A CROSS-SECTIONAL STUDY OF HEAT STRESS EXPOSURE, HEAT-RELATED SYMPTOMS, AND KIDNEY HEALTH AMONG KITCHEN WORKERS IN KAMPAR, PERAK, MALAYSIA

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Science (Hons) Environmental, Occupational Safety and Health

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"A CROSS-SECTIONAL STUDY OF HEAT STRESS EXPOSURE, HEAT-RELATED SYMPTOMS, AND KIDNEY HEALTH AMONG KITCHEN WORKERS IN KAMPAR, PERAK, MALAYSIA"** was prepared by **ABIGAIL KOH SHU HONG** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Hons) Environmental, Occupational Safety and Health at Universiti Tunku Abdul Rahman.

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ABSTRACT

Background: Kitchen workers are one of the heat-exposed occupations that are exposed to heat stress due to their work nature which requires them to work with radiant heat sources, coupled with poor ventilation and high humidity in the kitchen areas. These working conditions increase their risk of experiencing heat-related illnesses and heat-related symptoms. Heat stress coupled with dehydration also contributed to the risk of kidney-related complications, such as kidney stones and urinary tract infections. **Aim and objectives**: This study aims to study heat stress exposure, heat-related symptoms, and kidney health among kitchen workers in Kampar, Perak. **Methodology**: This cross-sectional study recruited 62 kitchen workers from local restaurants or hawker stalls in Kampar. Environmental monitoring, such as wet bulb globe temperature (WBGT), temperature, humidity, and thermal work limit was conducted in 14 kitchen areas of study respondents for three days using the Kestral 5400 WBGT Heat Stress Tracker. A self-administered structured questionnaire was also distributed to the participants to collect demographic information, living habits, working-related information, heat-related symptoms, and kidney-related symptoms of the participants. Urine samples of the participants (n=53) were collected pre-shift and post-shift to study their hydration status and kidney health using urinalysis dipstick tests. The collected data were keyed in and analyzed using IBM SPSS Statistics version 21. Wilcoxon Signed Rank test was conducted to compare urine test parameters in the urine samples of pre-shift and post-shift, and the Mann-Whitney U test was conducted to study the relationships between heat-related illnesses and kidney health, and the relationships between demographic factors, living habits, and working factors with heat-related symptoms. **Results:** In this study, The mean ± standard deviation (SD) for WBGT, temperature, relative humidity, and thermal work limit measured across 14 kitchen areas were 27.2 ± 1.0 °C, 29.9 ± 1.6 °C, 75.2 ± 6.2 %, and 157.5 ± 20.4. The mean WBGT of 27.2°C did not exceed the Threshold Limit Value established by the American Conference of Governmental Industrial Hygienists (ACGIH), i.e., 28°C, but exceeded the action limit of 25°C. In this study, 38.7% of the participants were identified as having heat-related illnesses with the most frequently reported heat-related symptoms being heavy sweating (45.1%), thirst (25.8%), and weakness/fatigue (24.2%). From the urinalysis dipstick test, it was found that there were no significant differences in the 10 parameters of the urine test between pre-shift and post-shift urine samples. There was also no significant association determined between kidney health and heat-related illnesses among the study respondents. Frequency of drinking caffeinated drinks was negatively related to vomiting symptoms (U=0.500, p=0.049), while the perception of respondents on feeling hard about their work was positively related to heavy sweating (U=339.5, p=0.039), weakness or fatigue (U=340.5, p=0.033), dizziness (U=122.0, p=0.031) and irritability (U=285.0, p=0.039). **Conclusion**: Kitchen workers in Kampar were identified as having a medium risk of heat stress and are advised to apply general controls recommended by ACGIH guidelines. More studies are required to further investigate the relationship between heat stress exposure with kidney health as well as risk factors that contribute to heat-related symptoms.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

°C	degree Celsius
ACGIH	American Conference of Governmental Industrial Hygienists
AKI	Acute Kidney Injury
ATP	Adenosine Triphosphate
CKDnt	Chronic Kidney Disease of Nontraditional Origin
DOSH	Department of Occupational Safety and Health
GFR	Glomerular Filtration Rate
HRI	Heat-Related Illnesses
HSN	Heat-Stress Nephropathy
IGFBP7	insulin-like Growth Factor Binding Protein 7
MeN	Mesoamerican Nephropathy
NGAL	Neutrophil Gelatinase-Associated Lipocalin
TLV	Threshold Limit Value
TWL	Thermal Work Limit
USG	Urine Specific Gravity
UTIs	Urinary Tract Infections
WBGT	Wet Bulb Globe Temperature

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Around the globe, extreme heat events have increased in frequency, intensity, and duration due to the climate change issue (John and Jha, 2023). Climate change also increases threats to workers who work with heat. The human body's ability to thermoregulate will be overwhelmed if prolonged exposure to extreme heat conditions, results in heat-related illnesses and exacerbation of pre-existing health conditions (Cheshire, 2016). There is an estimation of 880 000 work-life-years loss by the year 2030 due to occupational heat stroke fatalities for both indoor and outdoor workers (El Khayat et al., 2022). Additionally, it is also estimated that heat exposure will cause the loss of 70 million work-life-years in workforce productivity by 2030. International Labour Organization has estimated that when the workplace temperature reaches 33° - 34° C, the workers' productivity will decline by about 50% (International Labour Organization, 2019). In Southeast Asia, it is also estimated that around 20% of the working hours were lost due to heat exposure (Habib et al., 2021).

Occupational heat stress has posed a significant impact on the safety, health, and productivity of the workforce. Outdoor workers, such as farmers and construction workers are particularly vulnerable to heat-related illnesses due to exposure to extreme weather. Besides outdoor workers, indoor workers who are working with heat sources are also susceptible to heat stress. The Occupational Safety and Health Administration (OSHA) has listed indoor industries that are at risk of getting heat-related illnesses due to their nature of work, such as laundries, furnaces, bakeries, and kitchens (Occupational Health and Safety Administration, n.d.).

One of the indoor industries that has been identified by OSHA as having a high risk of heat stress is the kitchen. Kitchen workers are at risk of heat stress due to their work nature which requires them to work near a radiant heat source, such as stoves, ovens, and furnaces. They are exposed to a hot working environment, coupled with poor ventilation, physical activity, and inadequate rehydration breaks which causes them to be susceptible to heat-related illnesses (Nerbass et al., 2017). In the past ten years, much research has been done on kitchen workers in various aspects, particularly in work-related musculoskeletal disorders (Subramaniam and Murugesan, 2015); prevalence of lower back pain (Shankar, Shanmugam, and Srinivasan, 2015), heat and polycyclic aromatic hydrocarbons emissions in indoor kitchen air (Singh et al., 2016), burns and cut injuries (Haruyama et al., 2014), indoor air pollution and its association with poor lung function (Singh et al., 2017), and so on. In recent years, some researchers have been investigating occupational heat exposure among kitchen workers. However, more studies are required in this field to investigate the impact of heat exposure on kitchen workers to increase awareness as well as propose practical measures to mitigate negative impacts resulting from heat exposure.

The number of hot days (>30 °C) and heat waves are expected to increase globally over the next few decades due to climate change. As a result, heat-related illnesses, and injuries as well as kidney damage are anticipated to rise. Thus, chronic kidney disease of nontraditional origin (CKDnt) is being recognized as a global research priority by the International Society of Nephrology (Levin et al., 2017). Chronic kidney disease of nontraditional origin (CKDnt) is an emerging noncommunicable disease that has gained global concern among manual workers in tropical countries (Wasseling et al., 2020). Chronic kidney disease of nontraditional origin is linked to occupational heat exposure and dehydration in numerous studies (El Khayat et al., 2022). Continuous exposure to heat stress coupled with repeated dehydration is believed to increase the risk of subclinical kidney disease, which can lead to permanent kidney damage. There is increasing concern regarding the possibility of heat stress causing acute kidney injury and chronic kidney disease

(Alayyannur and Ramdhan, 2022). Therefore, it is important to study the relationship between heat-related illnesses and kidney health among workers to safeguard the health of the workers.

1.2 Problem Statements

Climate change over the years has contributed to the increase of global average temperatures by 1.1°C as compared to pre-industrial times (IPCC, 2021). Around the world, there are about 40% of the population lives in climate zones where the average daily temperature exceeds 30°C for the majority of the year (Nerbass et al., 2017). Moreover, heat waves have also increased in intensity, frequency, and duration all around the world (Perkins, 2015). Series of heat waves are created due to the combination of prolonged excessive warm weather and high humidity levels around the globe (Nizam et al., 2021). A majority of the world's areas have seen at least one additional day of heatwaves every decade between 1950 and 2017 (Perkins-Kirkpatrick and Lewis, 2020). It is estimated by the end of the century, there will be 4 times as many people who are currently impacted by extreme heat will experience heat stress (Li, Yuan, and Kopp, 2020). As a result of climate change, the workers' ambient working environment has been changed, posing additional hazards to the workers.

Malaysia is also one of the tropical countries that are being impacted by climate change and experienced increasing annual hottest periods over the years (Ahmad Rasdan Ismail et al., 2020). Malaysia has recorded more frequent heat wave events in recent years. In April 2023, the highest temperature recorded by the Malaysian Meteorological Department was 38.4°C in Negeri Sembilan state (Saieed, 2023). Past studies have shown that workers who work strenuously at temperatures above 35°C are more prone to experience heat stress or hyperthermia due to the failure of the body to dissipate the metabolic heat (Parsons, 2014). If the body's temperature exceeds 39.4°C, it will impair the physical and mental capacities of a person due to the dysfunction of body organs at high temperatures (Nizam et al., 2021). Unattended and untreated heat stress could lead to fatal heat stroke (Lundgren et al., 2013). From April to June 2023, there were 39 heat-related cases with one fatality case reported by the Health Ministry of Malaysia (Mahalingam, 2023). Thus, heat-exposed workers in Malaysia are exposed to an increasing risk of heat-related illnesses, such as heat stroke, heat rash, and heat exhaustion. Not only that but they are also exposed to the risk of heat-stress nephropathy (HSN). There is emerging evidence from various studies that show the association of heat stress with renal health. Heat stress has increased the incidence of kidney stones, acute kidney injury, chronic kidney disease, urinary tract infections, and so on (Borg et al., 2017).

Besides, exposure to hot temperatures will also reduce the focus of workers which can increase the likelihood of workplace injuries (Abokhashabah et al., 2021). It is determined that the worker’s performance will decline significantly, especially when their body temperature reaches 39° C where their body functions start to weaken (Krishnamurthy et al., 2017). According to statistics presented by the Department of Statistics (2022), There were a total of 381 cases of occupational accidents caused by exposure to or contact with extreme temperatures in Malaysia. Besides, the working environment (10,412) was the major cause of workplace accidents in 2021 in Malaysia. This shows that harsh working environments, such as extreme heat contributed to a higher risk of workplace accidents among the workers.

Kitchen workers who need to spend a long time in hot and humid work environments (i.e., kitchens) are susceptible to heat stress and heat-related illnesses. Kitchen work is quite physically demanding as the workers may need to lift pots, crates of food, boxes, and containers, unload food and drink deliveries, and take raw materials out of storage and off shelves which may increase internal heat production due to metabolism in addition to the heat generated by radiant heat source, i.e., stove (Saif Eldin et al., 2022). They are commonly exposed to heat stress due to high radiant heat and airflow, humidity, and air temperature in commercial kitchens (Occupational Safety and Health Administration, n.d.). These conditions are worsened by insufficient exhaust facilities and ventilation hoods to exhaust the hot and humid air outside of the kitchen (Singh et al., 2016), which has increased the risk of developing heat-related illnesses among kitchen workers (CDC, 2012). Not only that but regular exposure to thermal strain will also cause health complications such as discomfort, blood circulation problems, and acute heat stroke (Singh et al., 2016). Additionally, the tight aprons worn by some kitchen workers may enhance their heat stress exposure, increase sweating, and cause a higher risk of dehydration. Exposure to these conditions may cause the workers to have high urinary specific gravity, which is an indicator of dehydration (CDC, 2012). Dehydration can lead to various health complications in the kidney, such as acute kidney injury and kidney stones among kitchen workers. Therefore, heat exposure among kitchen workers is of concern and needs to be addressed to prevent the occurrence of occupational heat-related illnesses among them.

Hence, more studies are required to investigate occupational heat exposure of kitchen workers as they are at risk of heat stress due to exposure to thermal stress from the stove, high humidity in the kitchen area, and their heat stress levels are further exacerbated by hot weather due to climate change, as well as poor work practices, such as poor rehydration (Siti Marwanis Anua et al., 2021). However, there is a lack of studies in Malaysia on occupational heat stress among kitchen workers. Not only that but kidney health is often overlooked among heat-exposed workers, especially in Malaysia. Therefore, this study is needed to determine the prevalence of heat-related illnesses as well as the associations between heat stress with the kidney health of heat-exposed workers, particularly kitchen workers in Malaysia to raise awareness and also to encourage various parties to develop adaptation strategies to protect the safety, health, and well-being of heat-exposed workers including kitchen workers.

1.3 Significance of Research

In the past ten years, various studies regarding heat stress have been conducted around the world, such as in Thailand, India, Saudi Arabia, as well as Malaysia. Heat stress is gaining global concern due to climate change and extreme heat. Outdoor or heat-exposed workers are exposed to a higher risk of heat stress in which the impacts should not be underestimated. This research is significant as it can help to determine the prevalence of heat-related illnesses among kitchen workers in Kampar. The data collected can be used to predict and extrapolate to other areas in Malaysia to provide insight and statistics regarding the current situation of heat stress exposure among kitchen workers in Malaysia especially since Malaysia is being impacted by longer and hotter heat waves in the year 2023. It is important to address the heat-related illnesses prevalence among kitchen workers in Malaysia and to measure heat stress in real-working scenarios to understand the heat stress experienced by kitchen workers to safeguard their health and well-being. The results of the study can be used to raise awareness among employers as well as employees in food service industries so that adaptation strategies can be developed and implemented in kitchen work environments.

