% of the fish smokers, were included. It is important to note that the determination of this sample size was not based on an a priori assumption regarding effect size or statistical power calculations. Typically, in sample size determination, researchers calculate the effect size with the assumption that the sample is drawn from a population that follows a normal distribution (Mertler et al., 2021). However, in this study, it was not feasible to ascertain the normality of the target population before data collection (Mertler et al., 2021).

The decision to use a sample size of 2,018 was influenced by previous studies conducted on similar workplace hazards in coastal towns (Antwi-Boasiako, 2017; Barrow et al., 2022; Ofori-Danson et al., 2019), which employed a similar sample size. This approach facilitated meaningful comparisons of this study's results and findings with those of the previous research, eliminating concerns about an imbalanced sample size. Moreover, opting for a larger sample size enhances statistical power, enabling the detection of subtle associations that might go unnoticed with a smaller sample (Ogah, 2013).

Additionally, Willie, (2024) has emphasised that a survey that samples at least 60% to 70% of the target population suggests that the majority of the target population is represented. This enhances the generalizability of survey findings to the broader community. Therefore, a sample size of 2,018 is justified as it is considered a reasonable representation of the population, likely to yield reliable and valid findings in this study.

Regarding the sampling methods employed, the regions and communities were selected using purposive sampling, while the fish smokers were sampled using a convenient sampling approach. Purposive sampling allows researchers to select participants who meet specific criteria relevant to the research objectives. This targeted approach ensures that a large number of fish smoker samples are selected to represent the characteristics or experiences essential for the study, providing an in-depth understanding of the phenomenon under investigation.

Convenient sampling, on the other hand, is a practical and cost-effective method. It allows researchers to reach diverse groups, especially in situations where accessibility poses a challenge. While some early researchers have raised concerns about the generalizability of findings from studies using non-probability sampling methods like purposive and convenient sampling, it is important to note that these methods are widely accepted and utilized in the field of organizational health and safety research (Liu, Nkrumah, Akoto, Gyabeng, & Nkrumah, 2020; Simpson & Sam, 2020). Therefore, the results, findings, and conclusions drawn from these studies can indeed be valid, reliable, and applicable to fish smokers along the coastal areas in Ghana.

Inclusion criteria

1. **Communication Ability**: Includes adult fish smokers who do not face significant communication barriers, such as language differences, low literacy, or cognitive impairments, ensuring they can understand study procedures and provide reliable responses.
2. **Consent**: Includes fish smokers who voluntarily agree to participate in the study.

Additional Health and Lifestyle Requirements

To ensure comprehensive and accurate findings, the study considered including individuals with:

- **Genetic Background**: Includes individuals with no family history of hypertension or cardiovascular diseases.
- **Cardiovascular Health**: Includes individuals without any pre-existing cardiovascular conditions, such as heart diseases or related conditions.
- **Diabetes Status**: Includes individuals who do not have a diagnosis of Type 1 or Type 2 diabetes.

- **Lifestyle Factors**: Includes individuals who are moderate or light smokers, maintain a reasonably healthy diet, and have moderate to low alcohol consumption.

Exclusion criteria

1. Adult fish smokers who cannot communicate properly.
2. Fish smokers who will not consent to the study.

Data Collection Instruments

The following instruments: thermometer, heat stress monitor, ambulatory blood pressure monitor, body scale, meter ruler, and survey interview instruments were used for data collection. Fitria, Prihartono, Ramdhan, Wahyono, Kongtip, & Woskie, (2020) conducted similar research employing such tools to evaluate heat exposure and heat-related symptoms among sugarcane workers. The study by Fitria et al. (2020) involved the collection of physiological data, including blood pressure, heart rate, and body temperature, from fish smokers at three different time points: pre-work (early morning), during work (around afternoon), and post-work (around evening). This was to measure the influence of heat exposure on the fish smokers during at 15-minute fish smoking process and how that influences heat stress and ambulatory hypertension of these workers. The measurement of body temperature was also taken using a non-contact industrial GM320 digital infrared thermometer in China (Yalaz, GM320, China). Moreover, ambulatory blood pressure and heart rate were assessed utilising a sphygmomanometer (Omron, HEM-7320, Kyoto, Japan).

The study utilised a WBGT monitor (HSM 100 CASELLA, UK) to measure the heat exposure in the vicinity of the fish processing ovens. The WBGT index was then calculated, considering the impact of humidity and air movement, as well as the natural wet bulb temperature (TNWB), globe temperature (TG), and dry bulb air temperature (TD). The study involved recording WBGT measurements at pre-, during, and post-monitoring periods (each lasting 15 minutes) for fish smokers working in both indoor and outdoor environments while processing fish with a time-weighted average taken into consideration.

This study was conducted in duplicate for each fish smoking method, including both indoor and outdoor smoking techniques. The monitoring of heat stress and the classification of work activities were assessed under the guidelines established by the American Conference of Governmental Industrial Hygiene (ACGIH), 2017 version. The study followed the guidelines established by the American Conference of Governmental Industrial Hygiene (ACGIH) in their 2017 version to properly assess and classify heat stress among fish smokers. The ACGIH publishes Threshold Limit Values (TLVs) for different occupational hazards to assist in controlling health risks faced by workers.

With regards to heat stress, the TLVs provide temperature and humidity limits as measured by the Wet Bulb Globe Temperature (WBGT) index for varying levels of physical work and rest patterns. This helps determine if heat exposure poses a risk of illnesses. The study also utilised the ACGIH’s classification of work activities into light, moderate and heavy categories based on metabolic equivalent (MET) ranges. Considering the smoker’s work intensity along with the TLV guidelines allowed for an accurate evaluation of their heat risk. Furthermore, the ACGIH procedures for monitoring heat stress were adhered to in order to ensure reliable data collection using instruments such as the WBGT meter. By following this standardised methodology endorsed by health and safety experts, the study was able to comprehensively evaluate heat stress under different smoking conditions and make appropriate recommendations grounded in scientific guidelines. Weight measurements of the fish smokers were documented in conjunction with their height to ascertain their body mass index (BMI) (Khanna et al., 2022).

Plate 1: Measuring a Fish Smoker's Heat Stress Monitoring Using HSM 100 CASELLA Monitor (Casella CEL. (2022).

Plate 2: Measuring Fish Smoker's Ambulatory Blood Pressure Using a Sphygmomanometer (OMRON Healthcare, 2022)

Plate 3: Measuring a Fish Smoker's BMI Using a Body Scale and Stadiometer (Khanna et al., 2022).

Plate 4: A Medical Infrared Thermometer for Body Heat Temperature Measurement (Landy, 2022).

Survey interview

A questionnaire facilitated the recording of self-reported data. Moreover, physical measurement tools such as sphygmomanometer measured blood pressure, thermometers for ambient temperature assessment, weight scales for weight and stadiometers for height measurements, and heat stress monitoring meters to objectively quantify the heat stress experienced by participants. The questionnaire gathered data on employment history, current work tasks, level of water consumption, break frequency, payment structure (piece rate or hourly), resources provided by employers, typical attire and headgear worn, as well as behaviours exhibited at work, including cooling methods employed, specific health conditions, and demographic information. Furthermore, information on the diverse methods respondents employ to cool themselves when experiencing heat was collected. These included strategies such as sitting under trees, using fans, rest stations, and bathing with cooled water. The survey instrument was presented in the English language. The texts were translated into Fanti and Ga languages and subsequently underwent re-translation into English at the Department of Ghanaian Languages and Linguistics to facilitate comprehension for participants who lacked English language literacy skills.

The 62-item questionnaire comprised three sections. Section A, 14 items, was on the socio-demographic factors of the participants, consisting of age, gender, duration of employment, marital status, level of education, ethnic background, average monthly income, medical history, prior training on heat and related illnesses, dietary habits, alcohol consumption, and smoking behaviour. The response included "yes" or "no". Some of the items included "*What is the frequency of your workdays per week*", "*Do you drink alcohol*", *and* "*Smoking status?*"

Section B comprised 17 questions that aimed to investigate the risk factors associated with heat exposure at work and other related activities such as physical activity, duration of heat exposure, clothing comfort, work pace, and water consumption. Some items included, "*Does fish smoking involve a lot of repetitive activity*" *and* "*Does fish smoking require you to move a heavy load*". The respondents utilised a 4-point Likert scale including a range of responses of strongly disagree (SD), disagree (D), agree (A) and strongly agree (SA) to furnish their answers. The aforementioned items recorded a reliability coefficient of $\alpha = .752$.

The final four questions in Section B focused on interval training, performance in low sunlight areas, staying hydrated, and choosing suitable clothing. For example, "*Do you drink a lot of water in hot conditions*", "*Do you always take a break in the shade when smoking fish*" *and* "*Do you feel hot in your clothing during fish smoking*". Participants were given a set of response options and could choose the one they thought was best. Alternatively, respondents could indicate their agreement or disagreement by giving affirmative or negative responses to items related to heat stress and ambulatory hypertension. These items recorded a reliability coefficient ranging from 0.495 to 0.991.

Furthermore, following the Stoecklin-Marois approach, a sum of six (6) scores was acquired, with values ranging from 0 to 5. This approach evaluates six parameters related to an individual's heat stress response: core temperature, heart rate, sweat rate, skin temperature, thermal sensation, and exertion level. Each parameter is scored on a scale of 0-5 based on predefined criteria, with higher scores indicating greater heat strain. The scores for the six parameters are summed to produce a total heat strain score. This allows for an objective quantification of overall heat strain that can be compared within and between individuals. A higher total score signifies more physiological hardship from heat.

By applying this standardised Stoecklin-Marois method, the study comprehensively assessed and compared levels of heat strain experienced by fish smokers during occupational tasks. In this study, heat exposure was established whereby scores within the range of 4 to 5 indicated "high" heat exposure, whereas a score below four indicated "low" heat exposure. The respondents expressed their degree of comfort on five-point options, including very comfortable, comfortable, neutral, uncomfortable, or very uncomfortable.

For example, "*What is your level of concern about the risk of heat-related illnesses while smoking fish*" *and* "*What do you feel about heat exposure whilst smoking fish*". These items produced a reliability coefficient of 0.642.

Section C had a total of 31 questions that measured the health consequences associated with heat exposure and strategies the workers adapt against high temperatures. 19 items investigated the symptoms of heat stress and ambulatory hypertension illness, including skin rashes or skin bumps, painful muscle cramps or spasms, dizziness or light-headedness, fainting, headache, sweating, extreme weakness or fatigue, nausea or vomiting, and confusion. The workers responded with a binary option of "yes" or "no" to the presented items, which yielded a coefficient alpha value of 0.623. Nine other items measured adaptation practices to heat exposure at work. Six items focused on monitoring ambulatory blood pressure and heart rate, assessing body conditions while smoking fish, regulating rest cycles, the process of acclimatization, adaptation methods used, and utilising personal protective clothing, in particular heat-resistant attire.

Responses to these six items aimed to gain a better understanding of how the workers adapted to heat exposure on the job. The respondents were asked to indicate their level of agreement using a four-point Likert scale, ranging from "at no time", "some of the time", "most of the time", "All of the time", and "other" through multiple-choice options. This study includes an inquiry into the efficacy of heat-related illness prevention measures in the context of fish-smoking work environments. Specifically, the study poses three questions regarding the extent to which individuals implement effective heat-related illness prevention measures when engaging in such work activities. For example: "*Do you implement effective measures to prevent heat-related illnesses during your work in the fish smoking industry?*", "*Prior to commencing work in* *the fish smoking area, are you provided with guidance from healthcare professionals regarding preventative measures and management strategies for heat-related ailments?*" The participants were requested to respond by indicating their level of agreement on a scale ranging from strongly disagree (SD) to disagree (D) to agree (A). The items were measured and recorded with a reliability coefficient of α=.621

Pre-testing the instrument

To establish the reliability and validity of the research instruments (Creswell & Zhang, 2019), a pre-test was conducted with the questionnaire, heat stress monitor, sphygmomanometer, medical body thermometer, body scale, and stadiometer. The pre-test involved administering these instruments to a sample of 50 fish smokers in Duakor, a suburb of Cape Coast who also practice fish smoking. To guarantee the uniformity of measurements, a heat stress monitor, medical body thermometer, body scale, stadiometer, and sphygmomanometer underwent calibration at the Ghana Centre for Scientific and Industrial Research (CSIR) and Ghana Standard Authority (GSA). The psychometric properties of the heat exposure and questionnaire scales were assessed through alpha coefficient analyses utilising the SPSS version 25 software.

Data Collection Procedures

The study protocol received ethical clearance (RPN018/CSIR-IRB/2023) from the Center for Scientific and Industrial Research (CSIR). This was after my supervisors approved, and introductory letters issued from the Department of Health, Physical Education, and Recreation (HPR), UCC. These documents were used to seek permission and introduce the research team to fish smokers, chiefs, and elders of the fish-smoking communities.