In recent years, more and more studies have been conducted to investigate the impact of heat stress on kidney health. However, in Malaysia, there is still a lack of studies regarding the relationship of heat stress with workers' kidney health. Therefore, this research is significant to bridge the research gap in Malaysia to understand the association of heat-related symptoms with workers' kidney health and to highlight the potential long-term health impacts of working in the heat. Chronic kidney disease (CKD) is a global health crisis with about 16% of the population or 2.6 million people around the world requiring dialysis. Chronic kidney disease is also a health crisis in Malaysia with an estimated 8000 new patients every year since 2018 and an estimated 106 000 cases of kidney disease requiring dialysis by 2040 with 30% of the patients under age 45 (Daim, 2022). To tackle the increasing prevalence of chronic kidney disease in Malaysia, it is important to understand the risk factors of the disease, including heat stress. Heat stress could be one of the major risk factors for kidney disease among heat-exposed workers. Therefore, it is important to determine the association of heat stress with the kidney health of workers so that improvement can be made in current practices to reduce the risk of developing kidney disease among heat-exposed workers.

1.4 Aim and Objectives

Aim: This study aims to study heat stress exposure, heat-related symptoms, and kidney health among kitchen workers in Kampar, Perak, Malaysia.

The specific objectives of the study are shown as follows:

I. To determine Wet Bulb Globe Temperature (WBGT), temperature, humidity, and Thermal Work Limit (TWL) in the working area of kitchen workers
II. To identify the prevalence of heat-related symptoms and heat-related illnesses among kitchen workers
III. To determine the hydration status and kidney health of kitchen workers
IV. To study the relationships between heat-related illnesses and kidney health of kitchen workers
V. To study the relationship between demographic factors, living habits, and work-related factors with self-reported heat-related symptoms

1.5 Hypothesis

The hypotheses of the study are shown as follows:

I. There are significant associations between heat-related illnesses and kidney health of kitchen workers.
II. There are significant associations between demographic factors, living habits, and work-related factors with self-reported heat-related symptoms among kitchen workers.

1.6 Conceptual Framework

The independent variables in this study are the Wet-bulb globe temperature (WBGT), temperature, relative humidity, and thermal work limit (TWL) which signifies the heat exposure level in the workplace of the study participants. Dehydration is a condition that is contributed by the heat exposure level and will affect the dependent variable, which is heat-related illnesses and heat-related symptoms experienced by the participants, thus it is acting as a mediating variable in this study. Moderating variables, such as demographic factors (gender, age, weight, BMI, and pre-existing diseases), living habits (smoking, alcohol consumption, and caffeinated drinks consumption), and working factors (feeling of work) will affect the degree of the dependent variable, i.e., heat-related illnesses and heat-related symptoms in this study.

Besides, heat-related symptoms become the independent variable when investigating the association between heat-related symptoms with kidney health, which is the dependent variable in this case. Dehydration also serves as the mediating variable in this relationship as it can worsen the kidney health of participants. Demographic factors, living habits, and working habits also serve as moderating variables affecting the seriousness of kidney health in this relationship.

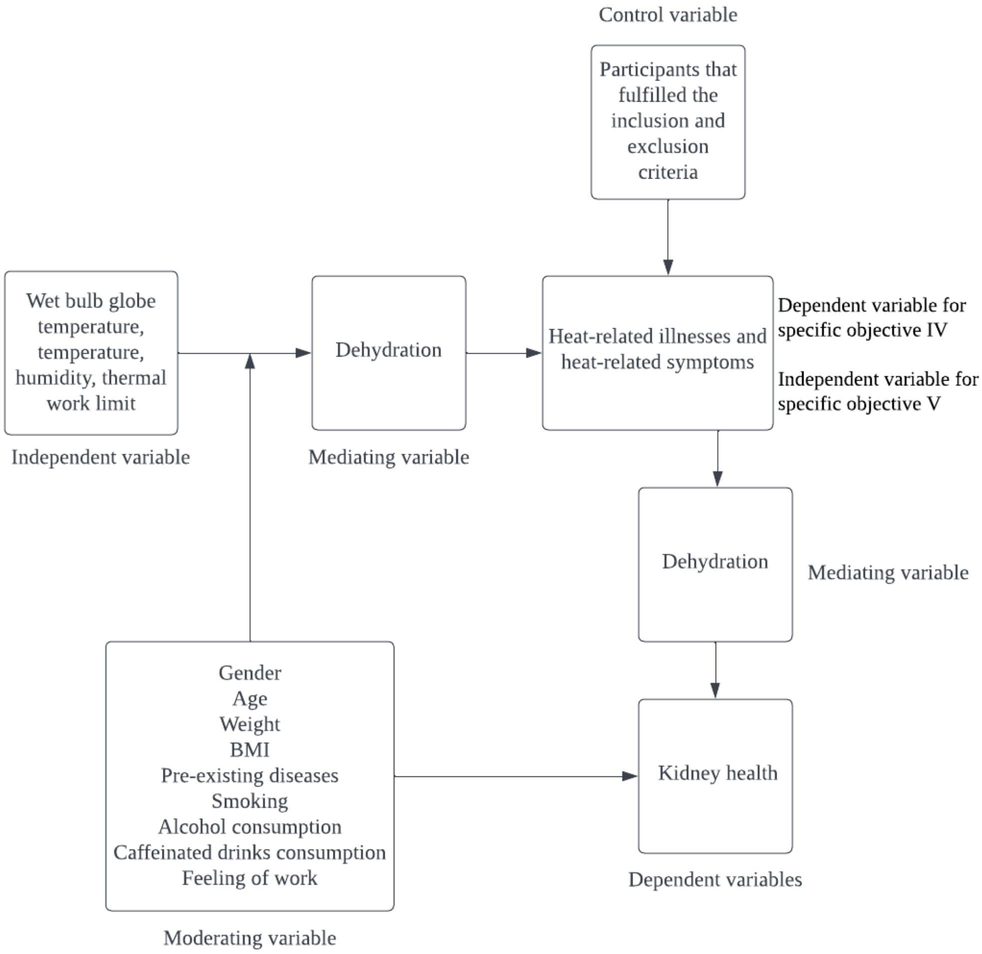

Figure 1.1 Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Heat Stress

Heat stress is the net heat load that leads to an increase in bodily heat storage through exposure to various factors, such as environmental factors, metabolic heat, and clothing (Jacklitsch et al., 2016). It is influenced by multiple factors such as temperature, air speed, humidity, shade, clothing, and physical activities (Zhang et al., 2014). Under heat stress, the body will experience a positive net heat load, leading to hyperthermia, which is a rise in core body temperature.

Human bodies are capable of maintaining the body temperature within a certain range (standard body temperature is between 36.5 to 37.5°C). The body has mechanisms in place to regulate temperature between 35 to 41°C. After this range, the body will fail to self-regulate and mitigate the external thermal loads (Leiva and Church, 2023). To mitigate risks, the American Conference of Governmental Industrial Hygienists (ACGIH) recommended that workers should not be allowed to work when their core body temperature exceeds 39.5°C (Logeswari and Mrunalini, 2017).

The core temperature of the body is determined by the summation of heat production during metabolism, heat exchange with the environment, and mechanical work. Heat exchange with the environment can be achieved through evaporation, convection, conduction, or radiation. When the external temperature and humidity increase to the point that radiation and conduction become ineffective, the body can only dissipate heat via evaporation (Leiva and Church, 2023). However, factors such as clothing or blocked sweat glands can hinder the evaporation process.

When the body fails to effectively dissipate heat and regulate rising core body temperature, heat stress can result in various heat-related illnesses, injuries, and decreased productivity (Jacklitsch et al., 2016). Common symptoms of heat-related issues include intense thirst, dizziness, fatigue, headache, vomiting, and nausea. Not only that but heat stress can lead to conditions such as ataxia (loss of muscle control), tachycardia (increased heart rate), syncope (fainting), and transient alterations in mental status (temporary loss of normal awareness) (Crowe et al., 2015). In a workplace having WBGT above 32°C, the workers will have high Urine Specific Gravity (USG) and a greater risk of developing hypohydration. Furthermore, prolonged exposure to WBGT above the recommended threshold will elevate the heart rate and blood pressure. When the air temperature and relative humidity increase, the oxygen uptake and heart rate of the body will also rise substantially. Over a few hours of work, workers may experience additional heat-related symptoms such as loss of appetite, impatience, or irritability (Nizam et al., 2021).

2.2 Heat-Related Illnesses (HRI)

Heat-related illnesses (HRI) can manifest either acutely or with a delay when the body is exposed to heat exceeding its compensatory thermoregulation mechanisms. HRI can range from mild (heat edema, heat cramps, heat syncope, etc.) to severe conditions (heat exhaustion), and even life-threatening conditions (heat stroke) (Khan, 2019). Given the potential severity of these conditions, early recognition of heat-related symptoms is crucial to prevent progression to irreversible severe conditions.

One of the mild HRI is heat edema, which is the swelling in the distal extremities, such as hands and legs, due to vasodilation of blood vessels and the pooling of fluids due to gravity (Leiva and Church, 2023). Heat edema can be due to the lack of acclimatization to a hotter environment and fluid loss causing increased salt content in the body (Khan, 2019).

Heat rash, the second kind of mild HRI, is brought on when eccrine sweat glands become blocked in a hot environment (Leiva and Church, 2023). Due to the blocked sweat glands, the consistent sweat production will rupture the ducts and induce an inflammatory reaction that will lead to chronic pruritic dermatitis (lasting itchy skin) (Khan, 2019). Factors that will worsen the heat rash include tight clothing or obstructive objects like bandages (Leiva and Church, 2023).

The subsequent mild HRI is heat cramp, which is the involuntary and intermittent spasm of large muscle groups (e.g., arms, calves, and abdominal walls) after heat exposure. This condition is induced by the deficiency of sodium, potassium, magnesium, or chloride due to excessive perspiration coupled with inadequate compensation of fluid/electrolyte (Leiva and Church, 2023) (Khan, 2019). Electrolyte imbalance leading to heat cramps is usually caused by profuse sweating when conducting physical activity in a hot environment. Heat cramps usually occur along with elevated heart rate and body temperature (Khan, 2019).

Heat syncope is another mild HRI, which is manifested by temporary dizziness, weakness, or loss of consciousness, especially when standing too long in a hot environment (Leiva and Church, 2023). This condition may be due to an inadequate blood supply to the brain coupled with dehydration. During heat exposure, the body will dissipate heat by escalating blood flow via vasodilation to the skin. Excessive blood circulation in the skin may lead to a drop in blood pressure and decreased blood flow to the brain, which leads to syncope (Khan, 2019).

Heat exhaustion or heat stress is manifested in a wide range and combination of symptoms, such as dizziness, headache, thirst, nausea, vomiting, excessive sweating, weakness, muscle cramps, and low urine output, coupled with high core body temperatures of 38°C to 40°C (Leiva and Church, 2023) (Khan, 2019). Heat exhaustion can develop into a life-threatening condition, i.e., heatstroke if it is not being addressed timely (Leiva and Church, 2023).

A severe HRI, i.e., heat stroke may occur when the body temperature is elevated above 39°C (Nerbass et al., 2017). It is characterized by hyperthermia, which is a condition of body temperature beyond 40.6°C when the body is unable to regulate the temperature and will result in delirium, seizures, coma, and multiorgan failure (Johnson et al., 2019). Heat stroke is often detrimental, even patients who are able to recover from it often have a high probability of suffering permanent damage to the central nervous system and other organs. Two main categories of heatstroke are identified, which are classic and exertional. Classic heatstroke is caused by the influence of the external environment and often impacts individuals who are immunocompromised, such as children and old people. Whereas exertional heat stroke results from elevated body temperature due to demanding physical activity in a hot environment and failure to dissipate excessive heat produced in the body (Khan, 2019). Both categories of heatstroke are severe and are characterized by delirium or confusion, often accompanied by acute failure of the liver and kidney (Johnson et al., 2019).

Thus, early recognition of heat-related symptoms is of supreme importance to prevent the progression of mild symptoms to irreversible severe conditions. Mild HRIs such as heat edema, heat rash, and heat cramps are often recoverable with proper hydration and rest. However, if these conditions are not addressed timely, they can develop into more severe complications such as heat stroke. Thus, recognizing the signs of HRI and taking protective measures are important to minimize risks and preserve the health and well-being of heat-exposed individuals.

2.3 Association of Heat Stress with Kidney Health

Kidneys are a highly vascularized organ. It is one of the important organs in the body to maintain homeostasis such as regulation of water and electrolytes, blood pressure, and acid/base balance. Therefore, kidneys often respond to the physiological challenges of these regulatory processes to maintain homeostatic balance in the body. For example, when subjected to heat stress, kidneys will perform mechanisms to conserve water and electrolytes, maintain blood pressure, and redirect blood flow from the kidneys to the skin to dissipate heat (Chapman et al., 2020b). An important function of kidneys is concentrating the urine, which can help to minimize fluid loss in the body and simultaneously excrete unwanted nitrogenous wastes. This process is particularly important under conditions of heat stress and dehydration. The unique ability of the kidneys to protect the body against heat and dehydration also makes them a significant site of heat-related disease.

Kidneys play an important role in maintaining euhydration, which is a status of optimal water content in the body. Under normal circumstances, water primarily exits the body through the kidneys, with minimal losses occurring through respiration, skin evaporation, and the gastrointestinal tract. However, in hot environments, excessive sweating can lead to dehydration, as the amount of water lost through sweating exceeds the compensatory capacity of the body, even with sufficient water consumption (Chapman et al., 2020b). Heat stress which causes the rise in core body temperature, especially when coupled with dehydration exacerbates the kidney-related pathology (Chapman et al., 2020b). Dehydration leads to high urine concentrations due to reduced body water content, potentially resulting in decreased glomerular filtration rate which leads to reduced kidney function, or even acute kidney disease (Alayyannur and Ramdhan, 2022). Another contributing factor to kidney injury is workload. Studies have shown that biomarkers of acute kidney disease, such as urea and creatinine, increase shortly (less than an hour) after physical exertion. Thus, when physical activity is prolonged, more significant changes in the biomarkers are likely to be observed (Alayyannur and Ramdhan, 2022).

Several studies have revealed that increased temperatures are associated with increased emergency room admissions due to renal problems, such as acute kidney injury (AKI), chronic kidney disease (CKD), urinary tract infections (UTIs), and kidney stones (Borg et al., 2017; Borg et al., 2019). There is also an association between occupational heat stress exposure with higher incidence rates of kidney disease (Tawatsupa et al., 2012). Not only that, but chronically dehydrated individuals often have higher concentrations of toxins in serum and kidneys compared to well-hydrated individuals because they are unable to excrete toxins effectively (Glaser et al., 2016). Thus, various studies have revealed the possible association of heat stress with kidney health.

2.3.1 Acute Kidney Injury (AKI)

Acute kidney injury (AKI) is characterized by a rapid (ranging from hours to days) decline in kidney function, often detected by increased concentrations of nitrogen metabolism by-products in the plasma, such as creatinine and urea, accompanied by decreased urine output. There are two distinct types of acute kidney injury (AKI) with varying etiologies. The first type, known as rhabdomyolysis, occurs due to the release of muscle cell contents into the bloodstream following the breakdown of damaged muscles (usually with creatine phosphokinase levels >1000 μ/L). The first type of AKI is often accompanied by hyperuricemia and signs of dehydration. This type of AKI is commonly linked with exertional heatstroke. Conversely, the second type of AKI, more prevalent in epidemic heatstroke cases, is typically characterized by normal or slightly increased levels of creatine phosphokinase (Johnson et al., 2019). This form of AKI is primarily associated with acute tubular injury, which is manifested clinically as acute interstitial nephritis—an acute inflammation of the renal interstitium. Accompanying symptoms may include urinary leukocytosis, indicative of high levels of leukocytes in urine, as well as hematuria, or blood in the urine. Additionally, renal biopsy often reveals evidence of acute tubulointerstitial nephritis, indicating inflammation within kidney tubules and interstitial tissue (Johnson et al., 2019). Studies have shown that these two types of AKI are both associated with different events of heatstroke.

Exercise, particularly in hot environments and accompanied by dehydration, imposes additional stress on the kidneys, increasing the risk of AKI, as evidenced by elevated AKI biomarkers. A few research has demonstrated that prolonged exercise under heat leads to increased core temperature, dehydration, and a rise in serum creatinine and plasma neutrophil gelatinase-associated lipocalin (NGAL) levels, indicating renal stress and potential injury (Schlader et al., 2017; Junglee et al., 2013; McDermott et al., 2018). The mechanisms that cause the increase of biomarkers are possibly multifactorial. Exercise, hyperthermia, and dehydration, each is capable of independently reducing renal blood flow, and the effect is exacerbated by a combination of these factors. Animal studies have shown that both hyperthermia and dehydration cause significant reduction in blood flow within the renal cortex-- where sodium reabsorption primarily occurs in the proximal tubules. Increased sodium reabsorption (caused by a greater extent of dehydration during prolonged work in heat) coupled with reduced oxygen delivery to the renal cortex, have potentially contributed to greater renal ATP depletion. Renal ATP depletion is hypothesized to be one of the mechanisms by which physical exertion in hot environments increases the risk of AKI (Chapman et al., 2020a).

2.3.2 Kidney Stones and Urinary Tract Infections (UTIs)

Research suggests that increasing temperatures due to climate change have increased the prevalence of kidney stones, with concentrated urine and low urine volumes resulting from heat stress and dehydration posing a significant risk factor for their development (Johnson et al., 2019). High temperatures elevate the risk of renal disease by promoting sweating, which will lead to decreased extracellular fluid (ECF) levels followed by dehydration. This condition can lead to urolithiasis or kidney stones. The decrease in ECF will prompt the secretion of vasopressin which will increase water reabsorption from renal filtrate. This will increase the concentration of the urine which will lead to an increase in calcium and uric acid concentration (Borg et al., 2017). This condition will predispose individual to supersaturation of these solutes which will accelerate the stone formation. The stones can grow rapidly over a few hours in a conducive urinary environment. Moreover, declined ECF will result in a decrease in blood volume which will lead to reduced blood filtration by the kidneys, as a result lowering the glomerular filtration rate and potentially leading to AKI (Borg et al., 2017). Furthermore, the interaction of aldosterone (hormone to stimulate salt reabsorption in the kidney) and lactate formation during work contributes to urinary acidification which further exacerbates urolithiasis. The combination of increased urine concentration and acidification, together with increased serum urate levels, may contribute to the formation of urate crystals leading to urolithiasis (García-Trabanino et al., 2015).

Besides, urinary tract infections (UTIs) are suggested to be related to underhydration and possibly influenced by climate change (Johnson et al., 2019). A study conducted in the USA has revealed an upsurge in admissions for UTI during heat waves. Chronic decreased urine volume due to dehydration has been shown to elevate the risk of UTI, the mechanism of which is hypothesized but unproven. The decreased water content in urine leads to an increase in bacterial concentration (which makes people susceptible to infection) and an increase in urine osmolality and urine acidity, which promote the adhesion of bacteria to the urinary epithelium. Not only that, but a decreased urine volume may also result in reduced “flushing out” of bacteria from the body which further exacerbates the risk of UTI (Borg et al., 2017). A study has shown that increased water consumption could boost urine volume and subsequently lower the risk for UTIs (Hooton et al., 2018).

2.3.3 Chronic Kidney Disease of Nontraditional Origin (CKDnt)

Chronic kidney disease (CKD) is a growing global health concern, contributing significantly to mortality rates worldwide. CKD impedes the kidney’s ability to filter blood effectively, which results in the accumulation of waste in the body and leads to various chronic health complications, such as cardiovascular diseases, anemia, and mineral bone disorders (Webster et al., 2017). There has been an emergence of a cluster of CKDs of unknown origin among agricultural workers and other manual workers in different regions around the world in recent years. This CKD is known as

Mesoamerican nephropathy (MeN) (Johnson, Wesseling, and Newman, 2019). This type of CKD with substantial and prolonged reductions in glomerular filtration rate (GFR) is not contributed by typical risk factors such as diabetes mellitus, glomerular diseases, and hypertension. The actual cause is not known. However, the workers in these regions shared a common characteristic, which is frequent exposure to occupational heat stress (Johnson, Wesseling, and Newman, 2019). Diagnosis of this kind of CKD poses great challenges due to the absence of early symptoms as well as a lack of surveillance infrastructure, leading to late-stage detection. The diagnosis of CKDnt is hard as it requires several months of monitoring of the physiological changes. However, a risk factor can serve as early detection of CKD, which is AKI, particularly recurrent episodes of AKI. AKI is identifiable through a rapidly increased level of serum creatinine that is detectable within hours or days (López-Gálvez et al., 2021).

Johnson (2017) suggests that there is emerging evidence that CKD development is associated with repeated AKI caused by subclinical or clinical heatstroke. Experiments have supported this hypothesis that repeated heat stress and dehydration can indeed induce chronic inflammation and tubular injury in mice and rats (Roncal Jimenez et al., 2019). Although there are still disputes regarding whether heat stress is the main causal agent or accelerator of the underlying pathology, the current evidence indicates that heat stress induces tubular kidney injury, which can be made worse by dehydration, higher core temperatures, muscle-damaging exercise, and longer working hours (Chapman et al., 2021). There is also a theory that suggests that the mechanisms leading to CKDnt could be multifactorial, such as pesticide and heavy metal exposure, pain medications, and so on (López-Gálvez et al., 2021).

Recent studies suggest that kidney injury leading to chronic kidney disease is tubular in nature. It was found in a few laboratory-controlled studies that the markers of kidney injury, such as NGAL and urinary insulin-like growth factor binding protein 7 (IGFBP7) increase after physical work in the heat. Although the exact mechanisms causing this type of kidney damage are not entirely understood, data support that the increase of kidney injury markers after strenuous activity in heat is worsened by longer working hours and a greater degree of hyperthermia and dehydration (Chapman et al., 2020a).

The current theory associated with heat-related kidney injury is the renal blood flow (due to physical work in heat) has led to localized hypoxic environments that decrease tubular oxygen delivery. This reduction in renal perfusion causes the depletion of Renal adenosine triphosphate (ATP), especially with increased tubular sodium reabsorption (an ATP-dependent process that is elevated during physical work in heat to alleviate dehydration) (Chapman et al., 2020b). The depletion of ATP in the kidney tubules can lead to inflammation and oxidative stress that can eventually lead to renal tubular injury (Chapman et al., 2020b). The rodent model supported this hypothesis by showing that a higher extent of hyperthermia during repeated heat exposure results in greater kidney damage and the development of tubulointerstitial and functional maladaptation that are consistent with kidney disease (Sato et al., 2019).

2.4 Summary of Different Studies

The table below shows the evidence that indicates the association between heat stress and kidney health from various studies.

Table 2.1 Summary of Different Studies

Source (s)	**Interest of study**	**Research methods**	**Summary of findings**
(Flouris et al., 2018)	Effects of occupational heat strain on the health and productivity of workers	Systematic review and meta-analysis of health and productivity of workers under occupational heat strain	15% (10 studies with a total of 21 721 workers) of individuals suffered kidney disease or acute kidney injury under frequent exposure to heat stress.
(Venugopal et al, 2023)	Heat stress, heat-related symptoms, and kidney	Survey of 7 Indian salt pans (352 workers) from 2017 to	41% of workers had an eGFR of 60 to 89 ml/min per 1.73 m^2 (mild decrease of kidney function) and 7% had an eGFR

	function among salt pan workers in Tamil Nadu, India.	2020. Measurements of pre- and post-shift heart rate, tympanic temperatures, urine specific gravity (USG), sweat rates (SwR), serum creatinine (SCr), serum uric acid, and urine dipstick and estimation of the glomerular filtration rate (eGFR; ml/min per 1.73 m2).	lower than 60 ml/min per 1.73 m^2 (moderate or severe decrease of kidney function). The odds ratio for eGFR less than 90 ml/min per 1.73 m^2 among workers with exceeding TLV compared to workers below TLV was 2.9. In simple words, workers exposed to above TLV are 2.9 times more likely to have reduced kidney function than workers exposed to below TLV.
(Venugopal et al., 2020a)	Renal health effects for workers in steel manufacturing in southern India.	Cross-sectional study with 340 steelworkers. Collection of self-reported heat-strain and kidney symptoms using questionnaires and diagnosis of structural renal anomalies/kidney stones using renal ultrasound by occupational	33% out of 91 workers undergoing renal ultrasound were identified for kidney/ureteral stones and other structural renal anomalies. Heat-exposed workers have a higher prevalence of renal/urologic anomalies (11.8% prevalence from the exposed group and 3.3% prevalence from the unexposed group). There was a significant positive association between exposure beyond TLV-WBGTs and renal anomalies.

		health specialists on 91 workers.	
(López-Gálvez et al., 2021)	The kidney function of migrant and seasonal farm workers (MSFWs) with pesticide exposure, heat stress, and dehydration in a large-scale farm in Mexico.	A longitudinal study of 101 MSFWs and 50 office workers as the reference group. Collection of urine and blood samples from workers and estimation of heat strain using physiological strain index (PSI).	Kidney function was found to decrease significantly from pre-harvest to late harvest among MSFWs while no significant kidney function change among office workers. All workers had normal kidney function at baseline, but MSFWs experienced a significant reduction in kidney function after working in grape fields for several months. There was a significant association between heat strain along with dehydration and kidney function decrease during the study timeline.
(García-Trabanino et al., 2015)	The possible associations of heat stress, dehydration, biomarkers of renal function, and prevalence of pre-shift renal damage and possible causal factors.	Study of 189 Sugarcane cutters from three regions in El Salvador. Examination of before and after shift changes in dehydration and renal function markers and assess the associations with temperature,	High prevalence of reduced kidney function among 189 sugarcane cutters (14% of reduced eGFR (<60 mL/min) among male workers pre-shift). The hypothesis that kidney damage is caused by repeated dehydration and heavy physical work in a hot and humid environment is supported by the association between cross-shift increase in serum creatinine and temperature and liquid intake.

		work time, region, and fluid intake.	

2.5 Factors Affecting Heat-Related Illnesses

There are different factors that affect the susceptibility of an individual to heat stress which may be due to personal factors, environmental factors, or working factors. A few of the factors will be discussed below.

Environmental factors, such as humidity are an important factor affecting the susceptibility of individuals towards heat stress. When the humidity level is high, an individual may feel hotter because the sweat does not evaporate from the skin as effectively (Laborers' Health & Safety Fund of North America [LHSFNA], n.d.). Sweating is one of the most important mechanisms for cooling down the body during heat exposure, thus, high humidity can contribute significantly to the risk of HRI due to the inability of the body to regulate body temperature effectively (LHSFNA, n.d.). Therefore, monitoring the humidity level of the workplace is just as important as monitoring the temperature to mitigate the risk of HRI.

Age is one of the factors that play a crucial role in influencing the risk of HRI. Older individuals generally are more prone to HRI. However, in the previous studies conducted by Kakamu et al. (2021), younger workers are at higher risk of HRI. Generally, older individuals are more susceptible to classical HRI while younger individuals are more prone to exertional HRI. This difference in susceptibility can be due to different factors. Younger people often overlook the importance of preventive measures against HRI, probably due to a lack of awareness or mental complacency. Additionally, younger individuals are more likely to engage in physically demanding work, increasing their exposure to heat stress. Contrarily, older individuals may experience a decline in physical work capacity (about 50% compared with average 25-year-old young individuals), making them more vulnerable to heat stress even with less physically demanding work. Although the energy consumption observed in workers 60 years old or older is generally much lower compared to the younger age group, the risk of HRI does not decrease in this age group. This difference can be explained by the reduced thermoregulatory capacity and declined cardiovascular function due to aging (Kakamu et al., 2021). Therefore, age should be considered a significant factor in assessing and mitigating the risk of heat-related illnesses in occupational settings.

Another significant factor affecting heat stress is workload. When engaging in strenuous work, body muscles will generate internal heat as a result of metabolism to provide necessary energy to the body. When the workload increases, the metabolism of the body increases so does the internal heat production of the body. This increase in heat production will pose a greater risk of an individual getting HRI (LHSFNA, n.d.). Therefore, individuals with physically demanding jobs are more susceptible to heat stress.

Dehydration is also a significant risk contributing to heat-related illnesses. Under heat exposure, the body needs to replenish the amount of water lost as sweat to maintain a proper hydration level. Dehydration occurs when water intake cannot compensate for the water lost from the body through sweating, which will make an individual more susceptible to HRI (LHSFNA, n.d.). Dehydration not only reduces the body's ability to dissipate heat through sweating but also disrupts other bodily functions, such as maintaining blood pressure. Prolonged dehydration can lead to HRI such as dizziness, weakness, or confusion. Therefore, adequate hydration plays a crucial role in preventing HRI.

Last but not least, alcohol and highly caffeinated drinks consumption may lead to vulnerability to HRI. This is because both alcohol and caffeine act as diuretics, which means that they can increase urination and subsequently contribute to dehydration, especially in hot environments (LHSFNA, n.d.). As discussed earlier, dehydration can compromise the body's ability to regulate temperature through sweating, thus making an individual more susceptible to HRI.