Four research assistants (RAs) were involved in the data collection. The RAs underwent training sessions that covered the objectives of the study, as well as guidelines on effectively engaging with the fish smokers. The RAs also received instructions on the methods for obtaining entry into the communities for the study. The RAs participated in an intensive four-day training. Moreover, all participants either gave oral consent or signed a consent form before taking part in the study. Participants were assured of confidentiality and anonymity in the study and that their identities would not be revealed. They were informed that the study was for academic use only and that participating in the study was without financial compensation. Finally, participants were made aware that the results and findings from the study could be shared at academic conferences, workshops, and in scholarly journal publications.

The next step involves setting up monitors and wearable devices to measure heat exposure and perform ambulatory blood pressure monitoring. Each morning before the fieldwork, the researcher calibrated several instruments in a mini-laboratory to ensure proper functioning and accurate measurements. The instruments used included a heat stress monitor, medical body thermometer, body scale, stadiometer and sphygmomanometer. The heat stress monitor and body thermometer were used to continuously measure the core body temperature of participants during fish smoking activities, to determine their level of heat exposure. The body scale was employed for evaluating participants' weight as a means of assessing their body mass. The stadiometer helped take anthropometric measurements like height.

The sphygmomanometer was used to monitor the ambulatory blood pressure of participants throughout the day. Participants wore the monitors and intermittently monitored their blood pressure levels while engaging in their daily smoking activities. Readings were taken periodically depending on the monitoring schedule. This data collection phase lasted approximately sixteen weeks and took place across four regions.

Data Processing and Analysis

Statistical Package for Social Sciences (SPSS) version 25.0 was used to manage and analyse the data. Data was screened for missing values, and univariate and multivariate outliers using frequency distributions and box plots. Missing quantitative data were replaced with serial means whereas qualitative missing data were replaced with their nearby points (Mertler, Vannatta, & LaVenia, 2021). Histograms were used to test for the normality of the data. Leven's test of equality of variance was used to test for homogeneity of variance. Participants' backgrounds and demographic characteristics were examined using mean, frequency, and percentage analyses. The analyses were presented in tables.

Research question 1: What is the level of heat exposure and ambulatory hypertension among fish smokers in the coastal areas of Ghana?

The purpose of this research question was to report the prevalence of heat stress and ambulatory hypertension among fish smokers in Ghana. Heat stress and ambulatory blood pressure of fish smokers were measured simultaneously. To better monitor and understand the fishmongers' occupational heat stress levels, various environmental factors were measured in addition to measuring their physiological responses The environmental factors measured included air temperature, humidity, radiant heat and wind speed at the workstations. Through continuous monitoring of these parameters, it determined the Actual Heat Index, which provides a more accurate measure of felt heat levels compared to dry bulb temperature alone.

The environmental heat load data were then correlated with participants' core body temperature, heart rate, sweat rate and other physiological indicators that were measured throughout the workday using portable monitors. This allowed the evaluation of their deep body temperature response to heat over time under varying ambient conditions. The mean scores for heat stress and ambulatory blood pressure readings were calculated for each participant. These were then compared to international standards and benchmarks from organizations like ACGIH, OSHA and EPA to categorise the levels of physical exertion and potential health risks associated with different work activities as light, moderate or heavy.

Specifically, concerning ambulatory blood pressure, participants' 24-hour average readings were ranked according to the established hypertension thresholds from clinical studies. Readings above 135/80 mmHg for the daily average, 140/90 mmHg for awake periods and 124/75 mmHg for sleep were considered elevated. By taking a more integrated ergonomic and physiological monitoring approach, it characterised individual and job-specific heat exposures and related these objectively to health impacts like elevated blood pressure.

Research question 2: What are the differences in heat stress scores during work shift period among fish smokers in the coastal areas of Ghana?

Research question two examined whether differences in heat stress scores (DV) exist because of categories of work shift period. Though the DV was measured on the scale, it violated the homogeneity of variance assumption suitable for one-way analysis of variance, hence, the Kruskal Wallis *H* Test was applied. I checked the shape distributions of the scores in each group to test whether to compare the median of heat stress for the three groups of morning, afternoon, and evening or to compare their mean ranks. The shapes of distributions were different; therefore, the mean ranks were reported. The Chi-Square (X^2), degree of freedom (*df*), and the *P-value* were reported. The pairwise test of Bonferroni adjustments was used to compare the work shift period and the accompanying effect size (η^2) reported.

Research question 3: What are the differences in ambulatory hypertension scores based on working days in the week among fish smokers in the coastal areas in Ghana?

Research question three examined whether differences in ambulatory hypertension scores (DV) exist because of categories of working days in the week. Though the DV was measured on the scale, it violated the homogeneity of variance assumption suitable for one-way analysis of variance; hence, the Kruskal Wallis *H* Test was applied. Moreover, I checked the shape distributions of the scores in each group to test whether to compare the median of ambulatory hypertension for the three groups of 1-2 days, 3-5 days and 5-7 days work in a week or to compare their mean ranks. The shapes of distributions were different; therefore, the mean ranks were reported. The Chi-Square *(X^2),* degree of freedom (*df*) and *P-value* were the statistics reported. Bonferroni adjustments test was used to compare working days in the week and the accompanying η^2 reported.

Research question 4: What socio-demographic and work-related factors are associated with the occurrence of heat stress among fish smokers in the coastal areas of Ghana?

Based on research question four, the occurrence of heat stress among fish smokers was the dependent variable (DV). The DV (heat stress) had three categories (no heat stress, moderate heat stress, and high heat stress). Therefore, multinomial logistic regression was suitable since it allowed modelling with multiple categories as the three categories of heat stress were defined based on scores on a standard heat stress scale. The independent variables were socio-demographic factors (age, gender, education) and work-related factors (experience, workload, access to breaks and water). Before running the multinomial logistic regression, preliminary tests would be conducted. The model fit would be assessed using tests like the likelihood ratio test and Pearson's chi-square test. Significant p-values ($p < 0.05$) in these tests would indicate a good model fit.

The significance of each independent variable in predicting category membership would be determined using p-values and confidence intervals from the regression. Odds ratios would also be reported and interpreted to understand the influence of factors on the likelihood of membership to a given heat stress category compared to the reference category. This would help identify which socio-demographic and work-related characteristics best distinguish between the three heat stress categories experienced by fish smokers.

Research question 5: What socio-demographic and work-related factors are associated with the occurrence of ambulatory hypertension among fish smokers in the coastal areas of Ghana?

Concerning research question five, multinomial logistic regression was conducted to assess the association between socio-demographic and work-related factors, and the occurrence of different categories of ambulatory hypertension among the fish smokers. The dependent variable, ambulatory hypertension, had three categories: normal, pre-hypertension, and hypertension. These categories were defined based on clinical cut-offs from 24-hour ambulatory blood pressure monitoring. The independent variables included socio-demographic factors such as age, gender, and education level, as well as work-related factors like work experience, workload, and access to breaks and water. These were measured as either continuous or categorical variables.

Preliminary model tests fit using the likelihood ratio test and Pearson's chi-square test was performed before conducting the multinomial logistic regression. Good model fit would be indicated by significant p-values less than 0.05 on these tests. The multinomial logistic regression estimated coefficients for each independent variable and reported odds ratios representing the effect on the likelihood of category membership compared to the reference category of normal. It helped to determine the probability of each ambulatory hypertension category occurring in relation to socio-demographic and work-related factors. The significance of independent variables was assessed using p-values and confidence intervals from the model. This analysis identified which specific characteristics best distinguish the three groups in terms of ambulatory blood pressure levels among this occupational population.

Research question 6: What is the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers in the coastal areas of Ghana?

The analysis of the association between ambulatory hypertension and its potential predictors was conducted using multinomial logistic regression. This statistical method was selected as the dependent variable, ambulatory hypertension, consisting of three categories rather than being binary. The dependent variable categories were normal, pre-hypertension, and hypertension. Prior to conducting the main analysis, preliminary tests of model fit using the likelihood ratio test and Pearson's chi-square test were performed. Significant p-values less than 0.05 on these tests would indicate a good model fit. Data were carefully prepared with the dependent variable categorised into three levels and independent variables appropriately formatted.

For nominal independent variables, dummy variables were created to facilitate a more detailed analysis. In SPSS, multinomial logistic regression was performed via the 'Regression' option. Ambulatory hypertension with its three categories was specified as the dependent variable, and socio-demographic factors as well as heat stress levels were included as independent covariates. A reference category was selected for comparison purposes.

The analysis produced model-fitting information and parameter estimates which provided an overview of the model's significance and insights into each covariate's impact on ambulatory hypertension categories. The significance of coefficients indicated the strength and direction of associations between predictors and hypertension levels. Odds ratios derived from coefficients demonstrated how variations in socio-demographic/heat stress factors influenced category classification likelihood. Diagnostic checks focusing on goodness-of-fit ensured model robustness, validating findings while also identifying limitations in understanding covariate effects on the ambulatory hypertension categories.

CHAPTER FOUR

RESULTS AND DISCUSSION

The objectives of this study are to (1) explore the level of workplace heat exposure and ambulatory hypertension, (2) examine differences in heat stress scores based on work shift periods, (3) examine the differences in ambulatory hypertension scores based on working days per week, (4) explore how socio-demographic and work-related factors associate with heat stress (5) examine how socio-demographic and work-related factors associate with ambulatory hypertension, and (6) explore the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers along the coastal cities in Ghana. Chapter Four presents the results and discussions based on the research questions. The chapter first presents the demographic features and proceeds to answer the research questions. The results are discussed in tandem with the previously reviewed literature in Chapter Two.

Characteristics of the Fish Smokers

A total of 2,018 fish smokers, including 25% (n = 504) males, and 75% (n =1,514) females (M= 1.75, SD= 0.433) between 19 and 60 years (average age =39) were involved in this study. Participants have been in the fish smoking work between one and 49 years (with 18 years average). Also, these fish smokers make an average monthly profit of ₵200 to ₵1000, after deducting operational costs and other expenses, a profit margin which varies depending on several factors. The height of the workers indicated that the shortest among them was 1.27m while the tallest was 1.64m, and their weights varied from 42 to 94 kilograms (BMI range between 28.97 and 58.30 kg/m^2).

Ambulatory blood pressure was taken based on the fish smokers' systolic and diastolic blood pressure before, during, and after their daily fish-smoking activities. The average systolic blood pressure before fish smoking was approximately 136.62 mmHg which increased to about 144.29 mmHg during smoking and fell to about 134.93 mmHg after smoking. In addition, the average diastolic blood pressure was 86.32 mmHg before the start of the day's work, and raised to 89.78 mmHg during the day and fell to 85.75 mmHg after work. These figures suggest elevated ambulatory blood pressure which raises concerns for compromise or risk of cardiovascular health among 12.73 of these groups of workers. Besides, their average heart rate (before, during, and after) was 87.28 beats/minute which also raises similar cardio health concerns.

The relative humidity and dew point for heat stress, (measured using the WBGT index), after daily fish smoking was 46.87°C (*SD* =11.38°C) which was 18.68 °C (*SD* = 8.81°C) before the start of the workday. The time-weighted averages between 1.08±0.27 and 2.79±0.40 hours were measured before, during, and after fish smoking. The total time measured was approximately 4.87 hours (SD = 0.52). Many of the participants reported HRI, including symptoms of profuse sweating (28.30%), dehydration (29.60%), headache (50.20%), and weakness/fatigue (64.30%). This indicates that most of these fish smokers cannot properly cool their bodies during fish processing because of the high-temperature environment making it important to take immediate cooling and rehydration measures.

Research Question 1: What is the Level of Heat Exposure and Ambulatory Hypertension among Fish Smokers in the Coastal Areas of Ghana?

This research question aimed to measure the levels of heat stress and ambulatory hypertension among fish smokers along the coastal areas in Ghana. Using the WBGTs and sphygmomanometer, frequency and percentage of heat stress and ambulatory hypertension scores were reported for a total of 2,018 fish smokers. The results, as shown in Table 1, revealed that with an average workplace temperature of 31.11ºC, a 87.6% (n = 1,768) of these fish smokers experienced heat stress, and far more than half, 59.0% (n = 1,190) experienced ambulatory hypertensive with average systolic (144) mmHg and diastolic (90) mmHg blood pressures. Therefore, the majority of the fish smokers in the coastal areas of Ghana are experiencing heat stress and ambulatory hypertension.

Table 1: Level of Heat Stress and Ambulatory Hypertension among Fish Smokers in the Coastal areas of Ghana

	Frequency & Percentages	Mean	SD	Level of Risk
Heat stress:		31.11	1.37	**High**
Heat stressed	1,768 (87.6%)			
Not heat stressed	250 (12.4%)			
Ambulatory hypertension:		S= 144 D= 90	S= 22.36 D= 13.71	**High**
Hypertensive	1,190 (59.0%)			
Non-hypertensive	828 (41.0%)			

***SD** =Standard deviation ****S** =Systolic, **D** =Diastolic

The findings revealed that the majority of the fish smokers in the coastal areas of Ghana are experiencing high levels of heat stress and ambulatory hypertension. This may be a result of the physiological stress experienced when exposed to extremely high temperatures during fish smoking. Heat stress occurs when the body's temperature regulation fails. Unfortunately, inadequate regulation of workplace temperature has the potential to reduce job satisfaction, heightened levels of stress, and an elevated frequency of prolonged sickness-related absenteeism and or reduce productivity at work. Furthermore, the fish smoking process typically involves subjecting the fish to temperatures within the range of 175°F (80°C) to 250°F (121°C) which heightens the level of heat exposure of the fish smoker, depending on other climatic factors and the smoking technique being used.