2.5 Summary

Heat exposure in some occupations is inevitable. Exposure to heat stress coupled with physically demanding activities, inadequate compensation of fluid or electrolytes, and failure of the body to regulate core body temperature during hyperthermia will lead to various heat-related symptoms, heat-related illnesses, and loss of productivity. Heat-related illness can range from mild symptoms to severe and even permanent or detrimental conditions. Some mild HRI include heat cramps, heat edema, or heat rash can usually go away after applying treatment. However, if the HRI, such as heat exhaustion is left untreated, it may develop into heatstroke, which is life-threatening. Patients with heatstroke may suffer multiorgan failure or damage to the central nervous system that might be irreversible. Therefore, it is important to recognize heat-related symptoms among heat-exposed workers before they progress into serious heat-related illnesses that may cause permanent damage or death. It is also important for various parties, especially employers as well as employees to take steps to mitigate the effects of heat exposure to prevent the occurrence of occupational heat-related illnesses.

Not only HRI, but exposure to heat stress could also affect kidney health. There is emerging evidence that heat exposure is associated with various kidney anomalies, ranging from urinary tract infections, kidney stones, and acute kidney injury to chronic kidney disease. Most of these kidney problems are associated with dehydration coupled with heat stress. There is also the emergence of a cluster of chronic kidney diseases with nontraditional origin (CKDnt) in various regions around the world, particularly among agricultural and manual workers. The exact mechanism of this type of kidney disease is not fully understood. However, more and more studies and experiments using rodent models have revealed evidence that CKDnt is associated with manual work under heat stress. More studies are still required to verify the association of heat stress with kidney health and mitigation actions should be put in place to protect the workers’ kidney health.

Several factors can influence the susceptibility of an individual to heat-related illnesses, such as age, humidity, dehydration, workload, and so on. It is important to understand the association of various factors with heat stress to better mitigate the effect of heat stress and the risk of HRI.

In conclusion, workers who work with heat are susceptible to various complications, whether be it heat-related symptoms or kidney-related complications. Therefore, it is important to investigate the potential health effects of heat-exposed workers, such as kitchen workers to safeguard their safety and health as kitchen workers are also one of the indoor industries that is often exposed to heat due to their work nature. Workers who work for longer periods in hot environments like kitchens, in particular, might experience chronic health effects due to heat exposure. Therefore, it is important to understand the effects of heat exposure to mitigate their risks.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This study is a cross-sectional study that aims to achieve five objectives, which include: i) to determine Wet Bulb Globe Temperature (WBGT), temperature, humidity, and Thermal Work Limit (TWL) in the working area of kitchen workers; ii) to identify the prevalence of heat-related symptoms and heat-related illnesses among kitchen workers; iii) to determine the kidney health of kitchen workers; iv) to study the relationships between heat-related illnesses and kidney health of kitchen workers, and v) to study relationship between demographic factors, living habit, and work-related factors with self-reported heat-related symptoms. In order to achieve these objectives, this research was started by conducting a literature review to understand the knowledge and findings of similar past research. This study was followed by an environmental assessment of the selected worksites by measuring the heat stress using WBGT. A self-administered questionnaire was distributed to each participant to report their heat-related symptoms and renal symptoms. A urinalysis dipstick test was also performed in this study to determine the hydration status of the participants before and after their work shifts.

3.2 Methodology

3.2.1 Study Design

This is a cross-sectional study that was carried out at local restaurants and hawker stalls in Kampar, Perak, Malaysia in January 2024 to assess the impacts of heat stress among selected kitchen workers. This study consisted of three parts, which include, an environmental heat stress assessment, a questionnaire, and urinalysis dipstick tests to determine the prevalence of heat-related illnesses and their relationship with kidney symptoms. The study was conducted for a month from 2 January 2024 to 31 January 2024. The data collection flowchart is shown below.

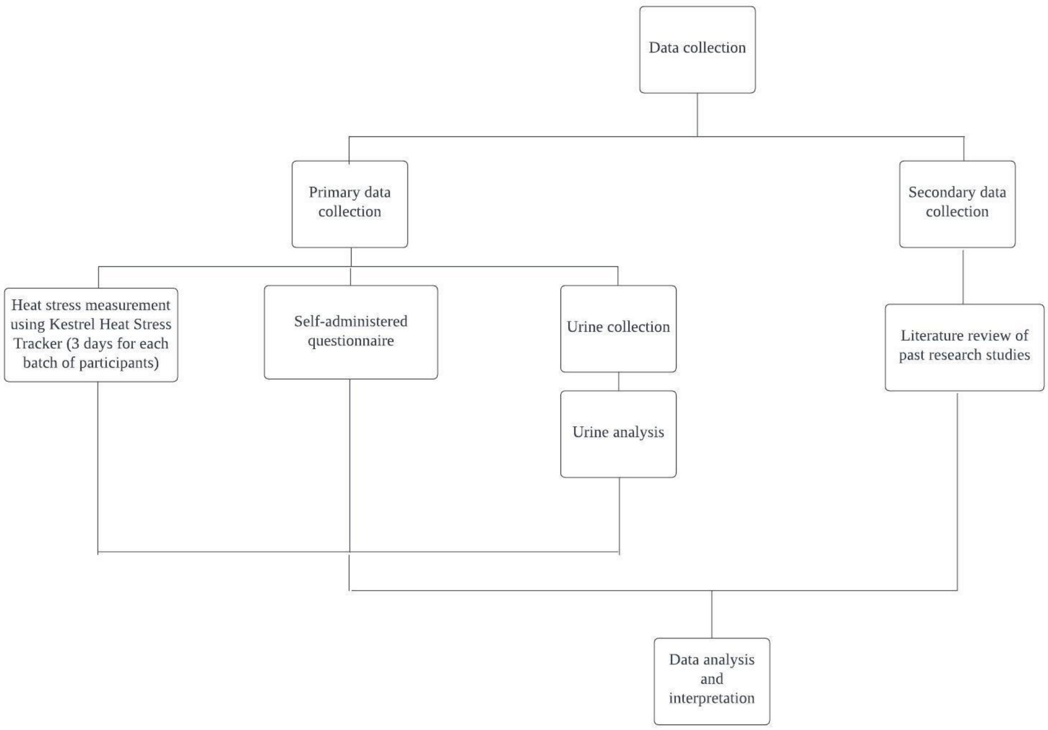

Figure 3.1 Data Collection Flowchart

3.2.2 Study Location

Malaysia is a tropical country with year-round warm to hot temperatures, averaging between 21°C and 32°C daily (Department of Information, 2016). Warm to hot temperatures during the day in Malaysia can threaten the health of heat-exposed workers. Figure 3.2 shows the maximum temperature per day in different states in Malaysia. Perak is among the states with the hottest maximum daily temperature, with a maximum daily temperature of 32.4°C.

Regions in Malaysia

All figures per year. For detailed climate data click on the name of the region.

Region	Temperature max Ø day	Temperature min Ø night	Sunshine hours	Rainy days	Precipitation	Humidity
Johor	31.6 °C	24.6 °C	2,008 h	138	2,183 l	84.0 %
Kedah	31.8 °C	24.8 °C	2,446 h	150	2,336 l	83.0 %
Kelantan	31.3 °C	24.1 °C	2,519 h	139	2,683 l	84.0 %
Labuan	31.7 °C	24.5 °C	2,555 h	178	3,395 l	85.0 %
Melaka	32.1 °C	24.3 °C	2,300 h	136	2,051 l	84.0 %
Negeri Sembilan	32.5 °C	24.4 °C	2,263 h	150	2,420 l	84.0 %
Pahang	32.5 °C	24.1 °C	2,154 h	161	3,015 l	84.0 %
Penang	31.8 °C	24.8 °C	2,446 h	150	2,336 l	83.0 %
Perak	32.4 °C	24.5 °C	2,336 h	149	2,383 l	83.0 %
Putrajaya	32.8 °C	24.5 °C	2,227 h	160	2,694 l	83.0 %
Sabah	31.7 °C	24.2 °C	2,519 h	164	2,997 l	83.0 %
Sarawak	31.8 °C	23.7 °C	2,336 h	192	3,661 l	85.0 %
Selangor	32.8 °C	24.5 °C	2,227 h	160	2,694 l	83.0 %

Figure 3.2 Average Daily Temperature of Different States in Malaysia (WorldData.info, n.d.)

The study location is at Kampar, which is one of the districts in Perak. The average daily temperature in Kampar (taken from more than 12 years of historical data) is about 28°C to 30°C at day time and 21°C to 23°C at night time (World Weather Online, n.d.). Kampar is selected as the study location for a few reasons: 1) Although Kampar is blessed with high humidity and rainfall, the climate in Kampar is warm and the temperature can fluctuate throughout the day, which poses a threat to the heat-exposed workers; 2) the temperature in Kampar is quite average (not too hot or cold), therefore the data collected here at Kampar can be indicative of other states in Malaysia. The kitchen or cooking area of the local restaurants and hawker stalls was selected as the study location as the kitchen area sometimes is congested, hot, and poorly ventilated, which threatens the safety and health of kitchen workers.

3.2.3 Sampling Population

Kitchen workers, including the cooks and workers, were selected as the participants due to the nature of their job which is exposed to the heat source (stove) every day. Some kitchen areas may be very congested and poorly ventilated which increases the risk of kitchen workers exposing to heat stress. A list of local restaurants and hawker stalls in Kampar was compiled through online and ground research. Then, the total number of kitchen workers was surveyed through interviews with the restaurants. The sampling method was purposive simple random sampling and voluntary participation of participants that fulfilled the inclusion and exclusion criteria. The inclusion criteria include kitchen workers who are exposed to or work in a hot environment, aged between 18 to 60 years old, worked more than six months, and working for at least 8 hours a day during lunch or dinner hours. Whereas the exclusion criteria include workers with pre-existing diseases, including hypertension, diabetes, and kidney disease, and workers with less than 8 hours of working time. Workers with pre-existing diseases, such as hypertension, diabetes, and kidney disease were excluded from the study as they are more vulnerable to heat-related and kidney symptoms which may not be representative of the majority of other kitchen workers and may affect the reliability of the result.

The participants were approached through site visits and an explanation of the study was conducted to obtain the participants' consent to participate in the study. A follow-up with the participants was conducted via phone calls to confirm their willingness to participate in the study.

By adopting a 95% confidence interval and 5% margin error, the calculated sample size for frequency in a population using an online sample size calculator (Dean, Sullivan, and Sue, 2013) is 52. A non-respondent rate of 20% is taken into account.

Thus, a total of 62 participants were selected for this study. Each worker was briefed regarding the study protocols and asked for their consent by signing the consent form before participating in the study. The study obtained the ethical approval of the UTAR Scientific and Ethical Review Committee (SERC) (Appendix 1).

3.3 Instrumentation

3.3.1 Heat Stress Tracker

Firstly, the environmental heat stress measurement was conducted in the kitchen areas of the selected local restaurants and hawker stalls by using the Kestrel 5400 WBGT Heat Stress Tracker. Kestral Heat Stress Tracker is a handheld, portable, user-friendly, and accurate device that can be used to measure WBGT on the spot to detect heat-related conditions in the workplace. The device can measure up to 24 parameters including Wet Bulb Globe Temperature (WBGT), wind speed, temperature, relative humidity, heat stress index, wet bulb temperature, wind direction, moisture content, air density, thermal work limit (TWL), globe temperature, etc. (Kestrel Instrument, n.d.).

Figure 3.3 Kestrel 5400 Heat Stress Tracker (Kestrel Instrument, n.d.)

The WBGT was calculated and estimated according to ACGIH guidelines. Structured observations were made to observe the workload and clothing of the participants to estimate the metabolic rate and clothing adjustment factors.

3.3.2 Questionnaire

Next, a survey was conducted using a self-administered structured questionnaire (Appendix 2). The questionnaire is a structured questionnaire with six sections which include the demographic information (gender, age, height, weight, and medical history), life habits (alcohol consumption, caffeine intake, smoking, and fluid intake per day), employment and work pattern (work experience, working hours, working days, and feeling of work), heat-related illness symptoms (heavy sweating, weakness/fatigue, dizziness, muscle cramps, headache, rash on the skin, irritability, nausea, dry and cracking skin, vomiting, swelling hands and feet, blisters on skin, fainting, thirst), kidney-related symptoms (pain/burning sensation when urinating, blood in urine, cloudy urine, urinary tract infections, kidney stones, urinating frequently but very little urine each urination), and contact information.

All the questions are close-ended. The questionnaire is to collect information regarding the participants' backgrounds. The questionnaire is also designed for the workers to self-report their heat-related symptoms and renal symptoms in the past 1 year. For self-reported symptoms, the participants were asked whether a symptom had occurred "every day", "often" (1-6 times per week), "sometimes" (1-3 times per month), "rarely (1-3 times per year)", or "never" in the past 1 year. The design of the questionnaire is derived and modified from several studies, such as Kiatkitroj et al. (2021), Boonruksa et al. (2020), Wesseling et al. (2016), and Venugopal et al. (2020). The designed questionnaire was translated into Chinese and Malay language and back-translated to ensure the accuracy of the translation (Tsang, Royse, and Terkawi, 2017). Due to the questionnaire has not been used in previous studies, a pilot test of the questionnaire was conducted with 10% of the study population to ensure the validity and reliability of the questionnaire.

Following that, a urinalysis dipstick test was conducted using a 10-parameter urinalysis dipstick (Accusure Urine H-10, Germany) to estimate the workers' hydration status and kidney health. The urine test strip contained 10 parameters with semi-quantitative measurements (leukocytes, nitrites, glucose, pH, protein, ketones, specific gravity, blood, bilirubin, and urobilinogen). The urine specific gravity (USG) is used to determine the hydration status of the workers with a USG value of 1.026-1.030 indicating dehydration (Boonruksa et al., 2020). Protein in the urine may indicate a loss of kidney function of the worker. Leukocytes in urine may indicate urinary tract infections. A pH below normal may indicate the presence of kidney stones or urinary infections. Blood in urine may also indicate a kidney problem or infection (National Kidney Foundation, 2016).

3.3.3 Statistical Analysis Software

The data collected from the environmental measurements, urine analysis results, and questionnaires were keyed in and analyzed using the software IBM SPSS Statistics 21. IBM SPSS is a statistical software that consists of a set of useful statistical features that helps researchers analyze valuable information from research data to draw conclusions and make predictions from the research results (IBM, n.d.).

3.4 Data Collection Procedures

3.4.1 Environmental Heat Stress Assessment

The handheld heat stress monitoring device (Kestrel 5400 WBGT Heat Stress Tracker) was held by the researcher to conduct the heat stress measurement. The device was held in the workers' work area as recommended by Guidelines on Heat Stress Management at Workplace 2016 (DOSH, 2016), but without disturbing the workers performing their work. The device was held at least 1 m from the ground. Each selected kitchen or cooking area of local restaurants and hawker stalls had one measurement. Each direct reading measurement was taken three times and measured at one-hour intervals in each kitchen area. The measurements were taken for the workers' work shifts, which were during breakfast and lunch hours (8.00 am-4.00 pm) and dinner hours (5.00 pm-11.00 pm). Due to the different operating hours of the restaurants, the sampling time for each restaurant and hawker stall was not fixed. The measurements were taken during the opening hours of the restaurants and hawker stalls. The heat stress measurement was taken for 3 days for each restaurant. Nearby restaurants were grouped together as one batch and will be conducted on the same day. Three different batches of heat stress measurements were taken.

The metabolic rate and clothing of workers were observed and recorded. The metabolic rate was estimated by observing the workers' arm movement, leg movement, trunk movement, pushing and lifting, working speed, usage of tools, and lateral and vertical movement; and later determining the metabolic rate using the ACGIH Table for Metabolic Rate Categories and the Representative Metabolic Rate with Example Activities (Maquiladora Health and Safety Support Network, n.d.). The clothing type was categorized by referring to the ACGIH Clothing Adjustment Factors for Some Clothing Ensembles and added to the effective WBGT ($WBGT_{eff}$) (Maquiladora Health and Safety Support Network, n.d.). The steps to measure workers' heat stress exposure are summarized in the flowchart (Figure 3.4) Ahmed et al. (2019). The WBGT TWA was compared with ACGIH threshold limit values (TLVs) for heat stress according to the intensity of the workload (Boonruksa et al., 2020).

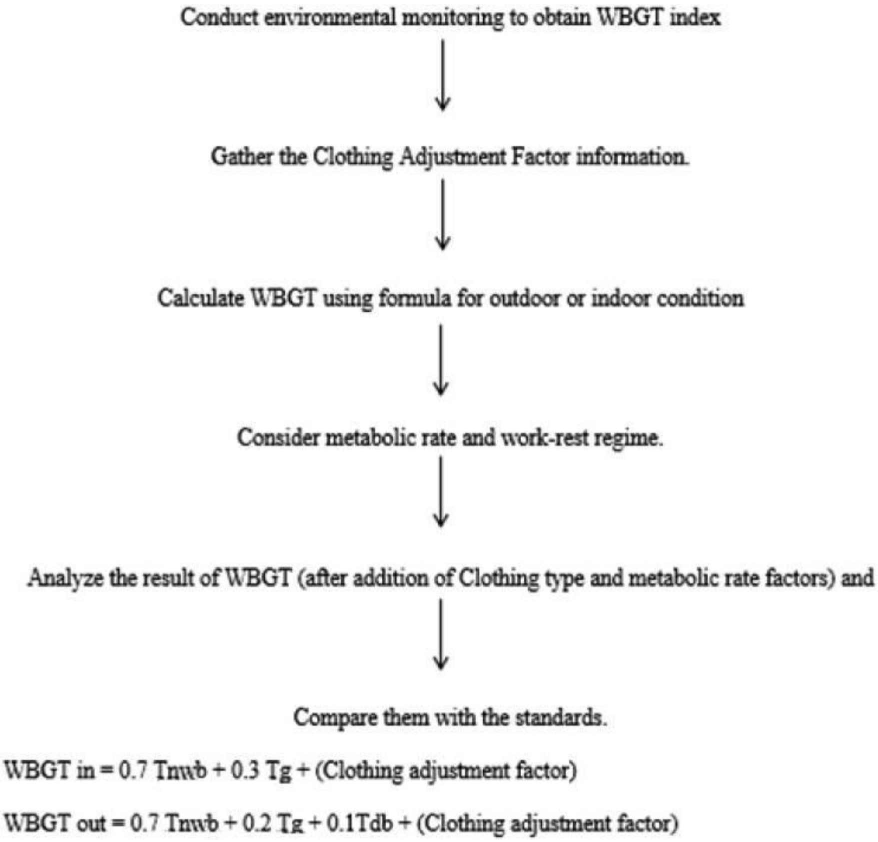

Figure 3.4 1 ACGIH Procedures (Ahmed et al., 2019)

3.4.2 Questionnaire

A self-administered questionnaire was distributed to every participant to collect the data required which took about 15 to 20 minutes to complete. The questionnaires are available in three languages English, Mandarin, and Malay depending on the preferences of the participants. For participants who could not understand the questionnaire, the researcher and enumerators helped to guide and explain to the workers. All the questionnaires were checked and followed up to ensure the content of the questionnaire was properly filled. The collected data was keyed into the data analysis software for further statistical analysis.

3.4.3 Urinalysis Dipstick Test

A name list of all the participants was requested from each restaurant and hawker stall. Urine bottles were prepared and labeled with the name and workplace of each participant. The urine test was conducted on the first sampling day. Two sterilized urine bottles were distributed to each worker to take urine samples before and after his/her work shift. All the labeled urine bottles were collected and stored in an ice box to be transported to the analysis laboratory within 24 hours by the researchers.

The color of the urine was observed and compared with the urine color chart shown in Figure 3.5. Subsequently, urine dipsticks (Accusure Urine H-10, Germany) were dipped into each urine sample and left for 60 seconds before reading the result by comparing the color (Figure 3.6). Each urine sample was measured three times to increase the reliability of the result. The results of leukocytes, nitrites, glucose, pH, protein, ketones, specific gravity, blood, bilirubin, and urobilinogen of each respondent were recorded. However, the result of the dipstick only serves as an early detection or prediction and does not have any clinical significance. Further examination by medical professionals is needed to confirm the diagnosis.

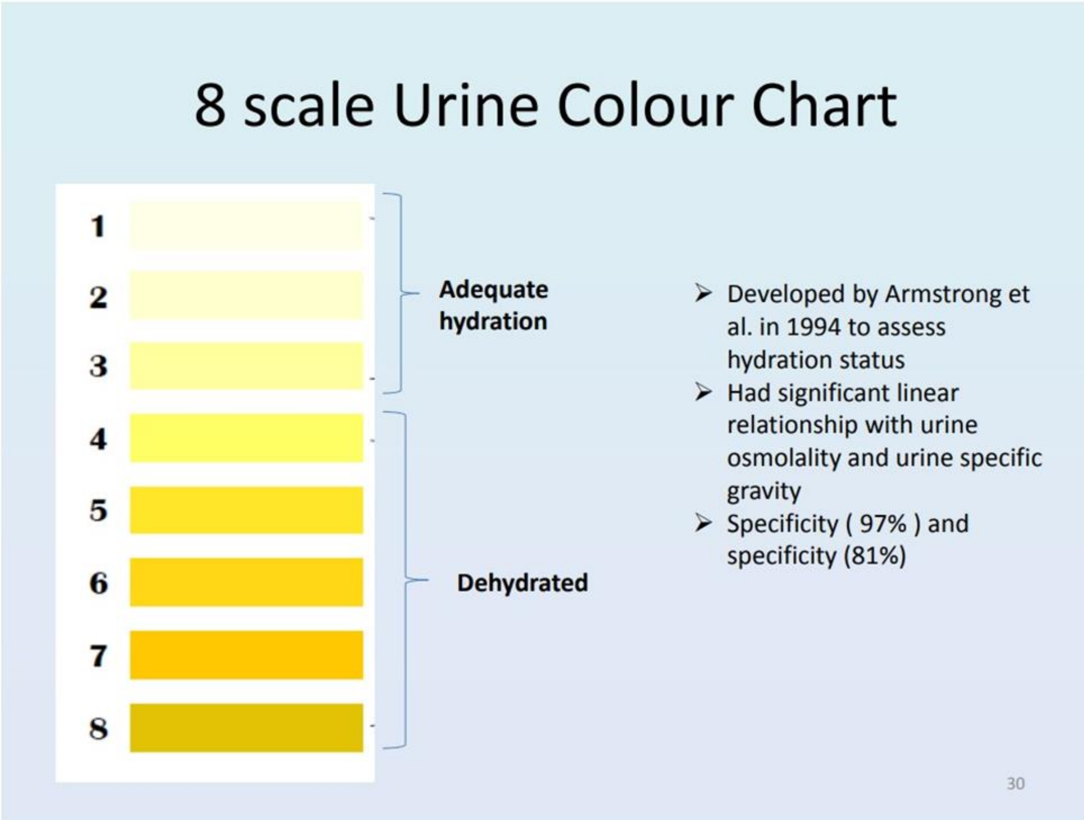

Figure 3.5 Eight Scale Urine Colour Chart (Mansor, 2017, p.30)

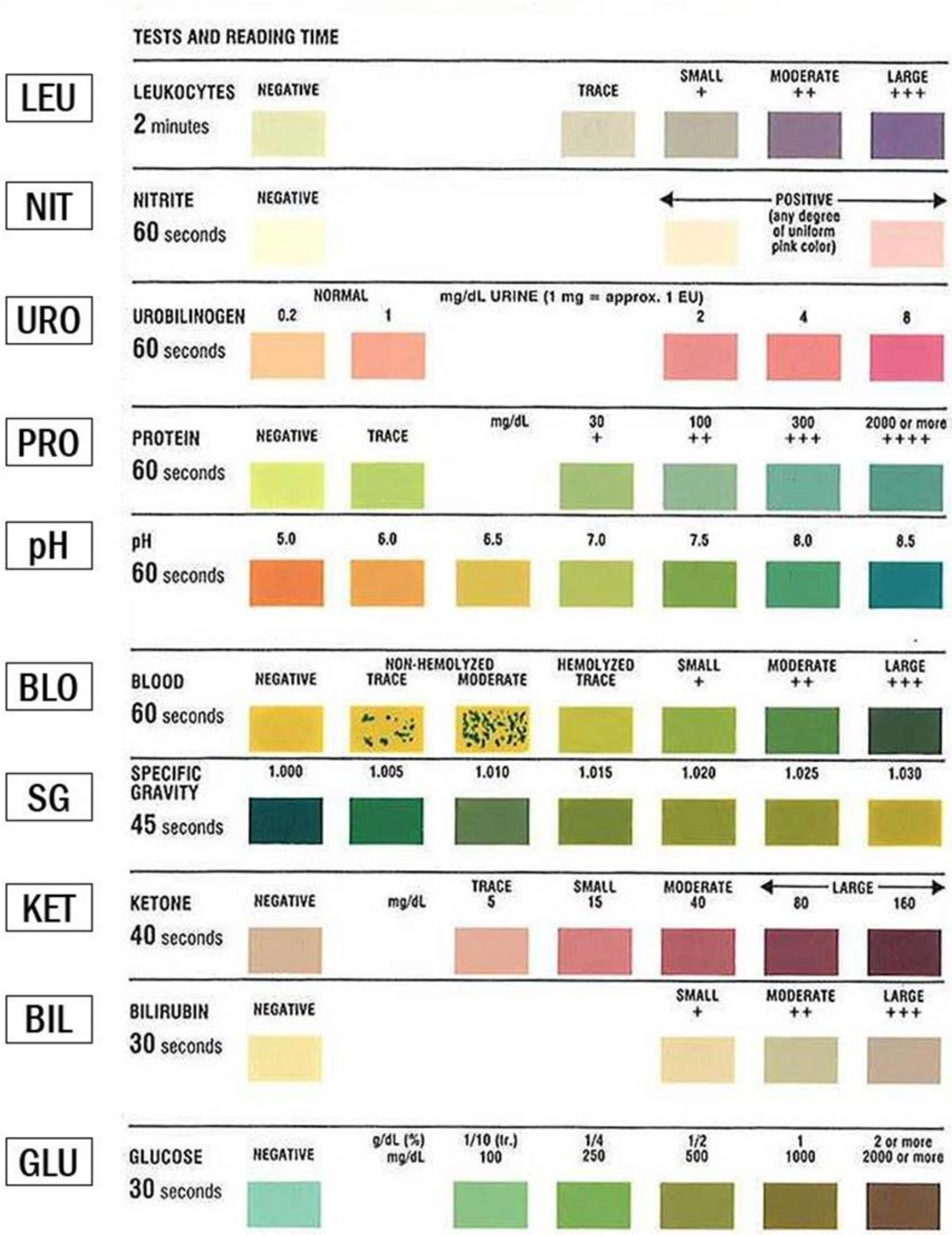

Figure 3.6 Color Chart (Ministry of Health Malaysia, n.d.)

3.5 Data Analysis

Frequency analysis was used to describe the minimum, maximum, and mean ± standard deviation to analyze the environmental monitoring data. The frequency and percentage of each heat-related and kidney-related symptom were calculated and presented. A Wilcoxon Signed-Ranks Test was conducted to compare the 10 parameters of the urinalysis test between morning and evening urine samples, which including to compare the changes in pre-shift and post-shift urine specific gravity of the participants to determine changes in hydration status. A Mann-Whitney U test was used to study the relationships between heat-related illnesses and kidney health (urine test parameters) of kitchen workers. Mann-Whitney U tests were also conducted to study the relationship of demographic factors (gender, age, weight, height, and BMI), living habits (frequency of drinking alcohol, frequency of smoking, amount of water drink per day, and frequency of drinking caffeinated drinks), and working factors (months of working, working days per week, working hours per day, and feeling of work) with heat-related symptoms. The result tables and their analysis were discussed in the following chapter.

3.6 Quality Control and Assurance

To assure the quality of the data collected, firstly, all the measurements, i.e., WBGT, relative humidity, etc. were taken three times and the average was calculated to improve the accuracy and reduce human errors of the measurements. The heat stress measurement was taken as close as possible to the participants' work area to ensure that the data collected represents the participants' actual heat exposure. The measurements were taken on another day if that day is a rainy day which cannot represent the normal working conditions of the participants.

The questionnaire was briefly explained to the participants to ensure that they fully understood the content of the questionnaire. For participants who could not understand the questionnaire, the researcher and enumerators guided the participants to answer the questionnaire. This is to ensure that the content of the questionnaire truly represents the conditions of the participants.

For the urine sample collection, the urine bottles were distributed two times to the participants instead of only one time in the morning to ensure the urine collected truly represents the urine sample of the participant for pre- and post-work shifts. Besides, the urine bottle was collected on the spot and all the urine samples were stored in an icebox which was kept below 4 °C immediately after the sample collection to avoid sample deterioration under room temperature. The urine was transported and analyzed at the laboratory within 24 hours to ensure that the conditions of the urine samples had not changed. When using the urinalysis dipstick, after the dipstick was dipped into the urine samples, it was wiped carefully to remove excess moisture to avoid the colors staining each other and affecting the result. To improve the accuracy of the results, the urinalysis dipstick test was repeated 3 times when comparing the colours.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Sociodemographic Background of Study Respondents

Table 1 shows the demographic information of the participants. A total of 62 participants who work in local restaurants and hawker stalls in Kampar, Perak were recruited to participate in the study. Among the 62 participants, 35 (56.5%) were male and 27 (43.5%) were female. The majority of the participants were Chinese (83.9%) with a minority of Malay (6.5%), Indian (4.8%), and foreign workers (4.8%).