A reasonable indoor operating temperature is often not lower than 16°C, or 13°C for strenuous work although there is no upper limit for hot environments (Jacklitsch et al., 2016). The work environment along the coast also has an impact on both the relative humidity and heat stress levels. The coastal regions typically exhibit higher relative humidity levels as compared to the inland areas. This is because of the high level of water evaporation in the coastal areas, a process that results in the generation of moisture in the atmosphere (Yang, Zhao, & Oleson, 2023).

Moreover, the movement of air currents facilitates the transportation of water vapour from the ocean to the mainland thereby augmenting the atmospheric humidity along the coastal areas. Thus, coastal regions tend to have an increased relative humidity which can impede the evaporation process of the body of the fish smoker when they are at work. Such a high level of humidity might enhance heat stress in fish smokers because evaporation cools the body, but this is limited due to the high level of relative humidity (Hutagalung, Lawalata, & Hattu, 2022). For example, increased humidity can impede the evaporation of sweat from the skin leading to a rise in core body temperature and increased susceptibility to consequences of heat stress, including heat stroke and other heat-related illnesses during fish smoking or even after work (Obeng et al., 2023).

The study also reveals higher values when comparing the time-weighted average and the WBGTs during the fish smoking process to the threshold limit value guidelines provided by the American Conference of State Industrial Hygienists [ACGIH, 2017] (see Appendix A, Figure 2). The threshold limit value for heat stress is defined as the point at which the core body temperature exceeds 38°C which represents an increase of one degree Celsius above the normal body temperature of 37^0C. As an illustration, fish smoking is considered a moderate level of physical exertion with a rest cycle of 50% to 75%. The findings indicate high levels of heat stress, with mean WBGTs of 31.1±11.37ºC with corresponding threshold limit values of 29.0ºC and the action limit of 26.0ºC, suggesting that fish smokers are exposed to higher levels of heat stress while at work. Likewise, Kakaei et al. (2019) observed an upward trend in the average value of the WBGT index over time. The mean WBGT index for male and female participants was reported as 29.42 and 24.26 °C, respectively. Furthermore, Venugopal et al. (2020) found that a significant majority of workers (82.5%) encountered an elevated heat strain index. The aforementioned evidence necessitates significant attention towards incorporating clothing variables, adjusted weight usage, metabolic ratios, and physical reduction of heat at the source or the smoking area (NIOSH, 2017), to aid these fish smokers in coping with high temperatures.

Heat stress is common among individuals involved in fish fish-smoking business (Adeyeye, 2017). This is because the process involves exposure to high temperatures (Pemberton-Pigott et al., 2016). The symptoms associated with heat stress can range from mild discomfort to severe conditions such as heat exhaustion or heatstroke. Therefore, it is crucial to address heat stress to protect the health and well-being of these fish smokers (Adeyeye, 2017). The high prevalence of heat stress among these fish smokers indicates the urgent need for interventions to mitigate the risks associated with occupational heat exposure among these workers. These interventions may include providing education and training to the fish smokers about heat stress, providing protective clothing and adequate ventilation in smoking areas and promoting regular breaks and increasing hydration to reduce the risk of heat-related illnesses (Flouris et al., 2018). Furthermore, it is essential to raise awareness among employers and policymakers about the health risks faced by fish smokers and to develop and enforce OHS regulations to ensure the protection of these workers.

The findings further indicate a high prevalence of ambulatory hypertension (59.0%) among fish smokers in the coastal areas of Ghana, with a mean systolic and diastolic ambulatory blood pressure of 144±22.36 and 90±13.7 mmHg respectively. This finding corroborates that of Husain et al. (2017) which estimated that the prevalence of ambulatory hypertension among white American workers was 59% (P=0.012). Unfortunately, according to Heather Mpemwangi (2021) the average systolic and diastolic ambulatory blood should not exceed 130/80 mmHg for a 24-hour daytime ambulatory blood pressure (van der Merwe, 2020). Hypertension is a significant risk factor for cardiovascular diseases including heart attacks and strokes (Leyk, 2019). Thus, the observed high prevalence of ambulatory hypertension among these fish smokers suggests an increased risk of cardiovascular morbidity and mortality in this population.

The link between fish smoking and ambulatory hypertension may be attributed to several factors. First, when the body is exposed to high temperatures and heat stress, the blood vessels dilate, allowing more blood to circulate in the body causing a drop in blood pressure levels (Heather Mpemwangi, 2021). However, at chronic exposure to prolonged heat stress, the body may respond naturally to retain more fluid which leads to an increase in blood volume and blood pressure (Weng et al., 2020). Second, evidence suggests that high levels of workplace heat stress can affect the renin-angiotensin-aldosterone system (RAAS) (Rezaei-Hachesu et al., 2022) which plays a crucial role in regulating blood pressure. Heat stress can increase the activity of the RAAS (Rezaei-Hachesu et al., 2022) leading to vasoconstriction (narrowing of blood vessels) which tends to raise blood pressure. Moreover, heat stress can lead to oxidative stress and inflammation which can damage blood vessels and promote the development of hypertension (Cramer & Jay, 2016). Thus, fish smokers who are already predisposed to hypertension as a result of a family history of hypertension, obesity, and diabetes, are especially susceptible to these effects, but at a heightened level because of heat stress from work.

To address the issue of ambulatory hypertension among fish smokers, comprehensive interventions are needed especially, fishmongers with hypertension should take extra precautions to avoid heat stress, such as staying hydrated, wearing loose-fitting light-coloured clothing, and avoiding prolonged exposure to high temperatures during work (Munten et al., 2021). Monitoring blood pressure regularly and working with healthcare practitioners to control hypertension is essential in the fish-smoking industry, especially during times of heat stress. This also calls for the enforcement of OHS standards to promote industry best practices in the fish-smoking sector. The findings underscore the urgent need for interventions to protect the health, safety and well-being of these fish smokers. Similarly, efforts to prevent and manage hypertension among these fish smokers are essential to reduce the risk of cardiovascular diseases, including heart attack and stroke which are increasing among workers (Fitria et al., 2020).

Research Question 2: What are the Differences in Heat Stress Scores During Work Shifts among Fish Smokers in the Coastal Areas of Ghana?

The research question aimed to determine the differences in heat stress scores among fish smokers based on their shift periods. The analysis utilised the Kruskal-Wallis H test to compare the mean ranks of heat stress scores across the morning, afternoon, and evening work shift periods. The results indicated a significant difference in heat stress scores among the three groups ($\chi2 = 103.51$, df = 2, p < .001). Post-hoc analysis using the Bonferroni correction test indicated that fish smokers working during the afternoon shift had significantly higher heat stress scores (1,100.42) than those working at the morning shift (941.35) and the evening shift [982.42] (see Table 2). It is pertinent to highlight that, although the morning and evening shift groups did not exhibit statistically significant differences in their heat stress scores, the evening shift group demonstrated a marginally higher mean rank compared to the morning shift group. Therefore, fish smokers who work during the afternoon shift experience a greater amount of heat stress, which may compromise their health, than those working during the morning and evening shifts.

Table 2: Kruskal-Wallis H Test Results for Heat Stress by Categories of Work Shift Periods among Fish Smokers in the Coastal Areas of Ghana

Groups	N	Mean Rank	df	X^2	Sig	$\eta^2 p$
Morning	468	941.35				
Afternoon	626	1,100.42*	2	103.51	.000	.165
Evening	924	982.42				

The findings of the Kruskal-Wallis H test indicate significant differences in heat stress levels among fish smokers based on their work shift periods. Specifically, fish smokers working during the afternoon shift experienced higher levels of heat stress compared to those working in the morning and evening shifts. The higher heat stress during the afternoon shift can be attributed to the typical high-temperature environment and increased atmospheric temperature, which raises heat stress levels by intensifying the release of ultraviolet (UV) rays. This observation is supported by previous research (De Sario et al., 2023). Although there is no marked difference in heat stress scores between morning and evening shift workers, those working during the evening shift may still experience elevated levels of heat stress, possibly due to the residual impact from the afternoon shift.

These variations in heat stress scores by shift periods have critical implications for the health, safety, and overall well-being of fish smokers. Prolonged exposure to high levels of heat stress can lead to heat-related illnesses and pose significant health risks to workers. Consequently, it is crucial to implement targeted interventions and measures to mitigate heat stress, particularly during the more demanding afternoon shift. Enhancing ventilation and cooling systems in smoking areas can effectively reduce ambient temperature and improve thermal comfort for workers. Promoting micro-breaks in shaded or climate-controlled environments allows workers to rest and recover from heat stress. Equipping workers with appropriate personal protective equipment (PPE), such as lightweight and breathable clothing, can help minimize heat stress and enhance heat dissipation (Afshari et al., 2019). Employers and workers are also encouraged to adjust work schedules to coincide with cooler periods of the day, such as prioritising fish-smoking activities during morning and evening shifts, which are typically associated with lower levels of heat stress compared to afternoon shifts. Such scheduling adjustments not only help reduce the duration and intensity of heat exposure during peak periods but also align with best practices in OHS particularly in high-thermal-demand environments (NIOSH, 2017)

The implications of these findings extend beyond individual worker health and also impact healthcare system practices and policy. By addressing heat stress in occupational settings, healthcare systems can reduce the burden of heat-related illnesses and injuries, leading to improved healthcare practices. Policymakers need to recognise the significance of heat stress and establish guidelines and regulations that prioritize worker safety and well-being. These regulations can ensure that employers provide adequate measures to mitigate heat stress, such as implementing engineering controls, promoting rest breaks, and providing appropriate PPE. Policy interventions can also encourage research and development of innovative solutions to manage heat stress in various industries. Moreover, further research is crucial to explore other potential health hazards in the fish-smoking industry and to develop strategies for health promotion and disease prevention.

Research Question 3: What are the Differences in Ambulatory Hypertension Scores Based on Working Days in the Week among Fish Smokers in the Coastal Areas in Ghana?

The objective of this analysis was to investigate differences in ambulatory hypertension scores among fish smokers in the coastal areas of Ghana, based on the number of days they work in a week. Using the Kruskal-Wallis H test, the mean ranks of ambulatory hypertension scores were compared across three groups: those who worked 1-2 days, 3-5 days, and 5-7 days per week. The results indicated a significant difference in the ambulatory hypertension scores among the three groups ($\chi 2 = 96.04$, df = 2, $p < .001$). As indicated in Table 3, Post-hoc analysis using the Bonferroni adjusted test reveals that fish smokers who worked 3-5 days per week had significantly higher ambulatory hypertension scores (1,020.67 mmHg) compared to those who worked 1-2 days per week (752.77 mmHg). Additionally, fish smokers who worked 5-7 days per week had elevated ambulatory hypertension scores (1,080.63 mmHg) compared to those who worked 1-2 days per week (752.77 mmHg) and 3-5 (1,020.67 mmHg). Therefore, the longer the days these fish smokers work within a week, the higher the likelihood of the severity of ambulatory hypertension among them.

Table 3: Kruskal-Wallis H Test Results for Ambulatory Hypertension by Categories of Working Days in the Week Among Ghanaian Fish Smokers

Groups	n	Mean Rank	df	X^2	*Sig*	$\eta^2 p$
1-2 days	376	752.77				
3-5 days	338	1,020.67	2	96.04	.000	.352
5-7days	1,304	1,080.63				

The effect size of 0.352 points to a moderate to large impact of the number of workdays on ambulatory hypertension scores of the workers. Notably, the ascending trend in mean ranks, from the 1-2 days group to the 5-7 days group suggests that longer working hours correlate with higher ambulatory hypertension scores. This highlights an occupational health risk concerning hypertension conditions in the fish smoking industry. The implementation of effective work scheduling and job rotation is imperative to mitigate these health risks.

Several factors may contribute to the observed differences in ambulatory hypertension scores among fish smokers based on the number of working days. Firstly, prolonged and regular exposure to the smoking process, coupled with occupational stress or fatigue, could systematically increase ambulatory blood pressure levels. The cumulative effect of work hours and consecutive working days potentially exacerbates ambulatory hypertension among these workers (Zhang et al., 2019; Gao et al., 2023). For instance, the physical demands, acclimatization requirements, and environmental factors of the fish smoking occupation, alongside potential exposure to harmful substances during the smoking process, may further contribute to the development of ambulatory hypertension over extended periods (Zhang et al., 2019). Additionally, limited recovery time between workdays might lead to chronic fatigue and a diminished capacity for blood pressure regulation, thereby heightening the risk of hypertension for workers engaged in prolonged, consistent work (Mozos et al., 2019).

These findings align with similar research indicating that prolonged occupational exposure and extended working hours are linked to increased health risks, including hypertension (Luo et al., 2014). The association between the number of working days and the increased prevalence and severity of ambulatory hypertension among fish smokers underscores the necessity for interventions to mitigate the risks associated with prolonged workdays. Implementing work rotation systems that afford sufficient rest and recovery periods may alleviate occupational stress and reduce the risk of ambulatory hypertension for these fish smokers (Ortega et al., 2016; Reichow, 2016). Such interventions can help break the cycle of prolonged exposure and fatigue, allowing workers to recuperate and regulate their blood pressure levels more effectively.

The implications of these findings are significant for worker health, occupational safety, and healthcare system practices. Addressing the risk of ambulatory hypertension among fish smokers requires a comprehensive approach that includes not only work rotation systems but also education and awareness programs to promote healthy lifestyle behaviours and regular medical check-ups. Healthcare systems should prioritise the monitoring and management of ambulatory hypertension in occupational health practices, ensuring that appropriate screening and intervention protocols are in place. Policymakers should consider regulations and guidelines that promote adequate rest and recovery periods for workers in industries with prolonged workdays, aiming to protect worker health and reduce the burden of occupational hypertension.

To support the growth of the fish-smoking industry and ensure its sustainability in providing adequate protein and economic resources, it is crucial to establish and enforce Occupational Health and Safety (OHS) regulations that prioritize the health and well-being of workers. These regulations should encompass provisions for adequate rest breaks, reasonable working hours, and measures to mitigate exposure to harmful substances during the smoking process. Regular blood pressure checks, counselling services, and access to appropriate medical care should be made available to protect and preserve the socio-economic status of the workers while reducing the strain on the healthcare system (Gamage, 2019).

Research Question 4: What Socio-demographic and Work-related Factors are Associated with the Occurrence of Heat Stress among Fish Smokers in the Coastal Areas of Ghana?

This research question aimed to explore how socio-demographic and work-related factors are associated with the occurrence of heat stress among fish smokers in the coastal areas of Ghana. As can be seen in Table 4, the analysis involved examining the bivariate associations between heat stress and the various variables. This analysis revealed significant associations between heat stress and several socio-demographic and work-related factors. For instance, the period of the day was found to be significantly associated with heat stress ($\chi2$ = 8.319, p = 0.016), fish smokers who worked during the afternoon showed a higher prevalence of heat stress compared to those who worked during the morning or evening shifts. Moreover, gender was significantly associated with heat stress ($\chi2$ = 10.178, p = 0.001), with female fish smokers reporting higher heat stress scores (64.7%) compared to males (22.9%). Income ($\chi2$ = 24.472, p < 0.001), level of education ($\chi2$ = 21.472, p < 0.001), marital status ($\chi2$ = 80.438, p < 0.001), alcohol use ($\chi2$ = 35.243, p < 0.001), caffeine intake ($\chi2$ = 7.931, p

= 0.005), and water intake ($\chi2$ = 15.366, $p < 0.001$) were all significantly associated with heat stress. However, age, clothing (PPE), years of working, and working under shade did not show significant associations with heat stress among these workers. These results permitted further analysis using hierarchical multiple binary logistic regression.

The second level analysis, using hierarchical multiple binary logistic regression, as illustrated in Table 5, revealed that in Model 1 age, gender, income, and level of education were entered as predictors, while marital status, alcohol use, and caffeine intake entered Model 2. Finally, model 3 included years of working, period of the day, water intake, clothing (PPE), and working under shade. The results revealed that in model 1, female fish smokers recorded higher odds of experiencing heat stress compared to males (Adjusted Odd Ratio [AOR] = 2.132, $p < 0.001$). In model 2, being divorced (AOR = 3.775, $p < 0.001$), unmarried (AOR = 3.876, $p < 0.001$), former drinker (AOR = 4.105, $p < 0.001$), or a current drinker (AOR = 3.639, $p < 0.001$), and did not consume caffeine (AOR = 2.644, $p < 0.001$) had higher odds of heat stress. In model 3, fish smokers who did not consume water (AOR = 0.209, $p < 0.001$) and those working without shade recorded fewer odds of experiencing heat stress (AOR = 0.299, $p < 0.001$). Lastly, compared to working in the morning shift, working in the afternoon was associated with higher odds of heat stress (AOR = 1.639, $p = 0.045$). The overall model fit improved across the three models, as indicated by the increase in the pseudo-R-squared values. The final model (Model 3) accounted for 24.3% of the variance in heat stress, suggesting that the included socio-demographic and work-related factors have a substantial influence on heat stress among these fish smokers.

Table 4: Bivariate Association of Heat Stress and Socio-demographic and Work-Related Factors

Variable	Categories	Heat stress Yes	No	X^2	Phi	P-Value
Period of the day				**8.319**	**0.064**	**0.016**
	Morning	428(91.5%)	40(8.5%)			
	Afternoon	540 (86.3%)	86 (13.7%)			
	Evening	800(86.6%)	250(13.7%)			
Age				**0.002**	**-0.001**	**0.961**
	40 years or less	874 (87.6%)	124 (12.4%)			
	41+ years	894 (87.6%)	126 (12.4%)			
Gender				**10.178**	**0.071**	**0.001**
	Male	46(91.7%)	42 (8.3%)			
	Female	1306 (86.3%)	208 (13.7%)			
Income				**24.472**	**-0.110**	**0.000**
	GHS 500 or less	594 (82.7%)	124 (17.3%)			
	GHS > 500	1174 (90.3%)	126 (9.7%)			
Level of Education				**21.472**	**0.103**	**0.000**
	Formal Education	856 (91.3%)	82 (8.7%)			
	No Formal Education	912(84.4%)	168 (15.6%)			
Marital Status				**80.438**	**0.200**	**0.000**
	Married	1062 (92.7%)	84 (7.3%)			
	Divorced	252 (75%)	84 (25.0%)			
	Unmarried	454 (84.7%)	82 (15.3%)			
Alcohol Use				**35.243**	**0.132**	**0.000**
	Never drinker	598 (93.7%)	40(6.3%)			
	Former drinker	632(83.4%)	126(16.6%)			
	Current drinker	538(86.5%)	84(13.5%)			
				7.931	**0.063**	**0.005**
Caffeine						
	YES	1008(90.0%)	166(14.1.%)			
	NO	760(90.0%)	84(10.0%)			

Variable	Categories	Heat stress Yes	No	X^2	Phi	P-Value
				2.127	**0.032**	**0.145**
Years of Working						
	1-10 years	664(89.0%)	82 (11.0%)			
	11-25 years	1104 (86.8%)	168 (13.2%)			
Water Intake				**15.366**	**-0.087**	**0.000**
	YES	636(83.9%)	122(16.1%)			
	NO	1132(89.8%)	128(10.2%)			
Clothing (PPE)				**0.003**	**-0.001**	**0.959**
	No Protection	888(87.6%)	126(12.4%)			
	Protective Clothing	880(87.6%)	124 (12.4%)			
Working under shade				**0.147**	**-0.009**	**0.701**
	YES	854(87.3%)	124(12.7%)			
	NO	914(87.9)	126(12.1%)			

Table 5: Hierarchical Multiple Binary Logistic Regression of Socio-demographic and Work-Related Factors as Predictors of Heat Stress

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Model 3 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)	
			Lower	Upper			Lower	Upper			Lower	Upper
Age												
40 years or less	1				1				1			
41+ years	1.006	0.971	0.730	1.387	1.042	0.806	0.748	1.452	1.599	0.052	0.996	2.567
Gender												
Male	1				1				1			
Female	2.132	0.000	1.425	3.189	2.196	0.000	1.467	3.288	3.035	0.000	1.902	4.845
Income												
GHS 500 or less	1				1				1			
GHS > 500	0.655	0.110	0.474	0.906	0.524	0.000	0.369	0.746	1.080	0.741	0.684	1.705
Level of your highest education												
Formal Education	1				1				1			
No Formal Education	2.102	0.000	1.522	6.524	2.008	0.000	1.456	2.788	1.955	0.000	1.387	2.756
Marital Status												
Married	1				1				1			
Divorced	3.775	0.000	2.563	5.560	4.129	0.000	2.759	6.181	9.952	0.000	5.950	16.644
Unmarried	3.876	0.000	2.446	6.140	4.238	0.000	2.664	6.743	7.059	0.000	4.086	12.196
Alcohol Use												
Never drinker	1				1				1			
Former drinker	4.105	0.000	2.583	6.524	3.079	0.000	1.910	4.964	7.886	0.000	4.327	14.373
Current drinker	3.639	0.000	2.230	5.939	4.189	0.000	2.556	6.865	8.325	0.000	4.504	15.388
Caffeine intake												
YES	1				1				1			
NO	2.644	0.000	1.849	3.781	3.916	0.000	2.615	5.864	7.133	0.000	4.338	11.727

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Model 3 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)	
			Lower	Upper			Lower	Upper			Lower	Upper
Years of Working												
1-10 years					1				1			
11-25 years					2.262	0.000	1.555	3.289	3.590	0.000	2.280	5.653
Period of the day												
Morning					1				1			
Afternoon					1.639	0.045	1.011	2.656	4.209	0.000	2.293	7.725
Evening					1.228	0.386	0.772	1.952	2.166	0.005	1.262	3.715
Water Intake												
YES									1			
NO									0.209	0.000	0.132	0.333
Clothing (PPE)												
No Protection									1			
Protective Clothing									0.953	0.806	0.650	1.397
Working under shade												
YES									1			
NO									0.299	0.000	0.179	0.500
Pseudo R^2 Nagelkerke	**0.168**				**0.184**				**0.243**			

The higher prevalence of heat stress among female fish smokers, as observed in the study from Table 4, suggests potential gender differences in vulnerability to heat-related health issues. Several factors may contribute to this disparity.

Physiological differences between males and females can play a role in heat stress susceptibility. For instance, women generally have a higher body fat percentage compared to men, which can affect heat dissipation and make them more vulnerable to heat stress (Charkoudian & Stachenfeld, 2014). Hormonal differences, such as variations in estrogen levels, can also impact thermoregulation in women (Charkoudian & Stachenfeld, 2014). These physiological differences may make female fish smokers more susceptible to heat stress compared to their male counterparts.

Clothing choices can also influence heat stress levels. In some industries, including fish smoking, women may have different clothing options compared to men. Women may be more likely to wear clothing that provides less ventilation and thermal comfort, such as long sleeves or heavy garments, due to cultural or modesty considerations. These clothing choices can contribute to increased heat stress levels (Kjellstrom et al., 2018).

Variations in work tasks performed by males and females could also contribute to differences in heat stress levels. For example, if certain tasks are more physically demanding or involve higher heat exposure, female fish smokers who perform these tasks may experience higher levels of heat stress compared to males. Additionally, differences in work organization or job assignments could impact exposure to heat and subsequent heat stress levels (Parsons, 2019).

The occupation of smoking fish is predominantly pursued by females (Olapade et al., 2021). In addition, the high prevalence of heat stress among female fish smokers can be influenced by cultural norms, historical trends, and individual choices. In certain cultures, fish smoking may be traditionally associated with women (Adeyeye, 2017). This cultural connection can impact vocational preferences and skill development, leading to increased female participation in the field. Furthermore, in specific cultural contexts, women may acquire expertise in fish smoking through intergenerational transmission, relying on familial knowledge for the occupation (Olapade et al., 2021). These cultural factors can contribute to the higher heat stress observed among female fish smokers and underline the importance of considering cultural influences when addressing heat stress in this population.

Many other factors including marital status, alcohol use, and caffeine intake were identified as significant predictors of heat stress among the fish smokers. The elevated odds of heat stress among divorced or unmarried fish smokers may be linked to the absence of social support or an increased likelihood of engaging in riskier behaviours. This reemphasises the interactions between social relations and work-related determinants of the health and well-being of workers. Marital status affects fish smoking differently based on cultural, economic, and personal reasons (Adeyeye, 2017). According to Olapade et al. (2021), divorced or unmarried women may not experience collaborative participation in family-run enterprises through marriage relations.

The factors of marital status, division of labour within a marital partnership, financial implications, and social networks can potentially influence the experience of heat stress among workers in the fish-smoking industry. The division of labour between partners can impact the level of participation and heat exposure for each individual.

Financial responsibilities associated with marriage may lead workers to prioritize the well-being of their family unit over their own health, potentially continuing to work in conditions that expose them to heat stress. Additionally, being married can provide access to social networks that offer support, resources, and knowledge sharing on managing heat stress. These networks can introduce individuals to contacts, clients, and business partners who can contribute to the development of the fish-smoking enterprise, potentially leading to improvements in working conditions and measures to address heat stress. While the validity of these arguments may vary, further research is needed to establish the specific influence of these factors on heat stress experiences among fish-smoking workers.