Table 4.1 Demographic Information of Participants (n=62)

Demography information		**N (%)**	**Mean (SD)**
Gender	Male	35 (56.5)	-
	Female	27 (43.5)	-
Age (year)		-	41.19 (12.93)
Weight (kg)		-	66.70 (15.34)
Height (m)		-	163.95 (8.52)
BMI (kg/m^2)		-	24.77 (5.10)

SD = Standard deviation

The participants recruited were between 18 to 60 years old. According to the Department of Statistics Malaysia, the working age population of Malaysia is comprised 15 to 64 years old (Institute of Labour Market Information and Analysis, n.d.). Therefore, the participants recruited were within the working population age of Malaysia. The mean age of the total participants was 41 years old. The mean age of male participants was 38, which was 8 years younger than female participants, i.e., 46. The average BMI of the participants was 24.77 kg/m^2. There is not much difference between the mean BMI of male (24.90 kg/m^2) and female participants (24.61 kg/m^2). More than half of the participants are in the healthy weight range, which is between 18.5 kg/m^2 to 24.9 kg/m^2 (Centers for Disease Control and Prevention [CDC], 2022). BMI can influence the body's response to heat stress as obese individuals are more susceptible to heat stress due to the barrier of the subcutaneous fat layer which hinders heat loss and thermoregulation abilities of the body (Speakman, 2018). The majority of the participants (82.3%) have more than 1 year of working experience. The mean working days per week of the participants is about 6 days and the mean working hours of the participants is 9.4 hours per day.

4.2 Environmental Monitoring Data In the Kitchen Area

A normality test was conducted for the data obtained. All the environmental monitoring data are normally distributed as the skewness was ± 2 and the kurtosis was ± 7 (Curran, West, and Finch, 1996). Therefore, the mean and standard deviation of the results were reported in this study. Table 2 shows the average three days of environmental monitoring data at 14 different kitchen areas of the study respondents. The mean ± standard deviation (SD) for WBGT, temperature, relative humidity, and Thermal Work Limit (TWL) of the kitchen areas were 27.2 ± 1.0 °C, 29.9 ± 1.6 °C, 75.2 ± 6.2 %, and 157.5 ± 20.4,.

Table 4.2 Average Three Days of Environmental Monitoring Data At the Worksite of the Respondents (n= 62)

	WBGT (°C)	**Indoor temperature (°C)**	**Humidity (%)**	**Thermal Work Limit**
Mean	27.2	29.9	75.2	157.5
Std. Deviation	1.0	1.6	6.2	20.4
Skewness	-0.5	0.0	-0.2	0.6
Kurtosis	-1.0	-1.5	-1.1	-1.4
Minimum	25.4	27.5	65.2	135.7
Maximum	28.5	32.3	84.2	191.3

WBGT is a measurement of heat stress that takes into account different environmental parameters, i.e., temperature, humidity, wind speed, and solar radiation (Devlin, 2022). The WBGT value obtained from this study was compared against the ACGIH guidelines. All the kitchen workers were identified as having moderate metabolic rate, i.e., 300 watts, due to their work nature which involves moderate hand and arm movement. No clothing adjustment was made, as none of the kitchen workers were found to wear double-layer woven clothing or any coveralls. After estimating the workers' metabolic rates and clothing adjustment factors, the WBGT value of their workplace was compared against the ACGIH heat stress TLV. The overall mean WBGT (27.2°C) in the 14 kitchen areas was below the TLV recommended for moderate work (75 – 100% of work-rest regime) i.e., 28 °C. The kitchen workers working in restaurants in Kampar were identified as having a medium risk of heat stress because the measured WBGT is lower than TLV (28°C) but higher than the action limit (25°C) according to the ACGIH guidelines (Maquiladora Health and Safety Support Network, n.d.). In this study, 4 out of the 14 kitchen areas (28.6%) have exceeded the TLV recommended for moderate workload, i.e., 28 °C. Whereas all 14 kitchen areas exceeded the action limit of 25°C recommended by ACGIH, and are advised to apply general controls recommended by the guidelines.

The measurement of WBGT (27.2 ± 1.0 °C) in this study is similar to another study conducted by Siti Marwanis Anua et al. (2021) with a mean WBGT of 28.2±0.8 ºC across 14 kitchens of food stalls and cafeterias in Kelantan, Malaysia. The WBGT measured in that study was slightly higher than the TLV value recommended by ACGIH for a moderate workload. In another study conducted in New York City, the overall mean WBGT of 10 public school kitchens was 25.0 °C±2.0 ºC (Ierardi and Pavilonis, 2020). None of the kitchens exceeded the TLV recommended by ACGIH for a moderate workload. However, 60% of the kitchen areas were found to exceed the action limit for moderate workload. Thus, the kitchen workers in the New York City Public School were also identified as having a low to medium risk of heat stress similar to the finding of this study.

However, the mean WBGT of 27.2 ± 1.0 °C in this study was much lower than the finding of another study conducted in hospital kitchens in Cairo, Egypt with a mean WBGT of 32.4±1.4°C, which exceeded the TLV recommended by ACGIH of 28°C and identified as having a high risk to heat stress (Saif Eldin et al., 2022). This study was conducted in Cairo, Egypt from April to May, where the average temperature was around 28.3°C and 32°C (Weather Atlas, n.d.), which is similar to the average temperature of Malaysia during the data collection period of this study, which is about 24°C to 32°C in January (Weather & Climate, n.d.). The higher value of WBGT recorded in the study is possibly due to exposure to radiant heat which is exacerbated by the poor ventilation in the kitchen area as explained by Saif Eldin et al., (2022). In the study conducted by Saif Eldin et al., (2022), the majority of the studied workers (92.5% of the directly heat-exposed group and 89.4% of the indirectly heat-exposed group) reported insufficient ventilation in the kitchens. The poor air movement in the kitchen area may be a contributor to the higher WBGT measurement. However, in this study, most of the kitchen areas had good ventilation with an open-air kitchen or with at least one exhaust fan or ventilator. Thus, this difference in the measurement of WBGT in the kitchen areas can be explained by different ventilation conditions in the kitchen. WBGT values are affected by windspeed, thus, with better ventilation in kitchen areas, the WBGT values will be lower.

Another study conducted among bakeries in Assiut City, Egypt also shows a much higher mean WBGT value, i.e., 31.6 °C, which also exceeded the TLV recommended by ACGIH and identified as having a high risk of heat stress (Rabeiy, 2018). According to Rabeiy (2017), the average temperature of Assiut City can reach up to 44 °C during summer days. Thus, the higher WBGT value in this study could be due to the higher ambient temperature in Assiut City compared to Kampar, Perak, Malaysia.

Humidity is the measure of the amount of water vapor or moisture content in the air. There is no specific legislation that manages relative humidity in the kitchen environment in Malaysia. However, there are guidelines concerning relative humidity in indoor environments, particularly offices. According to the Malaysia Industry Code of Practice on Indoor Air Quality 2010, the acceptable range for indoor relative humidity is 40 – 70% (DOSH, 2010). Although this ICOP is mainly focused on indoor environments, particularly offices, it generally shows the range of relative humidity that is comfortable for indoor workers.

In a study conducted by Djamila, Chu, and Kumaresan (2014) in Kota Kinabalu, Malaysia, the calculated mean relative humidity corresponding to a normal temperature of 30˚C is around 73%, which means that in a neutral environment of 30˚C, a comfortable range of relative humidity is about 73%. In this study, the mean humidity value measured for 14 kitchen areas was 75.2 ± 6.2 % (with a range of 65.2 – 84.2%) which exceeded the comfortable limit of relative humidity established by DOSH as well as from the research conducted by Djamila, Chu, and Kumaresan (2014). This shows that the kitchen areas in this study were too humid and may cause discomfort to the kitchen workers. The mean relative humidity measured in this study is similar to another study conducted in domestic kitchens in the Jorhat district of Assam, India, with a mean humidity value of 75.65% and a range of 64.30 – 87.00% (Sangma and Kalita, 2023). The high humidity level found in the kitchen area may be due to condensation of water vapor from the cooking process as well as washing. Humidity level is one of the factors that affect heat stress in the workplace as high humidity may exacerbate heat stress by hindering the process of evaporation of sweat from the skin to cool down the body during heat exposure (Baldwin et al., 2023).

Thermal Work Limit (TWL), measured as metabolic heat per body surface area (W/m^2), is an index that takes into account five environmental parameters, including dry bulb, wet bulb, wind speed, globe temperature, and atmospheric pressure. It is used to determine the maximum sustainable metabolic rate that an acclimatized individual can maintain in a hot environment with a normal core body temperature of less than 38.2°C and a sweat rate of <1.2 kg/h (Ahmed et al., 2019). TWL is regarded as a simple and reliable indicator to predict the impact of heat stress (Ahmed et al., 2020). TWL is categorized into four zones with a higher value indicating the thermal conditions do not impose any restrictions on work. According to Miller and Bates (2017), the four zones of TWL are restricted access (TWL<115 W/m^2), buffer (115 W/m^2 < TWL < 140 W/m^2), acclimatization (140 W/m^2 < TWL < 220 W/m^2), and unrestricted (TWL > 220 W/m^2), that with different interventions recommended for each zone.

In this study, the overall mean TWL measures in 14 different kitchen areas were 157.5 ± 20.4 W/m^2, with a range of 135.7 – 191.3 W/m^2, which falls under the low risk, acclimatization zone (140 – 220 W/m^2). This means that workers who are unacclimatized should not be allowed to work alone in this zone (Ahmed et al., 2019). This finding is similar to a study conducted in one of the construction sites in Iran. The mean WBGT obtained for the construction site was 27.5 ± 1.2 °C, which is close to the WBGT value obtained in this study, and the mean TWL measured in the site was 144 ± 9.8 W/m^2, which is also located within the low-risk, acclimatized zone, similar to this study (Farshad et al., 2014).

4.3 Heat-Related Symptoms Among Study Respondents

Table 3 shows the frequency of self-reported symptoms by the participants. All the participants were asked to report their heat-related symptoms during work for the past 1 year in the questionnaire. The options provided were “never”, “rarely”, “sometimes”, “often”, or “every day”. For data analysis, “sometimes”, “often”, and “every day” were grouped into one “ever” variable. In this study, the participants were defined as having heat-related illness if they reported “ever” for two or more symptoms accompanied by heavy sweating or dizziness (Kiatkitroj et al., 2021). In this study, 24 (38.7%) of the participants were identified as having heat-related illness.

Table 4.3 Frequency Table For Self-Reported Heat-Related Symptoms By the Study Respondents (n=62)

Heat-related symptoms	**Frequency (%)**				
	Never	**Rarely (1-3 times/ year)**	**Sometimes (1-3 times/ month)**	**Often (1-6 times/week)**	**Everyday**
Heavy sweating	17 (27.4)	10 (16.1)	7 (11.3)	10 (16.1)	18 (29.0)
Weakness/fatigue	19 (30.6)	10 (16.1)	18 (29.0)	8 (12.9)	7 (11.3)
Dizziness	45 (72.6)	9 (14.5)	8 (12.9)	0 (0.0)	0 (0.0)
Muscle cramps	38 (61.3)	10 (16.1)	13 (21.0)	1 (1.6)	0 (0.0)
Headache	38 (61.3)	9 (14.5)	13 (21.0)	2 (3.2)	0 (0.0)
Rash on skin	51 (82.3)	6 (9.7)	2 (1.6)	1 (1.6)	2 (3.2)
Irritability	36 (58.1)	7 (11.3)	16 (25.8)	0 (0.0)	3 (4.8)
Nausea	56 (90.3)	5 (8.1)	1 (1.6)	0 (0.0)	0 (0.0)
Dry and cracking skin	46 (74.2)	6 (9.7)	8 (12.9)	1 (1.6)	1 (1.6)
Vomiting	58 (93.5)	3 (4.8)	1 (1.6)	0 (0.0)	0 (0.0)
Swelling hands and feet	58 (93.5)	1 (1.6)	3 (4.8)	0 (0.0)	0 (0.0)
Blisters on skin	57 (91.9)	3 (4.8)	1 (1.6)	1 (1.6)	0 (0.0)
Fainting	62 (100)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Thirst	21 (33.9)	9 (14.5)	16 (25.8)	8 (12.9)	8 (12.9)

Among all the heat-related symptoms, the most frequently reported symptoms experienced by the workers were heavy sweating (45.1%), followed by thirst (25.8%), and weakness/fatigue (24.2%). None of the participants reported they experienced fainting. In the study conducted among kitchen workers in Cairo, Egypt, the most reported heat-related symptoms are excessive sweating (85%), fatigue (82.5%), headache (82.5%), and excessive thirst (72.5%) (Saif Eldin et al., 2022). In a study conducted among gong factory workers in Bogor, Indonesia, the three most frequently reported heat-related symptoms were sweating (61.1%), thirst (61.1%), and tired (61.1%) (Puspita et al., 2018). Both of these studies supported that heavy sweating, thirst, and fatigue are the common symptoms experienced by heat-exposed workers.

4.4 Kidney Health: Kidney-Related Symptoms And Urinary Dipstick Test

Table 4.4 shows the frequency of self-reported kidney-related symptoms among the participants. Among all the kidney-related symptoms, only 8.1% (5) participants reported urinating frequently but very little urine each urination, 6.4% (4) reported cloudy urine, and 3.2% (2) reported having pain or burning sensation during urination. The rest of the participants did not experience any kidney-related symptoms.

Table 4.4 Frequency Table For Self-Reported Kidney-Related Symptoms Among the Study Respondents (n=62)

Kidney-related symptoms	**Frequency (%)**				
	Never	**Rarely (1-3 times/ year)**	**Sometimes (1-3 times/ month)**	**Often (1-6 times/week)**	**Everyday**
Pain/burning sensation when urinating	56 (90.3)	4 (6.5)	2 (3.2)	0 (0.0)	0 (0.0)
Blood in urine	61 (98.4)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)
Cloudy urine	55 (88.7)	3 (4.8)	4 (6.5)	0 (0.0)	0 (0.0)
Urinary tract infections/ inflammation	56 (90.3)	5 (8.1)	1 (1.6)	0 (0.0)	0 (0.0)
Kidney stones	61 (98.4)	1 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)
Urinating frequently but very little urine each urination	51 (82.3)	6 (9.7)	4 (6.5)	1 (1.6)	0 (0.0)

In this study, urinary dipstick tests were conducted two times, which were, pre-shift and post-shift for 53 study participants to analyze ten parameters in the urine sample, with each indicating different health complications.