Alcohol use and caffeine intake may contribute to dehydration, impaired thermoregulation, or influence behaviour in ways that increase the likelihood of heat stress (Kenefick & Cheuvront, 2016). Hence, providing access to clean drinking water and promoting awareness of its importance can help mitigate heat stress among these fish smokers. Alcohol and caffeine are diuretics that can dehydrate, worsen heat stress, and compromise the cardiovascular health of workers (Nerbass et al., 2017). The impact of alcohol and caffeine on heat stress can vary based on several factors, including the quantity consumed, an individual's tolerance, level of hydration, and climatic conditions.

It is recommended to limit the intake of alcohol and caffeine, particularly during periods of high temperatures (Tan & Lee, 2015), and to give precedence to hydration by drinking a lot of water or fluid to prevent heat stress. Therefore, water intake and working under shade become alternatives to protect the workers against heat stress (Nerbass et al., 2017). Also, adequate hydration is crucial for maintaining thermal equilibrium and preventing heat-related illnesses (NIOSH, 2017).

Furthermore, the finding indicates that fish smokers who do not drink water and work without shade are less likely to experience heat stress. This suggests that staying hydrated and having shade could help the body manage heat better in this group. However, it is crucial to remember that correlation does not mean causation (Barrowman, 2014), and there might be other factors such as dietary patterns or genetic predispositions, influencing these associations which were not considered in the present study (Glaser et al., 2016).

Working under shade can reduce direct exposure to ultraviolet (UV) rays and minimise heat absorption thereby lowering the risk of heat-related illnesses (Parisi & Turnbull, 2014). Although the task of working under a shade to prevent heat stress can present certain difficulties, shade has a significant impact on heat stress, provides relief from direct UV rays, and lowers the ambient temperature. Thus, shades create a cooler microclimate by reducing the air temperature and decreasing radiant heat in the shaded area thereby increasing the thermal comfort of the fish smokers (Rahman et al., 2021).

Furthermore, shade offers psychological relief and a feeling of comfort in hot environmental conditions (Morabito et al., 2020). The cognitive experience of perceiving a cooler environment can have a beneficial effect on an individual's psychological state and enhance their ability to manage the physiological strain of heat exposure (Gillerot et al., 2024). It is noteworthy that although shade can alleviate the effects of heat stress, it does not eliminate the necessity of implementing additional preventative measures, including drinking a lot of water, reducing sodium intake, and wearing light clothes in hot periods, among others.

The higher prevalence of heat stress among female fish smokers, as observed in the study, suggests potential gender differences in vulnerability to heat-related health issues. Several factors may contribute to this disparity, including physiological differences, clothing choices, work tasks, cultural factors, marital status, alcohol use, and caffeine intake. These findings have implications for workers, the healthcare system, and policy in terms of health promotion. Workers need to prioritise their health and safety, implement strategies to minimise heat exposure, receive education on preventive measures, and seek medical assistance if needed. The healthcare system should raise awareness, provide guidance, offer medical assistance, and collaborate with occupational health services. Policy interventions can be informed by the identified predictors of heat stress, setting regulations, providing training, and emphasising monitoring weather forecasts and heat advisories. The aim is to promote worker health, reduce the burden of heat stress, and create safer working conditions in the fish-smoking industry, benefiting both workers and the overall healthcare system.

Research Question 5: What Socio-demographic and Work-Related Factors are Associated with the Occurrence of Ambulatory Hypertension among Fish Smokers in the Coastal Areas of Ghana?

The purpose of this research question was to determine the influence of socio-demographic and work-related factors on the occurrence of ambulatory hypertension among fish smokers in coastal areas of Ghana. As can be seen in Table 6, the bivariate analysis indicated significant associations between several socio-demographic variables and systolic and diastolic ambulatory hypertension. There was a statistically significant association between the period of the day and systolic ambulatory hypertension ($\chi^2 = 26.402$, $p < 0.001$), where evening, 552(59.7%), and afternoon, 292(46.6%), workers were more likely to have higher systolic ambulatory hypertension than morning workers (56.4%). However, participants' diastolic blood pressure ($\chi^2 = 69.827$, $p = 0.186$) remained stable during daytime work. This suggests that the participants did not experience significant changes in this cardiovascular parameter. This may be due to the nature of their work tasks not exerting enough stress or physical exertion to impact diastolic blood pressure (Parsons, 2019).

Additionally, the participants may have developed effective coping mechanisms or adaptation to work-related stressors (Habib et al. 2021). However, it is important to consider other cardiovascular indicators and conduct long-term monitoring to fully evaluate the participants' cardiovascular health (Glaser et al., 2016). Further research and regular check-ups are needed to ensure the well-being of workers in similar contexts. Also, participants aged 41 years and above had significantly higher odds of having higher ambulatory hypertension compared with those aged 40 or less (systolic: $\chi^2 = 359.717$, $p < 0.001$; diastolic: $\chi^2 = 235.259$, $p < 0.001$). In addition, female fish smokers had higher odds of ambulatory hypertension compared to the males (systolic: $\chi^2 = 40.104$, $p < 0.001$; diastolic: $\chi^2 = 39.192$, $p < 0.001$). Moreover, fish smokers with income greater than GHS 500 recorded a higher odd of ambulatory hypertension compared to those with income of GHS 500 or less (systolic: $\chi^2 = 9.962$, $p = 0.002$; diastolic: $\chi^2 = 22.450$, $p < 0.001$).

Several other factors provide a significant association with ambulatory hypertension among these fish smokers. For instance, participants with no formal education recorded higher odds of ambulatory hypertension compared with those with formal education (systolic: $\chi^2 = 72.585$, $p < 0.001$; diastolic: χ^2

= 18.550, $p < 0.001$). Besides, unmarried participants had significantly higher odds of ambulatory hypertension compared with those who are married or divorced (systolic: $\chi^2 = 300.225$, $p < 0.001$; diastolic: $\chi^2 = 217.234$, $p < 0.001$). Moreover, alcohol use was significantly associated with a higher score of ambulatory hypertension (systolic: $\chi^2 = 69.954$, $p < 0.001$; diastolic: $\chi^2 = 85.202$, $p < 0.001$) with both former and current drinkers showing higher odds of ambulatory hypertension as compared with non-drinkers. Also, caffeine consumption showed a significant association with diastolic ambulatory hypertension ($\chi^2 = 10.311$, $p = 0.001$), but not systolic ambulatory hypertension ($\chi^2 = 0.521$, $p = 0.470$). Furthermore, years of working was significantly associated with systolic ambulatory hypertension ($\chi^2 = 18.494$, $p < 0.001$), but not diastolic ambulatory hypertension ($\chi^2 = 2.251$, $p = 0.134$), thus, participants with 11-25 years of working experience had higher odds of systolic ambulatory hypertension compared with those working 1-10 years.

The results further indicated that water intake was strongly associated with diastolic ambulatory hypertension ($\chi^2 = 83.215$, $p < 0.001$), but not with systolic ($\chi^2 = 3.609$, $p = 0.058$), and participants who consumed less than two litres of water per day had higher odds of diastolic ambulatory hypertension compared with those who consumed 2 litres or more. The smoking status also showed a significant association with systolic ambulatory hypertension ($\chi^2 = 38.220$, $p < 0.001$) but not with diastolic ambulatory hypertension ($\chi^2 = 1.043$, $p = 0.307$), with current smokers having higher odds of systolic ambulatory hypertension compared with the non-smokers. Also, fish smokers with recorded overweight or obesity had a 25% increase in ambulatory hypertension compared with those with normal BMI (systolic: $\chi^2 = 78.412$, $p < 0.001$; diastolic: $\chi^2 = 89.598$, $p < 0.001$). For instance, participants classified as overweight had a 1.5

times higher risk of ambulatory hypertension, while participants classified as obese had a 2 times higher risk compared with those with a normal BMI.

Further analysis was performed using hierarchical multiple binary logistic regression, as presented in Tables 7 and 8, to examine the relationship between socio-demographic and work-related factors and ambulatory hypertension. This analysis, encompassing three models, revealed that individuals aged over 41 years showed a significantly lower risk of ambulatory hypertension, evidenced by the AORs under 1 and p-values ($p < 0.001$) across all models. This finding is contrary to the commonly held belief that hypertension risk increases with age. In contrast, female participants in the study were found to have a significantly higher risk of ambulatory hypertension than males, as demonstrated in Model 1 (AOR = 3.065), Model 2 (AOR = 3.630), and Model 3 (AOR = 2.702), all with P-values of 0.001.

The unexpected inverse relationship between age and hypertension risk in this cohort calls for further investigation. It suggests that there may be underlying factors at play that contribute to this phenomenon. One possibility is that younger individuals are more exposed to certain risk factors associated with hypertension, such as unhealthy lifestyle behaviours or occupational stress (Xiang et al. 2014). On the other hand, it is also possible that older individuals have developed more effective strategies for managing hypertension, such as medication adherence or lifestyle modifications (Yue et al., 2024).

Additionally, factors like acclimatisation to certain environmental conditions or differences in risky behaviours among different age groups may also contribute to this unexpected relationship. This aligns with Raina et al., (2022) observation on the often-overlooked prevalence of hypertension in young adults, a significant global health concern. Factors such as smoking, obesity (Seravalle & Grassi, 2024), alcohol consumption (Nunfam et al., 2019), obesity (Seravalle & Grassi, 2024), sedentary lifestyle (Zhang et al. 2019), high salt intake (Poggio et al., 2016), illiteracy, ignorance about illnesses (Busingye et al., 2019) and societal gender biases (Zhang et al. 2019) have been identified as key contributors to hypertension risk in this demographic.

The study also highlights the increased susceptibility of women to ambulatory hypertension, pointing to the necessity of exploring gender-specific health issues and potentially contributing factors like hormonal differences, stress levels, work-life balance, and societal dynamics. This underlines the need for targeted health interventions and educational initiatives for women. However, the influence of unaddressed confounding factors, including lifestyle choices, genetic predispositions, and environmental conditions, should be considered. Han et al. (2022 noted the higher propensity for hypertension in women with subclinical hypothyroidism, possibly due to unique sex-related physiological changes. Zhang et al. (2019) emphasised the role of behavioural, environmental, and social factors in hypertension in sub-Saharan Africa, influenced by variables like age, sex hormones, and lifestyle.

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Table 6: Bivariate Association of Socio-demographic and Work-related Factors with Ambulatory Hypertension

Variable	Systolic High	Normal	X^2	Phi	P-Value	Diastolic High	Normal	X^2	Phi	P-Value
Period of the day			**26.402**	**0.11**	**0.000**			**69.827**	**0.186**	**0.000**
Morning	264(56.4%)	204(43.6%)				264(56.4%)	204(43.6%)			
Afternoon	292(46.6%)	334(53.4%)				208(33.2%)	418(66.8%)			
Evening	552(59.7%)	372(40.3%)				470(50.9%)	454(49.1%)			
Age			**359.717**	**-0.422**	**0.000**			**235.259**	**-0.341**	**0.000**
40 years or less	336(33.7%)	662(66.3%)				294(29.5%)	704(70.5%)			
41+ years	772(75.7%)	248(24.3%)				648(63.5%)	372(36.5%)			
Gender			**40.104**	**0.141**	**0.000**			**39.192**	**0.139**	**0.000**
Male	338(67.1%)	166(32.9%)				296(58.7%)	208(41.3%)			
Female	770(50.9%)	744(49.1%)				646(42.7%)	868(57.3%)			
Income			**9.962**	**0.070**	**0.002**			**22.450**	**0.105**	**0.000**
GHS 500 or less	428(59.6%)	290(40.4%)				386(53.8%)	332(46.2%)			
GHS > 500	680(52.3%)	620(47.7%)				556(42.8%)	744(57.2%)			
Level of your highest education			**72.585**	**0.190**	**0.000**			**18.550**	**0.096**	**0.000**
Formal Education	610(65.0%)	328(35.0%)				486(51.8%)	452(48.2%)			
No Formal Education	498(46.1%)	582(53.9%)				456(42.2%)	624(57.8%)			
Marital Status			**300.225**	**0.386**	**0.000**			**217.234**	**0.328**	**0.000**
Married	774(67.5%)	372(32.5%)				692(60.4%)	454(39.6%)			
Divorced	210(62.5%)	126(37.5%)				126(37.5%)	210(62.5%)			
Unmarried	124(23.1%)	412(75.9%)				124(23.1%)	412(76.9%)			
Alcohol Use			**69.954**	**0.186**	**0.000**			**85.202**	**0.205**	**0.000**
Never drinker	436(683%)	202(10.0%)				394(61.8%)	244(38.2%)			
Former drinker	382(50.4%)	376(49.6%)				300(39.6%)	458(60.4%)			
Current drinker	290(46.6%)	332(53.4%)				248(39.9%	374(60.1%)			

Variable	Systolic High	Normal	X^2	Phi	P-Value	Diastolic High	Normal	X^2	Phi	P-Value
Caffeine			**10.311**	**-0.071**	**0.001**			**0.521**	**-0.016**	**0.470**
YES	428(50.7%)	680(57.9%)				386(45.7%)	458(54.3%)			
NO	680(57.9%)	494(24.1%)				556(47.4%)	618(52.6%)			
Years of Working			**18.494**	**0.096**	**0.000**			**2.251**	**-0.033**	**0.134**
1-10 years	456(61.1%)	290(39.9%)				332(44.5%)	414(55.5%)			
11-25 years	652(51.3%)	620(48.7%)				610(48.0%)	662(52.0%)			
Water Intake			**152.807**	**0.275**	**0.000**			**201.763**	**0.316**	**0.000**
YES	550(72.5%)	208(27.4%)				502(67.0%)	250(33.0)			
NO	558(44.3%)	702(55.7%)				434(34.4%)	826(65.6%)			
Clothing (PPE)			**125.603**	**0.249**	**0.000**			**57.088**	**0.168**	**0.000**
No Protection	682(67.3%)	332(32.7%)				558(55.0%)	456(45.0%)			
Protective Clothing	426(42.4%)	578(57.8%)				384(38.2%)	620(61.8%)			
Working under shade			**1.350**	**-0.026**	**0.245**			**36.288**	**0.134**	**0.000**
YES	524(53.6%)	454(46.4%)				524(53.6%)	454(46.4%)			
NO	584(56.2%)	456(43.8%)				418(40.2%)	622(59.8%)			

Table 7: Hierarchical Multiple Binary Logistic Regression of Socio-demographic and Work-Related Factors with Systolic-Ambulatory Hypertension

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 3 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper
Age												
40 years or less	1				1				1			
41+ years	0.082	0.000	0.061	0.110	0.079	0.00	0.058	0.106	0.018	0.000	0.010	0.031
Gender												
Male	1				1				1			
Female	3.065	0.000	2.148	4.375	3.630	0.000	2.478	5.318	2.702	0.000	1.682	4.339
Income												
GHS 500 or less	1				1				1			
GHS > 500	3.090	0.000	2.281	4.186	2.530	0.000	1.829	3.500	1.366	0.175	0.871	2.144
Level of your highest education												
Formal Education	1				1				1			
No Formal Education	2.943	0.00	2.243	3.861	3.342	0.000	2.536	4.405	3.884	0.000	2.762	5.461
Marital Status												
Married	1				1				1			
Divorced	0.988	0.988	0.680	1.435	1.202	0.377	0.788	1.807	0.547	0.009	0.348	0.861
Unmarried	16.112	0.000	10.882	23.855	23.892	0.000	15.559	36.687	357.773	0.000	651.859	771.749
Alcohol Use												
Never drinker	1				1				1			
Former drinker	20.783	0.000	13.011	33.198	17.241	0.000	10.555	28.163	31.829	0.000	15.966	63.454
Current drinker	18.290	0.000	12.174	27.479	26.546	0.000	16.873	41.765	78.282	0.000	41.343	148.228
Caffeine												
YES	1				1				1			
NO	1.540	0.000	1.127	2.103	2.439	0.000	1.732	3.436	3.207	0.000	2.085	4.339

Variable	Model 1				Model 2				Model 3			
	Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)	
			Lower	Upper			Lower	Upper			Lower	Upper
Period of the day												
Morning					1				1			
Afternoon					3.054	0.000	1.882	4.955	2.445	0.024	1.125	5.311
Evening					1.038	0.849	0.705	1.529	1.838	0.058	0.979	3.452
Years of Working												
1-10 years					1				1			
11-25 years					3.060	0.000	2.204	4.249	1.783	0.006	1.185	2.683
Water Intake												
YES									1			
NO									31.434	0.000	17.123	57.709
Clothing (PPE)												
No Protection									1			
Protective Clothing									3.200	0.000	2.191	4.673
Working under shade												
YES									1			
NO									7.177	0.000	4.267	12.072
Pseudo R^2 Nagelkerke	**0.557**				**0.576**				**0.695**			

Table 8: Hierarchical Multiple Binary Logistic Regression of Socio-demographic and Work-Related Factors with Diastolic AMHPT

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 3 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper
Age												
40 years or less	1				1				1			
41+ years	0.132	0.000	0.101	0.174	0.129	0.000	0.098	0.170	0.007	0.000	0.003	0.013
Gender												
Male	1				1				1			
Female	3.006	0.000	2.231	4.049	2.964	0.000	2.201	3.990	2.339	0.000	1.614	3.389
Income												
GHS 500 or less	1				1				1			
GHS > 500	3.978	0.000	2.977	5.316	4.110	0.00	3.068	5.506	2.292	0.000	1.499	3.506
Level of your highest education												
Formal Education	1				1				1			
No Formal Education	1.356	0.014	1.063	1.730	1.338	0.020	1.047	1.709	0.635	0.003	0.469	0.861
Marital Status												
Married	1				1				1			
Divorced	3.848	0.000	2.714	5.456	3.673	0.000	2.581	5.229	4.101	0.000	2.654	6.337
Unmarried	11.762	0.000	8.219	16.832	11.118	0.000	7.733	15.983	215.134	0.000	103.167	448.616
Alcohol Use												
Never drinker	1				1				1			
Former drinker	6.481	0.000	4.369	9.614	7.024	0.000	4.689	10.523	11.292	0.000	6.236	20.448
Current drinker	6.866	0.000	4.881	9.656	6.630	0.000	4.718	9.318	16.556	0.000	9.515	28.808

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper	Model 3 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI) Lower	Upper
Caffeine												
YES	1				1				1			
NO	1.724	0.000	1.300	2.285	1.581	0.003	1.170	2.136	1.975	0.001	1.308	2.981
Period of the day												
Morning					1				1			
Afternoon					4.123	0.000	2.704	6.285	3.746	0.000	1.981	7.084
Evening					1.579	0.010	1.115	2.235	2.241	0.003	1.318	3.810
Years of Working												
1-10 years					1				1			
11-25 years					0.794	0.098	0.604	1.043	0.093	0.000	0.055	0.159
Water Intake												
YES									1			
NO									27.784	0.000	16.732	46.138
Clothing (PPE)												
No Protection									1			
Protective Clothing									1.167	0.407	0.810	1.681
Working under shade												
YES									1			
NO									66.42	0.000	38.806	127.235
Pseudo R^2 Nagelkerke	**0.472**				**0.473**				**0.686**			

The study identified several factors associated with the occurrence of ambulatory hypertension among these fish smokers in the coastal areas of Ghana. These factors included age, gender, income, education, marital status, alcohol use, caffeine consumption, years of working, water intake, smoking status, and BMI. Specifically, age influences the development of ambulatory hypertension (Sanchez et al., 2022), because hypertension tends to increase with age. As individuals get older, the likelihood of developing high blood pressure rises. This can be attributed to several factors including changes in blood vessel elasticity, increased arterial stiffness, and age-related physiological changes. Thus, older fish smokers may be more prone to the white coat effect (Olapade et al., 2021) which raises blood pressure during clinic visits and causes a non-dipping pattern during sleep. Non-dipping blood pressure increases cardiovascular risk, ambulatory hypertension (Yu et al., 2020) and comorbidities. It is important to monitor and manage blood pressure effectively among these older fish smokers to reduce their cardiovascular risk, and complications, including death and associated burden on the healthcare system.

Gender differences in blood pressure trends may have an impact on ambulatory hypertension. Men tend to be diagnosed with hypertension at an earlier age and a higher prevalence than women (Baxter et al., 2024; Campbell et al., 2023). Menopausal hormone changes may have a role in hypertension in women, as women make up the majority of those affected in the study (Michos et al., 2024).

Furthermore, the complex interactions of income, education, and marital status can influence hypertension. For instance, lower levels of income are often associated with a higher prevalence of hypertension (Nerbass et al., 2017) and higher stress-dehydration symptoms (Jayasekara et al., 2019). Thus, there is a positive correlation between lower levels of education and an increased risk of developing ambulatory hypertension, because education is a leading factor to income levels.

Fish smokers with limited health education may have difficulty understanding ambulatory hypertension, the risk factors associated with it, and the needed lifestyle changes and medication adherence required. Fish smoker education increases access to supplemental health resources, and those with higher levels of education tend to exhibit healthier behaviours and undergo regular medical check-ups, leading to better control of their blood pressure. Thus, the more education, the better the awareness and the lower the risk of occupational hazards among many groups of workers (Olapade et al., 2021).

Moreover, marriage and or long-term relationships are linked to greater health, including decreased hypertension rates. This may be because marital support provides additional emotional stability and shared resources can reduce stress and improve lifestyle, and associated health. However, being unmarried, divorced, or widowed raises stress, and social isolation, with an associated propensity for ambulatory hypertension and cardiovascular health, perhaps, because of other associated factors including alcohol consumption and tobacco smoking.

Alcohol use, caffeine consumption, water intake, smoking, and BMI do influence ambulatory hypertension of workers. The consumption of alcohol, caffeine, and smoking are contributing factors to the development of hypertension (Fitria et al., 2020), and the more these actions are taken, the higher the likelihood of developing hypertension. The consumption of alcohol, caffeine, and smoking has been found to have a direct impact on elevating blood pressure levels, causing harm to blood vessels, and hindering the efficacy of blood pressure medications (Edward & Periasamy, 2019; Vallée, 2023). It is advisable to limit alcohol consumption to moderation or abstain from it entirely, particularly fish smokers who are also at risk of developing hypertension.

Water intake aids in the regulation of blood pressure because dehydration elevates blood pressure. Water in the body supports blood volume and kidney function which regulates blood pressure. Therefore, it is advisable to drink enough water to remain hydrated, especially in hot weather like fish smoking or when exercising (Nerbass et al., 2017). Such severe dehydration is associated with ambulatory blood pressure which is also associated with a high BMI. However, the link between fish smoking, BMI and ambulatory hypertension has not been conclusive and may depend on a wide range of individual characteristics, such as overall dietary and lifestyle behaviours.

Obesity can cause hormonal imbalances, insulin resistance, and inflammation that increase blood pressure (Martins et al., 2014). Therefore, healthy eating, exercise, and weight management prevent and control high blood pressure. Adopting a healthy lifestyle including drinking alcohol in moderation, staying well-hydrated, not smoking, and keeping a healthy BMI control blood pressure to improve heart health. Though the number of years of working is not a direct predictor of ambulatory hypertension in this study, understanding this association can help inform targeted preventive strategies to reduce the risk of hypertension in this population. Thus, attention to heat stress-associated hypertension among workers who work in high temperatures is urgently needed, especially when the general atmospheric temperatures continue to rise (Habib et al., 2021). Such conditions will not only impose health and economic costs on the workers but also escalate the burden on healthcare, including an increased demand for experts who may be overloaded with professional duties.

Research Question 6: What is the Extent to which Worker Socio-demographic Variables and Heat Stress Scores Predict Ambulatory Hypertension among Fish Smokers in the Coastal Areas of Ghana?

This research question aimed to explore the predictive relationship between socio-demographic factors, heat stress, and ambulatory hypertension among fish smokers, utilising hierarchical multiple linear regression analysis. The focus is primarily on the predictive power of heat stress, considering the analyses of research questions four and five have addressed the impact of socio-demographic variables on ambulatory hypertension. Despite employing a similar analytical approach, as indicated in Tables 9 and 10, the emphasis of this research question is distinct.

The analysis reveals a significant negative correlation between heat stress and ambulatory hypertension levels, with an odds ratio (OR) of 0.271 ($p < 0.001$, 95% CI: 0.193 to 0.381). This finding is contrary to prevailing expectations. Model fit evaluation using Pseudo R2 Nagelkerke shows an incremental increase from Model 1 (0.392) to Model 2 (0.420), suggesting a modest enhancement in explanatory power with the inclusion of heat stress. Contrary to typical associations between stress and increased blood pressure, the results indicate that higher heat stress might reduce the risk of ambulatory hypertension in this occupational group.

Despite the methodological rigour of the study, the high prevalence of hypertension (87.6%) among participants underscores a critical occupational health issue (O’Brien et al., 2013). This prevalent concern warrants attention independently of the study's primary results. Due to the correlational design of the study, causal inferences cannot be conclusively drawn. The lack of control for potential confounders, such as dietary habits or genetic predispositions, necessitates a cautious interpretation of these results (Glaser et al., 2016). Confounding variables, when correlated with both independent and dependent variables in a study, risk creating an illusion of causation where it may not exist. For example, in health research, overlooking lifestyle factors while evaluating a medication’s effect can lead to misattributing outcomes to the drug instead of these overlooked lifestyle elements. Such oversight can result in spurious relationships, falsely suggesting connections between two variables, and potentially misguiding researchers and policymakers with incorrect theories or actions. In physiological and environmental research, where numerous variables interact, neglecting confounders tends to oversimplify complex relationships and overlook crucial influencing factors. Furthermore, studies that fail to account for confounders often encounter replication challenges. Subsequent research that incorporates more variables may yield different results, causing confusion and eroding trust in the original findings.

Future research endeavours should embrace a more comprehensive methodological approach, encompassing randomized controlled trials and a broader, more diverse sample population, to more conclusively determine the impact of heat stress on ambulatory hypertension. As Nerbass et al. (2017) highlight, the manifestation of heat-related illnesses in individuals or groups within hot work environments serves as a “sentinel health event”. Such occurrences signal potential deficiencies in heat control measures, medical screenings, or environmental monitoring.