In this study, none of the participants had abnormal values for Urobilinogen. If Urobilinogen level ⩾17 µmol/L, it is an indicator of liver disease, i.e., cirrhosis. Two (3.8%) of the morning urine samples and none of the evening urine samples detected with glucose value of ⩾5.6 mmol/L, which may indicate diabetes mellitus. None of the participants detected ketone exceeding 1.0 mmol/L, which is an indicator of diabetes. None of the urine samples detected Bilirubin, which is an indicator of liver damage or jaundice. One (1.9%) urine sample in the morning and 2 (3.8%) urine samples in the evening detected contained traces of protein that were more than the normal range (⩾0.3 g/L) which might indicate kidney problems or loss of kidney function.

Next, 7.6% of the pre-shift samples and 3.8% of post-shift samples detected blood in their urine exceeding the normal range, i.e., ⩾15 cells/µL which may indicate kidney damage, infection, kidney or bladder stones, or other problems. However, the detection of blood in urine may be affected by menstruation (all the positive cases for detection of blood were female participants), causing false positive results. Next, 9.4% of the pre-shift urine samples and 7.5% of post-shift urine samples detected leukocytes exceeding the normal range of ⩾15 cells/µL, which may indicate urinary tract infection. Overall, the majority of the participants obtained negative test results for urobilinogen, glucose, ketone, bilirubin, protein, blood, and leukocytes in their urine samples. This finding is in accordance with the study conducted by Boonruksa et al. (2020), which also reported a high percentage of negative results for glucose, protein, blood, and leucocytes measured among sugarcane cutters. Another study conducted among female rice farmers in Thailand also reported a majority of negative test results for glucose (100%), blood (80%), protein (78.5%), and leukocytes (76.9%) (Arphorn et al., 2021), which were similar to the findings of the study.

In the current study, 70% and 64.2% of pre-shift and post-shift urine samples were measured with acidic urine (pH ≤ 5.5). This finding is in accordance with the study by Boonruksa et al. (2020) from Thailand where 70% of sugarcane cutters and 50% of factory workers were found to have acidic urine for both pre-shift and post-shift. Similar findings are also found in sugarcane cutters in El Salvador (García-Trabanino et al., 2015) and Nicaragua (Wesseling et al., 2016), which also reported low urinary pH among sugarcane cutters. Another study conducted in Thailand shows that 83% of female rice farmers had an acidic pH of 5 – 6 (Arphorn et al., 2021). This similar trend of findings shows that heat-exposed workers are more likely to have acidic urine as supported by this study. Generally, a urine pH value of 4.5 to 8.0 is not of great concern. However acidic urine can create an environment that favors the development of kidney stones (Nall, 2022). According to Boonruksa et al. (2020), the acidic urine may be due to lactate formation by muscle, the effect of aldosterone, and volume depletion due to heat, exercise, and recurrent dehydration.

Next, Urinary Specific Gravity (USG) is an indicator of the workers' hydration status. In the urinary test, 41.5% and 32.1% of pre-shift and post-shift urine samples were measured with a USG of 1.030 which indicates dehydration. This finding is similar to the finding of Arphorn et al. (2021) which reported that 38.5% of participants had a USG of 1.030 among female rice farmers. However, the decrease in the percentage of dehydrated participants (USG ≥ 1.030) in post-shift urine samples contradicts the findings of Boonruksa et al. (2020) which reported dehydrated participants (USG ⩾ 1.030) has increased by 36.6% post-shift as compared to pre-shift. Results of higher USG in post-urine samples are anticipated as the workers are expected to become more dehydrated due to water loss through sweat while at work. However, the results obtained contradict the initial expectations probably due to the period of data collection was carried out during off-peak season (during semester break when the majority of the students were not around), the participants had more time to rest and rehydrate, which caused a decrease in USG as observed in the urinary test.

Wilcoxon signed-rank test was conducted to compare urinalysis results pre-shift and post-shift (Table 4.5). There were no statistically significant differences in the pre-shift and post-shift urine samples. However, there was a significant difference in the concentration of urobilinogen between pre-shift and post-shift urine samples (p=0.046). There was a cross-shift increase of urobilinogen detected in the urine samples. According to Kawthalkar (2010), the amount of urobilinogen excreted through urine fluctuates throughout the day with the highest levels observed in the afternoon. This probably explains the cross-shift increase of urobilinogen as the post-shift urine samples were collected during the late afternoon.

Table 4.5 Comparison Between Morning And Evening Urine Test Parameters of the Study Respondents (n=53)

Urine test parameters	Morning urine sample	Evening urine sample	Average	z-value	p-value
	Median (IQR)	Median (IQR)	Median (IQR)		
Urobilinogen (µmol/L)	0.000 (16.000)	0.000 (16.000)	0.000 (16.000)	-2.000	**0.046***
Glucose (mmol/L)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-1.342	0.180
Ketone (mmol/L)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-1.000	0.317
Bilirubin (µmol/L)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000	1.000
Protein (g/L)	0.150 (0.150)	0.150 (0.150)	0.150 (0.150)	-0.243	0.808
Nitrite (µmol/L)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-1.414	0.157
pH	5.000 (1.000)	5.000 (1.000)	5.000 (1.000)	-1.916	0.055

Blood (cells/µL)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-1.084	-.279
Specific Gravity	1.025 (1.010)	1.025 (1.010)	1.025 (1.010)	-1.201	0.230
Leukocyte (cells/µL)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.707	0.480

*p<0.05

4.5 Relationships Between Heat-Related Illnesses And Kidney Health of Kitchen Workers

A Mann-Whitney U test was conducted to identify the association between urine test parameters and heat-related illnesses (Table 4.6). There was no significant association found between the urine test parameters and heat-related illnesses as $p > 0.05$. The association between heat-related illnesses and self-reported kidney-related symptoms was not further investigated using statistical tests because only 1 participant reported "urinating frequently but very little urine each urination" for "1-6 times per week". Table 4.6 shows the results of the association between urine test parameters and heat-related illness.

Table 4.6 Association Between Urine Test Parameters And Heat-Related Illness Among the Study Respondents (n=53)

Urine parameters	**No heat-related illnesses**	**Heat-related illnesses**	**Z**	**p-value**
	(Mean rank)	**(Mean rank)**		
Urobilinogen (µmol/L)	27.780	25.810	-0.521	0.602
Glucose (mmol/L)	27.660	26.000	-1.157	0.247
Ketone (mmol/L)	27.330	26.500	-0.810	0.418
Bilirubin (µmol/L)	27.000	27.000	0.000	1.000

Protein (g/L)	28.420	24.830	-0.874	0.382
pH	28.090	25.330	-0.724	0.943
Blood (cells/µL)	26.940	27.10	-0.72	0.943
Specific Gravity	25.550	29.210	-0.862	0.389
Leukocyte (cells/µL)	27.410	26.380	-0.430	0.667

Across the shift, it is expected to detect an increase in the percentage of urine samples with protein, USG, and leukocytes. This is because, after working in a hot environment for a few hours, the body is expected to lose water through sweating. Without proper rehydration, the body can be depleted of water content, causing dehydration. As discussed in the literature review, reduced water content will lead to decreased ECF which will lead to a decrease in blood volume as well. The reduced blood volume causes a reduction in blood filtration by kidneys (lower glomerular filtration rate), thus, some substances, i.e., protein may escape due to reduced filtration efficiency of kidneys and be excreted in the urine (Borg et al., 2017). Excretion of protein in the urine is known as proteinuria. Next, Boonruksa et al. (2020) reported a 9% increase in leucocytes in urine post-shift, which is also expected to be observed in this study. Based on the theory, the decreased water content in the urine will cause an increase in bacterial concentration as well as a reduction in the “flushing out” of bacteria from the body, which can cause bacterial infection in the urinary tract, which could be detected by the presence of leukocytes in urine (Borg et al., 2017). However, the trend of increasing leukocytes in post-shift urine samples was not observed in this study. Post-shift urine samples are also expected to have higher USG due to decreased water content and more concentrated urine after work. However, this trend was not observed in this study as well.

There could be a few possible reasons leading to a lack of association between the urine parameters of the pre-shift and post-shift with heat-related illnesses. Firstly, the timeline for conducting the urinalysis dipstick test might not be aligned with the timeline of heat-related illnesses of the participants. This is because the participants were asked to self-report their heat-related symptoms for the past 1 year, not on the day when conducting the urinalysis test. So, the participants may not have experienced any heat-related symptoms during the day when the urinalysis test was conducted. Besides, there may also be other variables that have not been taken into account when analyzing the results. For instance, the medications and supplements taken by the participants were not taken into account in this study, which may be an important factor affecting the urinalysis results. For instance, taking antibiotics may cause false positive results for USG, and taking vitamin C may cause false negative results in detecting blood and bilirubin (Ministry of Health, n.d.). Thus, the medications of the participants may play a role in affecting the accuracy of the urinalysis results leading to no significant association being determined. Another reason as previously discussed was the data collection period was conducted during the off-peak season of the kitchen workers due to a lack of customers (students) during the end of the semester and semester break. This could cause the data collected to only represent the heat stress exposure of the participants during the off-peak season. For instance, when there were few customers, the participants tended to have more breaks and could rehydrate themselves more than usual, and could stay hydrated even after their work shift. All of these reasons could lead to the lack of associations between the urinalysis test results and heat-related illnesses.

4.6 Relationships Between Demographic Factors, Living Habits, and Work-Related Factors With Self-Reported Heat-Related Symptoms

Following that, Mann-whiney U tests were conducted to determine the association between demographic factors, living habits, and working factors with heat-related symptoms as shown in Tables 4.7, 4.8, and 4.9.

Table 4.7 Relationship Between Demographic Factors And Self-Reported Heat-Related Symptoms (n=62)

	Gender		**Age**		**Height**		**Weight**		**BMI**	
Heat-related symptoms	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**
Heavy sweating	418.000	0.368	449.500	0.744	432.500	0.569	424.500	0.495	423.500	0.487
Weakness/fatigue	335.000	0.18	426.500	0.463	431.500	0.506	418.000	0.393	427.500	0.472
Dizziness	138.000	0.057	204.000	0.801	174.000	0.376	177.500	0.418	188.000	0.557
Muscle cramps	308.000	0.583	280.500	0.350	267.500	0.247	321.000	0.800	323.000	0.827
Headache	336.000	0.752	325.500	0.657	349.500	0.961	320.000	0.593	336.000	0.786
Rash on skin	137.000	0.869	111.500	0.422	129.000	0.726	111.500	0.423	113.500	0.453
Irritability	386.000	0.689	297.000	0.860	397.500	0.866	394.000	0.825	390.500	0.783
Nausea	13.000	0.255	29.000	0.933	4.000	0.137	18.500	0.502	9.000	0.230
Dry and cracking skin	290.000	0.256	2245.000	0.774	228.000	0.539	141.500	**0.023***	158.000	0.051
Vomiting	17.000	0.380	18,500	0.502	28.000	0.889	12.500	0.314	12.000	0.301
Swelling hands and feet	67.000	0.412	47.500	0.178	65.000	0.439	88.000	0.987	80.000	0.780
Blisters on skin	56.000	0.853	35.500	0.329	60.000	1.000	56.000	0.873	57.500	0.921
Thirst	478.000	0.974	424.500	0.434	470.500	0.893	439.000	0.563	447.000	0.642

*p<0.05

There was no significant association found between gender, age, and BMI with heat-related symptoms. However, in this study, there was a significant association between weight and dry and cracking skin ($P<0.05$), while the association between BMI and dry and cracking skin was nearly significant ($P=0.051$). A study conducted by Ye et al. (2022) found that BMI significantly correlated negatively with stratum corneum hydration levels in the forearm (in both females and males) and shin (only in females) of the study participants, which means that people with higher BMI tend to have more dry skin (due to lower stratus corneum hydration levels). Another study conducted by Mori et al. (2017) also discovered that obese skin tended to have higher surface roughness and lower water content which further proves the relationship between weight and dry skin. However, in this study, this is not the case as the majority of the participants who reported having dry and cracking skin were of lower weight. This association observed in this study may occur due to chance.

Table 4.8 Relationship Between Living Habits And Self-Reported Heat-Related Symptoms (n=62)

	Frequency of drinking alcohol		**Frequency of smoking**		**Amount of water drink per day**		**Frequency of drinking caffeinated drinks**	
Heat-related symptoms	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**
Heavy sweating	412.500	0.303	464.500	0.881	426.000	0.483	472.000	0.993
Weakness/fatigue	417.500	0.298	454.500	0.657	435.500	0.519	464.000	0.810
Dizziness	209.000	0.859	184.000	0.378	188.500	0.539	190.000	0.522
Muscle cramps	307.000	0.555	272.000	0.157	291.500	0.426	330.500	0.914
Headache	321.500	0.538	321.000	0.497	310.000	0.457	341.000	0.825
Rash on skin	132.500	0.755	134.500	0.786	134.500	0.826	128.500	0.671
Irritability	332.500	0.161	376.000	0.515	407.000	0.981	390.000	0.740
Nausea	20.500	0.499	22.500	0.557	19.500	0.513	19.500	0.471
Dry and cracking skin	238.000	0.611	180.000	**0.044***	169.000	0.064	182.000	0.080
Vomiting	20.500	0.499	22.500	0.557	18.000	0.458	0.500	**0.049***
Swelling hands and feet	58.500	0.234	64.500	0.301	62.500	0.364	55.500	0.204
Blisters on skin	40.000	0.336	44.000	0.403	58.500	0.949	38.000	0.304
Thirst	457.000	0.695	424.500	0.305	386.000	0.159	448.500	0.603

*$p<0.05$

In this study, there was no significant association identified between the frequency of drinking alcohol and the amount of water drunk per day with heat-related illnesses. There was a significant association between smoking and dry and cracking skin ($P<0.05$). However, the association found in this study might occur due to chance as no dry and cracking skin was reported among all the 16 smokers. Theoretically, smoking is damaging to skin cells and is a risk factor for skin aging and wrinkles. A study conducted by Langton et al. (2020) showed that there was a significant loss of elastic fibre architecture in the skin of smokers as compared to non-smokers, which shows the damaging effect of smoking on the skin. Dry skin could be one of the possible long-term health effects of smoking. However, in this study, the years of smoking of the participants were not investigated which limits further data analysis.