In occupational health research, the fish-smoking process, inherently involving prolonged exposure to heat and smoke, warrants in-depth examination, particularly concerning ambulatory hypertension. The preliminary identification of heat stress as a significant factor implies that individuals engaged in fish smoking, especially those operating in environments with insufficient ventilation and temperature control, are potentially at an elevated risk. This assertion underscores the need for targeted, comprehensive research in this area to better understand and mitigate the health risks associated with such occupational environments.

Regarding standards and risk mitigation in the fish smoking industry, implementing strategic interventions to reduce heat exposure-related risks is crucial. These measures might include improved ventilation, regular breaks, and promoting hydration among workers, potentially reducing hypertension incidence and severity. In public health policy development, the insights from this study could inform policies targeting occupational health in sectors with prevalent heat exposure. Initiatives could focus on facilitating regular health screenings, establishing, and enforcing workplace safety standards, and educating about heat stress risks.

In conclusion, this study introduces a new perspective on occupational health risks, challenging established paradigms and advocating for reevaluating health strategies within such environments. The evidence presented supports a complex understanding of hypertension risk factors and calls for tailored intervention strategies.

Table 9: Bivariate Association of Socio-demographic and Heat stress Predicts Ambulatory Hypertension

Variable	Ambulatory Hypertension				
	No Ambulatory	Ambulatory	X^2	Phi	P-Value
Age			**238.217**	**.344**	**0.000**
40 years or less	580(58.1%)	418(41.9%)			
41+ years	248(24.3%)	772(75.7%)			
Gender			**18.190**	**-.095**	**0.000**
Male	166(32.9%)	338(67.1%)			
Female	662(43.7%)	852(56.3%)			
Income			**19.404**	**-.098**	**0.000**
GHS 500 or less	248(34.5%)	470(65.5%)			
GHS > 500	580(44.6%)	720(55.4%)			
Level of your highest education			**26.626**	**-.115**	**0.000**
Formal Education	328(35.0%)	610(65.0%)			
No Formal Education	500(46.3%)	580(53.7%)			
Marital Status			**129.946**	**.254**	**0.000**
Married	372(32.5%)	774(67.5%)			
Divorced	126(37.5%)	210(62.5%)			
Unmarried	330(61.6%)	206(38.4%)			
Alcohol Use			**106.552**	**.230**	**0.000**
Never drinker	162(25.4%)	476(74.6%)			
Former drinker	334(44.1%)	424(55.9%)			
Current drinker	332(53.4%)	290(46.6%)			
Caffeine			**6.459**	**.057**	**0.011**
YES	374(44.3%)	470(55.7%)			
NO	454(38.7%)	720(61.3%)			
Heat stress			**80.766**	**-.200**	**0.000**
Heat stress	660(37.3%)	1108(62.7%)			
Not Heat stress	168 (67.2%)	82(32.8%)			

Table 10: Hierarchical Multiple Binary Logistic Regression of Socio-demographic and Heat stress Predicts Ambulatory Hypertension

Variable	Model 1 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)		Model 2 Adjusted Odds Ratio	P-Value	95 Confidence Interval (CI)	
			Lower	Upper			Lower	Upper
Age								
40 years or less	1				1			
41+ years	6.897	0.000	5.370	8.859	7.336	0.00	5.676	9.481
Gender								
Male	1				1			
Female	0.692	0.008	0.527	0.908	0.771	0.074	0.579	1.026
Income								
GHS 500 or less	1				1			
GHS > 500	0.339	0.000	0.260	0.441	0.296	0.000	0.224	0.391
Level of your highest education								
Formal Education	1				1			
No Formal Education	0.575	0.00	0.454	0.728	0.637	0.000	0.499	0.813
Marital Status								
Married	1				1			
Divorced	0.874	0.424	0.628	1.216	0.998	0.991	0.704	1.415
Unmarried	0.209	0.000	0.153	0.285	0.228	0.000	0.165	0.314
Alcohol Use								
Never drinker	1				1			
Former drinker	0.908	0.000	0.098	0.138	0.112	0.000	0.079	0.158
Current drinker	0.081	0.000	0.058	0.113	0.079	0.000	0.056	0.112
Caffeine								
YES	1				1			
NO	0.700	0.007	0.540	0.909	0.788	0.083	0.602	1.032
Heat stress								
Heat stress					1			
Not Heat stress					0.271	0.000	0.193	0.381
Pseudo R^2 Nagelkerke	**0.392**				**0.420**			

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Having presented the results of the analysis and discussed them in tandem with previous literature, this chapter presents the summary, main findings, conclusions, and recommendations. To reiterate, the objectives of this study were to (1) explore the level of workplace heat exposure and ambulatory hypertension, (2) examine differences in heat stress scores based on work shift periods, (3) examine the differences in ambulatory hypertension scores based on working days per week, (4) explore how socio-demographic and work-related factors associate with heat stress, (5) examine how socio-demographic and work-related factors associate with ambulatory hypertension, and (6) explore the extent to which worker socio-demographic variables and heat stress scores predict ambulatory hypertension among fish smokers along the coastal cities in Ghana. These objectives guide the presentation of the main findings of the research.

Summary

Heat stress constitutes a mounting predicament for numerous workers, especially those situated in heavily populated regions nearer to the equator where temperatures are anticipated to escalate because of the warmer climate (Lucas et al., 2014). Unfortunately, individuals who are subjected to high temperatures or perform physically demanding tasks, whether indoors or outdoors, are susceptible to heat stress. Unfortunately, prolonged exposure to high temperatures leads to heat stress-related occupational illnesses such as heat stroke, heat exhaustion, heat syncope, heat cramps, heat rashes, or even fatality.

Heat exposure among Ghanaian fish processors is a significant occupational health concern, particularly when fish smoker's inadequate workplace conditions and limited access to proper occupational health and safety measures. The indigenous work environment of the fish-smoking industry is characterised by high temperatures which have not received sufficient attention about its potential impact on heat exposure and health outcomes. Consequently, workers may encounter extended duration of elevated temperatures thereby increasing the likelihood of experiencing ambulatory hypertension and other heat-related illnesses.

The challenge is that some fish smokers in Ghana may not have access to the right PPE due to economic situations, and in the absence of appropriate equipment, workers are compelled to engage in physically demanding tasks in high-temperature environments, resulting in a significant expenditure of energy. Moreover, the relationship between BMI and both heat stress and ambulatory hypertension is complex and can vary among individuals who engage in fish smoking. Additionally, the combination of strenuous physical activity and hot temperatures has the potential to worsen heat-related health concerns such as ambulatory hypertension among fish smokers and lead to a huge loss of productivity in Ghana.

This cross-sectional study was conducted to explore the relationship between socio-demographic factors, and work-related factors associated with heat stress, and ambulatory blood hypertension among fish smokers in the coastal regions in Ghana. The current study employed a survey interview questionnaire consisting of 62 items to collect data from the participants. Measurements were also taken to assess heat stress, ambulatory blood pressure, and BMI of fish smokers, using a heat stress monitor, sphygmomanometer, medical body thermometer, body scale, and stadiometer. The data was collected from a sample of 2,018 fish smokers in Keta, Tema New-Town, Teshie, Awutu Senya, Moree, Elmina, and Shama. Six research questions guided the study. The towns were sampled using a purposive sampling method while the fish smokers in target towns were selected using a convenient sampling approach. The research questions were analysed using mean, frequency, and percentage, Kruskal-Wallis H and Eta square, bivariate and hierarchical binary logistic regression. SPSS version 25 statistical software was used for data management and analysis.

Key Findings

The following findings are revealed based on the results:

1. Fish smokers living in the coastal regions of Ghana exhibit high levels of incidence of heat stress with a prevalence rate of 87.6%. Additionally, ambulatory hypertension is prevalent among this population at a rate of 59.0%.
2. The findings suggest that fish smokers who work during the afternoon shift exhibit significantly elevated levels of heat stress in comparison to their counterparts working during the morning and evening shifts.
3. The occurrence and severity of ambulatory hypertension among individuals who smoke fish in coastal regions of Ghana are influenced by the number of days devoted to working each week. There is a correlation between the frequency of workdays among individuals engaged in fish-smoking activities and the prevalence and severity of ambulatory hypertension. Specifically, those who work for 3-5 days and 5-7 days per week exhibit a

greater incidence and severity of ambulatory hypertension in comparison to individuals with a lesser number of working days.

4. The prevalence of heat stress among fish smokers in coastal areas of Ghana is found to be significantly influenced by various socio-demographic and work-related factors, like gender, divorced or unmarried status, alcohol use, caffeine consumption, low water intake, and working without shade during the afternoon shift are associated with a higher likelihood of experiencing heat stress.
5. The findings indicate that an association exists between ambulatory hypertension and a range of socio-demographic and work-related factors among fish smokers living in coastal regions of Ghana, i.e., old age, female gender, lower income, lower education, unmarried status, alcohol consumption, caffeine intake, inadequate water consumption, smoking, and higher BMI.
6. The study's finding is that age is a key determinant of ambulatory hypertension risk, with individuals aged 41 and older being significantly more likely to suffer from ambulatory hypertension compared to those who are 40 years old or younger.

Conclusions

In conclusion, this study highlights the significant occupational health challenges faced by fish smokers in coastal Ghana, with alarmingly high prevalence rates of heat stress (87.6%) and ambulatory hypertension (59.0%). The study identifies crucial risk factors associated with these conditions, including work patterns, socio-demographic characteristics, and lifestyle choices. Notably, afternoon shift work, increased weekly workdays, older age, and various modifiable factors such as alcohol consumption and inadequate hydration significantly contribute to the heightened risk of heat stress and hypertension. These findings underscore the urgent need for targeted interventions to improve working conditions, promote healthier lifestyles, and implement occupational health policies to protect this vulnerable workforce from the detrimental effects of their occupation on their cardiovascular health and overall well-being.

Recommendations

The following recommendations are made based on the conclusions:

1. It is essential to develop and implement OHS measures in close collaboration with the Ministry of Fisheries and Aquaculture Development (MOFAD), National Fisheries Association of Ghana (NAFAG), Fisheries Scientific Survey Division (FSSD), Coastal Development Authority (CODA), National Fish Processors and Traders Association (NAFPTA), and Ghana Health Services to reduce the health risks of heat-induced stress and ambulatory hypertension among the fish smokers living along Ghana's coast. Additionally, MOFAD should employ industrial hygienists and OHS officers in the fisheries sector to provide proper guidance for heat-related controls such as ventilation systems or air conditioning, mechanical lagging, preventive maintenance of equipment, thermal assessment to optimise a safe work environment, and infrastructures for smoking fish. MOFAD needs to employ an industrial hygienist to provide guidelines for ambulatory hypertension monitoring in the fishing industry. As part of OHS procedures, regular monitoring and recording of blood pressure, as well as surveillance of employees in the industry are needed. This method has the potential to

facilitate the identification of individuals at risk for ambulatory hypertension and the prompt initiation of treatment. It is recommended that employers provide hypertension prevention and management training and educational to enable the fish smokers to acquire the necessary knowledge about their health.

2. The Ministry of Fisheries and Aquaculture Development (MOFAD) and the Coastal Development Authority (CODA) should work with the National Fish Processors and Traders Association (NAFPTA) to develop and disseminate shift management strategies to reduce heat stress among fish smokers. The techniques should consider afternoon climatic circumstances such as high ambient temperature, air velocity, and sun radiation and a shift scheduling system that accounts for daily weather changes will be crucial. Fish smokers may improve their working circumstances by arranging early shifts during cooler seasons and avoiding afternoon hours when the temperatures are very high.
3. MOFAD and the Ministry of Employment and Labour Relations should provide training to fish smokers on managing heat stress, coping strategies for ambulatory hypertension, addressing shift-related concerns, and establishing guidelines for appropriate working hours and rest breaks. Effective shift management necessitates comprehensive training for fish smokers regarding the physiological effects of heat stress, early warning signs, and appropriate responses.
4. NAFPTA programmes should raise awareness about the risks and consequences of heat stress while providing practical strategies for the prevention and management of heat-related health conditions among fish

smokers. By focusing on divorced or unmarried individuals, who may face unique challenges and have fewer support systems, these programmes can effectively reach out and engage this specific demographic group.

5. The Ministry of Employment and Labour Relations and the Ministry of Food and Agriculture in Ghana must work together to institute occupational health and safety for the fishing sector that will not only protect the workers but also help increase productivity in the industry, lower the cost of healthcare, protect and promote Ghana’s international labour image and sustainable development goals.

Recommendations for future studies

1. Future research should expand the study of heat stress and ambulatory hypertension among fish smokers to all coastal regions of Ghana, including both urban and rural areas. This expanded geographical scope should aim to recruit a minimum of 500 participants from each region, ensuring a more representative sample.
2. It is necessary to investigate the effect of ambient air emissions on the prevalence of COPD among fish smokers in Ghana’s coastal regions.
3. There is a need for longitudinal and randomised controlled trials to examine changes in the physical and incidence of heat-related illness among fish smokers in the coastal regions of Ghana.

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APPENDICES

APPENDIX A

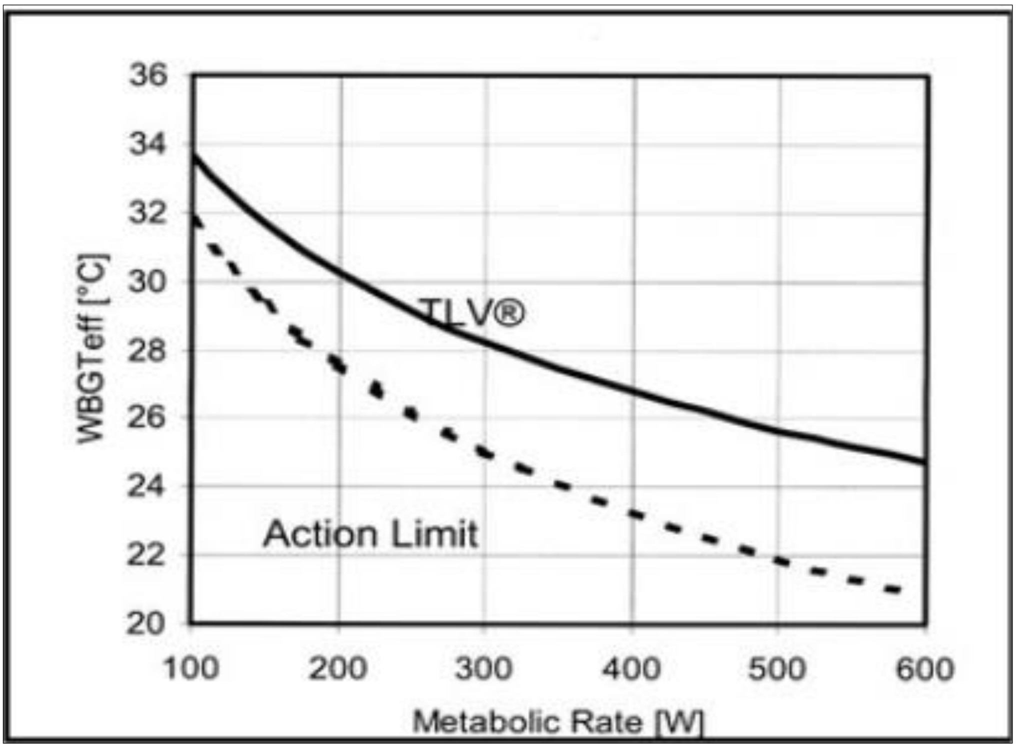

Fig. 1 Determine the Threshold Limit Value or Action Limit

ACGIH Screening Criteria for Heat Stress Exposure (WBGT values in °C) for 8 hour work day five days per week with conventional breaks								
Allocation of Work in a Work/Rest Cycle	TLV®				Action Limit			
	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
75-100%	31.0	28.0	--	--	28.0	25.0	--	--
50-75%	31.0	29.0	27.5	--	28.5	26.0	24.0	--
25-50%	32.0	30.0	29.0	28.0	29.5	27.0	25.5	24.5
0-25%	32.5	31.5	30.5	30.0	30.0	29.0	28.0	27.0

Fig.2 Screening Criteria: Action Limit and TLV by % of Work and Metabolic Rate Category

APPENDIX B

UNIVERSITY OF CAPE COAST

COLLEGE OF EDUCATION STUDIES

DEPARTMENT OF HEALTH, PHYSICAL EDUCATION AND RECREATION

QUESTIONNAIRE FOR FISH SMOKERS

Dear fish smoker,

I am Emmanuel Ankomah-Appiah, a researcher. I'm inviting you to participate in a research study titled "Heat exposures associated with heat stress and ambulatory hypertension among fish smokers in Ghana's coastal areas." The purpose of this study is to gain a better understanding of occupational heat stress in small-scale household fish mongers and its association with ambulatory hypertension. You are required to respond to a 62-item survey. This survey will likely take between 20 to 30 minutes of your time. You are a poll participant, and your responses will be analysed collectively. By taking part in this study, you will contribute to a better understanding of the level of occupational heat exposure and associated occupational health risks among Ghanaian fish smokers. Your identity is protected, your participation is completely voluntary, and you have the right to stop responding to survey items or withdraw from the study at any time.

If you understand your responsibilities completely and agree to participate in this survey, please sign below in the space provided.

Signature …………………………… Date………………………………….

For any information contact my supervisors **Dr. Edward W. Ansah (+233 247703379)** or **Dr. Thomas Hormenu (+233-244213465).** You may also contact me (Emmanuel) on 0242951727 or e.ankomah-appiah@stu.ucc.edu.gh

Thank you for your participation.

Section A: Sociodemographic characteristics

Please check the box OR write in the space next to the statement that best describes your opinion for each one below.

1. Period of the day ………………………………………….

2. Age (years) ………………………………………….

3. Gender Male ☐ Female ☐ Others ☐

4. Years of working in fish smoking? …………………………………….

5. Average monthly income? ………………………………………….

6. Ethnicity/tribe?

A. Akan ☐
B. Ga-Adangbe ☐
C. Ewe ☐
D. Others (Mole Dagbani, Guan, Grusi, Gruma, Mande) ☐

7. Level of your highest education?

A. No formal education ☐
B. Basic education ☐
C. Vocational training ☐
D. Tertiary education ☐

8. Marital status?

A. Married ☐
B. Divorced widowed/separated ☐
C. Unmarried ☐

9. How many days do you work in a week?

A. 1-3 days ☐
B. 3-5 days ☐
C. 5-7 days ☐

10. Smoking status?

A. Never smoker ☐
B. Former smoker ☐
C. Current smoker ☐

11. Do you drink alcohol?

A. Never drinker ☐
B. Former drinker ☐
C. Current drinker ☐

12 Do you take caffeine?
A. Yes ☐
B. No ☐

13. Do you have any illness prior to you starting this work?
A. Yes ☐
B. No ☐

14. Have you received any training on heat related illness?
A. Yes ☐
B. No ☐

Section B: Moderating and other risk factors associated with heat exposure. Please mark the box corresponding to your choice regarding each statement below.

		Strongly disagree.	Disagree	Agree	Strongly Agree
15.	Does fish smoking require you to move heavy loads?				
16.	Do you feel hot in your clothing during fish smoking?				
17.	Does fish smoking require rapid physical activity?				
18.	Does fish smoking involve a lot of time and heat exposure?				
19.	Does it involve working very fast at all times?				
20.	Does fish smoking involve a lot of repetitive activity?				
			Yes	**No**	
21.	Do you always take a break in the shade when smoking fish?		☐	☐	
22.	Are you able to drink water when smoking fish?		☐	☐	
23.	Do you have enough drinking water on hand when smoking fish?		☐	☐	
24.	Do you drink a lot of water in hot conditions?		☐	☐	

	1	2	3	4	5

Using methodology by Stoecklin-Marois et al, scores ranged from 0 to 5 with each correct response counting as one point. "High" heat exposure included scores of 4–5 and "low" heat exposure included scores of less than 4. Please answer with the best option provided by marking [√] the column that most accurately represents your opinion on heat exposure.		Very comfortable	comfortable	Neutral	Uncomfortable	Very Uncomfortable
25.	What is your level of concern about the risk of heat-related illnesses while smoking fish?					
26	How comfortable are you taking a water break while smoking fish?					
27.	What are your thoughts on the heat exposure sense in the fish smoking area?					
28.	How do you feel about the air circulation in the fish smoking area?					
29	How do you feel about the air (humidity) in the fish smoking area?					
30	How do you feel about the air quality in the fish smoking area?					
31	What do you feel about heat exposure whilst smoking fish?					

Section C: Health outcome and heat adaptation practices.
Please answer with the best option provided by checking [√] the column that most accurately represents your opinion on heat stress and ambulatory hypertension illness symptoms.

	Heat stress and ambulatory hypertension illness symptoms	Yes	No
32.	Weakness/fatigue	☐	☐
33.	Heavy sweating	☐	☐
34.	Headache	☐	☐
35.	Rashes on skin	☐	☐
36.	Muscle cramps	☐	☐
37.	Dry mouth	☐	☐
38.	Dizziness	☐	☐
39.	Fever	☐	☐
40.	Dry, cracking skin	☐	☐
41.	Swelling hands/feet	☐	☐
42.	Blisters on skin	☐	☐
43.	Fainting	☐	☐
44.	Nausea	☐	☐
45.	Dysuria	☐	☐
46.	Vomiting	☐	☐
47.	Breathing fast and shallow	☐	☐
48.	Dehydration	☐	☐

49.	Sweating	☐	☐
50.	Non- heat related illness, please state?	☐	☐

51. How often do you check your blood pressure?

A.	Once every month	☐
B.	Once every three months	☐
C.	Once a year	☐
D.	Check when I visit the hospital	☐

Please answer with the best option provided by marking the column that most accurately represents your opinion on heat adaptation measures.

		At no time	**Some of the time**	**Most of the time**	**All of the time**
52.	Are you able to tolerate heat exposure in order to complete your work?				
53.	Do you get used to a hot fish smoking environment quickly?				
54.	Do you get hot when you're smoking a lot of fish?				
55.	Do you feel exhausted all the time after smoking fish?				
56.	Do you wear dark clothing when you smoke fish?				

57. What is your work-rest?

A.	75-100% (Very High work-rest)	☐
B.	50-75% (High work-rest)	☐
C.	25-50% (Moderate work-rest)	☐

	D.	0-25% (Low work-rest)	☐

Using 0 to 6 to indicate the level of protection scale by using clothing and personal protective equipment (PPE). Counting 0 to 3 point are "Low" protection, point score between 4 to 5 is a "High" level of protection.

59. What PPE do you wear for heat exposure disorder (HED)?

Heat Clothing/Protection

No protective or work clothing worn	0	☐
Light work clothing	1	☐
Cotton coverall, jacket	2	☐
Double cloth coveralls, water barrier materials	3	☐
Light weight vapour barrier suits	4	☐
Fully enclosed suit with hood and gloves	5	☐
I don't know	6	☐

59 Which of these do you use to be comfortable while smoking fish?

A	Rest	☐
B	Clothing	☐
C	Shade	☐
D	Breaks	☐
E	Job rotation	☐

Please answer with the best option provided by marking [√] the column that most accurately represents your opinion on awareness of heat adaptations measures. There is no 'correct' or 'wrong' answer.

		Strongly disagree.	**Disagree**	**Agree**	**Strongly Agree**
60.	Do your fish-smoking household leaders postpone outdoor activities during heat warnings?				

61.	Do you take good heat-related illness prevention measures when you go out in the job area for fish smoking?				
62.	Do your health personnel educate you on how to prevent and cope with heat-related illnesses before you go out in the work area for fish smoking?				

PART 2: FIELD MEASUREMENT (Anthropometric Parameters)

1. Height in m^2

Height(m^2)	Value
1	
2	
Mean Height	

2. Weight

Weight(kg)	Value
1	
2	
Mean Weight	

3. BMI…………..Kg/m^2

4. Blood pressure in mmHg

Blood pressure	Systolic value	Diastolic value	Pulse rate
Before			
During			
After			
Mean blood pressure			

5. Body Temperature in degrees Celsius

Body Temperature	Body Temperature (^oC)
Before	
During	
After	
Mean body Temperature	

6. Heat Stress

Heat stress	Heat stress (WBGT)	Relative Humidity (100%)	Dew Point	Time Measured (Hours)
Before				
During				
After				
Time Weighted Averages of Heat Stress				

APPENDIX C

ETHICAL CLEARANCE

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
HEAD OFFICE

P.O. BOX M. 32
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GHANA
WEST - AFRICA

TEL: 233-30-2777651-4 (4 Lines)
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WEBSITE: www.csir.org.gh

Our Ref: *CSIR/IRB/AL/VOL1-025*

Date: 25th October 2022

ETHICAL CLEARANCE

RPN 018/CSIR-IRB/2022

The Council for Scientific and Industrial Research (CSIR) Institutional Review Board (IRB) has reviewed and approved your protocol.

TITLE OF PROTOCOL: HEAT EXPOSURES ASSOCIATED WITH HEAT STRESS AND AMBULATORY HYPERTENSION AMONG FISH SMOKERS IN COASTAL AREAS OF GHANA

PRINCIPAL INVESTIGATOR: EMMANUEL ANKOMAH-APPIAH

Please note that a final review report must be submitted to the Board at the completion of the study. Your research records may be audited at any time during or after the implementation.

Any modification of this research project must be submitted to the IRB for review and approval prior to implementation.

Please report all serious adverse events related to this study to CSIR-IRB within seven days verbally and fourteen days in writing.

This certificate is valid till **24TH OCTOBER, 2023**.

Mr. Okyere Boateng
(CSIR-IRB, Chairman)

Cc: Director General, CSIR