Besides, there was also a significant association between the frequency of drinking caffeinated drinks and vomiting ($P<0.05$). Drinking caffeinated drinks has beneficial effects, such as increased attentiveness and energy as well as enhanced mood. However, due to the stimulant effects of caffeine, excessive drinking of caffeinated drinks exceeding certain doses was found to cause hypertension, headache, gastrointestinal disturbances as well as insomnia (Saraiva et al., 2023). In this study, it was found that the participants who reported vomiting symptoms rarely drank caffeinated drinks. This association could be explained by participants who have vomiting feeling will tend not to drink caffeinated drinks as caffeinated drinks possess stimulant effects which may worsen the feeling of nausea and vomiting. Therefore, the participants who reported frequent vomiting tended to avoid caffeinated drinks.

Table 4.9 Relationship Between Working Factors And Self-Reported Heat-Related Symptoms (n=62)

	Months of working		**Working days per week**		**Working hours per day**		**Feeling about their work**	
Heat-related symptoms	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**	**U**	**p-value**
Heavy sweating	469.500	0.966	451.000	0.736	456.000	0.810	339.500	**0.039***
Weakness/fatigue	471.000	0.915	376.000	0.110	465.000	0.845	340.500	**0.033***
Dizziness	154.000	0.189	167.500	0.261	168.000	0.301	122.000	**0.031***
Muscle cramps	306.500	0.617	327.000	0.867	276.500	0.304	240.500	0.078
Headache	318.000	0.567	299.500	0.336	327.500	0.673	289.500	0.257
Rash on skin	121.500	0.584	109.000	0.339	126.500	0.671	98.000	0.207
Irritability	401.000	0.908	378.000	0.607	344.000	0.312	285.000	**0.039***
Nausea	5.500	0.159	8.500	0.174	20.500	0.566	19.500	0.501
Dry and cracking skin	177.000	0.109	210.000	0.290	254.000	0.906	214.500	0.340
Vomiting	21.000	0.592	8.500	0.174	17.000	0.439	14.500	0.327
Swelling hands and feet	47.500	0.175	48.000	0.142	82.000	0.827	66.000	0.419
Blisters on skin	28.500	0.206	41.500	0.415	56.500	0.886	21.500	0.093
Thirst	470.500	0.893	425.000	0.392	424.500	0.423	455.500	0.705

*$p<0.05$

There was no significant association found between months of working, working days, and working hours with heat-related symptoms. However, there was a significant association between how hard the participants felt about their work with heavy sweating, weakness/fatigue, dizziness, and irritability. In this study, the more the participants feel hard about their work, the more frequently they experience heavy sweating, weakness/fatigue, dizziness, and irritability. This is because, the participants who reported their work was hard, probably had a higher workload and less rest time. Therefore, they may be more susceptible to heat-related illnesses. They may sweat more due to a higher workload as the metabolism of the body will also produce heat, accompanied by a longer time working with the heat source, thus experiencing heavy sweating for body thermoregulation. Besides, when they work longer with the heat source, they also feel fatigued easily as they do not have time to rest and replenish themselves. The body constantly works to dissipate heat which makes them feel fatigued easily. Working with heat for a long time will cause the body to respond to the increased body temperature by increasing blood flow to the skin to dissipate heat which will compromise the blood flow to the brain and cause dizziness. Not only that, but the participants will also tend to be more irritated if they feel fatigued about their work. Thus, all of these symptoms were frequently reported among workers who think their work is hard.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Climate change has caused an increase in the number of hot days and heat waves globally, leading to an increase in heat-related illnesses as well as kidney complications around the globe. Malaysia, particularly, has been impacted by longer and hotter heat waves and there is an increase in heat-related illnesses being reported during heat waves. Heat-exposed workers are particularly vulnerable to climate change and extreme heat events, including kitchen workers who are one of the high-risk indoor occupations for heat stress exposure. To determine heat stress exposure, the prevalence of heat-related symptoms and illnesses, and its association with kidney health, a cross-sectional study has been conducted among 62 kitchen workers in Kampar, Malaysia.

From the study, the overall mean WBGT measured across 14 kitchen areas in local restaurants or food stalls was 27.2 ± 1.0 °C. Kitchen workers in Kampar are regarded as having a medium risk of heat stress as the WBGT value is lower than the TLV but higher than the action limit as recommended by the ACGIH guidelines. In this study, WBGT values for 28.6% of the kitchen areas exceeded the TLV, and 100% of kitchen areas exceeded the action limit recommended by ACGIH for moderate workload. The prevalence of heat-related illnesses in this study was 38.7%. The most reported heat-related symptoms were heavy sweating (45.1%), thirst (25.8%), and weakness/fatigue (24.2%). From the urinalysis dipstick test, it was found that the majority of the participants (70% of pre-shift urine samples and 64.2% of post-shift urine samples) had acidic urine (pH $\leqslant$ 5.5). Acid urine is found to be common among heat-exposed workers. The urinary dipstick tests also showed that 41.5% and 32.1% of pre-shift and post-shift urine samples were dehydrated with a USG of 1.030. There were no significant differences between the urine parameters in the urinalysis dipstick test pre- and post-shift. There was also no significant association determined between kidney health and heat-related illnesses among the study respondents. Frequency of drinking caffeinated drinks was negatively related to vomiting symptoms (U=0.500, p=0.049), while the perception of respondents on feeling hard about their work was positively related to heavy sweating (U=339.5, p=0.039), weakness or fatigue (U=340.5, p=0.033), dizziness (U=122.0, p=0.031) and irritability (U=285.0, p=0.039).

This study is important as it investigated the heat exposure of kitchen workers and heat-related symptoms experienced by kitchen workers which can help in developing mitigation strategies to protect the safety, health, and well-being of the workers. From the study, it can be concluded that the kitchen workers in Kampar are identified as having a medium risk of heat stress exposure. Thus, general controls recommended by DOSH and ACGIH guidelines should be implemented to mitigate the risks of heat-related illnesses. Even though no significant association was established between heat-related illnesses with kidney health in this study, more studies should be conducted to explore the relationship of heat stress with kidney health among heat-exposed workers in Malaysia, not limited to kitchen workers, as there is increasing evidence from other studies that the prevalence of kidney-related diseases, such as UTI, kidney stones, AKI, and CKD increases during heat waves and among heat-exposed workers. Besides, more studies should also be conducted to further investigate risk factors that affect heat-related symptoms of workers so that prevention measures can be taken to tackle the risk factors.

5.2 Study Limitation

This study is subjected to a few limitations. Firstly, the small sample size of this study has insufficient statistical power for the research question in the study. A small sample size may cause the statistical analyses to be underpowered which affects the reliability and validity of the results and at risk of type II or false-negative error. Although this study meets the minimum sample size needed, 62 participants (53 participants for the urinalysis dipstick test), it may be insufficient to generalize the results to a larger population. Next, this study is a cross-sectional study that identifies the kidney health of the participants in a single period. The participants may not show any kidney-related complications as detected in the urinalysis dipstick test during the data collection period which makes it hard to associate these parameters with heat-related illnesses. The third study limitation of this study was the data collection was conducted during the off-peak season. The population in Kampar is greatly affected by the population of the students. Thus, during the semester break, the population in Kampar will reduce substantially, affecting the business of local restaurants and food stalls. The reduction in business in local restaurants and food stalls causes the kitchen workers to have more time to rest and rehydrate themselves, causing the results of environmental monitoring and urinalysis dipstick tests to be affected and unable to represent the normal conditions of the participants.

There are also limitations to the detection of kidney health in this study. Firstly, the urinalysis dipstick test is only a screening test for kidney disease, and it is not the most accurate and reliable method to analyze the kidney health of the participants. However, due to financial and resource constraints, the urinalysis dipstick test is the best available method for this study. The urinalysis dipstick test used to analyze the kidney health of the participants may be subjected to inaccuracy due to the deterioration of the dipstick. The quality of the dipstick may deteriorate due to poor storage conditions which may cause the dipstick to be exposed to moisture and affect the accuracy of the results. Besides, the urinalysis dipstick test is also subjected to false-positive or false-negative results due to diet, medications, or exposure to sunlight. Not only that but the color of the urinalysis dipstick is being compared by the human eye which may be subjected to bias and human error. Furthermore, during the collection of urine, the urine may be subjected to deterioration because the urine is stored in a container with ice for a few hours before being analyzed in the laboratory. The temperature of the container may not be cold enough to preserve the urine samples which may cause the degradation of urine samples and affect the results of the urinalysis dipstick test.

Not only that but a lot of factors are not being taken into account when conducting the urinalysis dipstick test. For instance, the most accurate way of conducting a urine test is to take the first urine sample in the morning. However, this could not be done in this study due to difficulty in matching the timing of the participants. Moreover, the urine samples are collected at inconsistent intervals and timing due to variations in the schedules of the participants. Some urine samples are collected at shorter intervals, i.e., less than 6 hours, which can cause variability in the results obtained as urine compositions may fluctuate throughout the day. Besides, human psychology may also play a role in affecting the accuracy of the urine test. Based on observations during the urine sample collection, the participants tended to drink more water than usual when they knew they were undergoing urine tests. This behavior may be influenced by the phobias of the participants to detect any positive results in their urine. This factor may contribute to the observation of increased hydrated participants in the post-shift urine test.

Next, this study mainly relies on the questionnaire for the participants to self-report their heat-related symptoms and kidney-related symptoms for the past 1 year. The accuracy of the results may be affected by recall bias of the participants. The participants may under- or over-report their symptoms which will affect the accuracy and reliability of the results.

Thus, various factors and limitations affect the accuracy and reliability of the results which probably also lead to the failure in detecting significant associations in this study.

5.3 Recommendation

5.3.1 Recommendations for Future Studies

To improve the accuracy and reliability of similar future studies, a few improvements can be made. Firstly, increase the sample size and diversity of the study. A larger sample size can improve the statistical power of the study. A larger sample size also increases the validity of the study and enables the findings to be extrapolated and generalized to a broader population. Next, similar future studies can consider using a longitudinal study design instead of a cross-sectional design. This is because the changes in kidney health and the progression of kidney disease generally need a long period to be detected. Thus, conducting a longitudinal study, e.g., across a few months or years can increase the reliability of the results and enable the detection of significant associations between heat-related illnesses with kidney health. Besides, future similar studies can also consider incorporating control groups to compare the findings between the exposed and non-exposed groups. This can help the researchers to compare and establish significant differences between exposed and non-exposed groups to increase the validity of the results. A replication study is also encouraged to be conducted in different regions or heat-exposed groups in Malaysia to validate the findings of this study and overcome the limitations encountered in this study.

Next, if finances and resources are not a constraint, researchers should consider using a more reliable method in analyzing kidney health. For instance, a blood test is a more reliable method of detecting the reduced kidney functions of the participants by measuring the glomerular filtration rate. If the urinalysis dipstick test is still going to be employed in future studies, the methods of storage and preservation of urine samples should be improved to prevent the degradation of urine samples. For instance, the urine samples must be kept under a temperature of 4 °C and not longer than 24 hours or use urine preservatives, such as boric acid to preserve the urine samples. Efforts should also be made to ensure more consistent intervals of urine sample collection to reduce potential variability in the urine test results and improve accuracy. Besides, the accuracy of the urine test results can be improved by conducting briefings regarding the protocols of the urine test and their importance to the participants beforehand to ensure that they follow the protocol during urine collection. This can prevent the participants from intentionally drinking more water during the period of urine sample collection which will affect the accuracy of results.

5.3.2 Recommendations for Study Respondents

There are also several recommendations for kitchen workers who are exposed to a medium risk for heat stress as per the findings of this study. According to ACGIH guidelines, a few general controls should be implemented to mitigate heat stress in the workplace including kitchen areas. Firstly, kitchen workers should be encouraged to drink a small volume of cool and clean water every 20 minutes to keep themselves hydrated. Kitchen workers should also be educated about heat stress and its effects as well as mitigation measures to increase their awareness. Kitchen workers should be taught how to recognize signs of heat-related illnesses as well as proper interventions to safeguard their health and well-being. Kitchen workers are also encouraged to self-limit their heat exposure. For instance, if they have been exposed to the heat source for a period, they should take a break and move to a cooler place to allow the body to cool down. Besides, kitchen workers are also encouraged to maintain a healthy lifestyle, such as maintaining an ideal body weight and reducing smoking or consumption of alcohol which will subject them to a higher risk of heat-related illnesses (Maquiladora Health and Safety Support Network, n.d.).

Kitchen workers are also encouraged to wear light summer clothing to allow effective sweat evaporation and free air movement. Light-coloured or reflective clothing is also recommended to minimize heat being trapped in clothing during work (Siti Marwanis Anua et al., 2021). Besides, personal water bottles on the job should be provided to kitchen workers to encourage the workers to drink small volumes of water frequently to replenish themselves. Employers should also implement better ventilation methods in kitchen areas to ensure sufficient airflow and air movement to reduce the risk of heat stress for kitchen workers (Singh et al., 2016). Furthermore, it is also encouraged to conduct environmental monitoring in the kitchen areas, i.e., measuring the WBGT and workplace temperature to ensure that the workplace conditions do not exceed the acceptable limit. Lastly, kitchen workers are also encouraged to conduct regular health monitoring for early detection and treatment of kidney or other diseases before they progress into severe chronic diseases (Saif Eldin et al., 2022).

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APPENDICES

Appendix 1 Ethical Approval For Research Project

UNIVERSITI TUNKU ABDUL RAHMAN DU012(A)
Wholly owned by UTAR Education Foundation Co. No. 578227-M

Re: U/SERC/282/2023

3 November 2023

Prof Dr Mohammed J. K. Bashir
Head, Department of Environmental Engineering
Faculty of Engineering and Green Technology
Universiti Tunku Abdul Rahman
Jalan Universiti, Bandar Baru Barat
31900 Kampar, Perak.

Dear Prof Dr Mohammed,

Ethical Approval For Research Project/Protocol

We refer to the application for ethical approval for your students' research projects from Bachelor of Science (Honours) Environmental, Occupational Safety and Health programme enrolled in course UGNB4916. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
1.	The Challenges Towards Complying with the OSH (Amendment) Act 2022 from the Perspective of Safety and Health Officer	Yew Li Bing	Ts Chin Yik Heng	3 November 2023 - 2 November 2024
2.	A Cross Sectional Study of Heat Stress Exposure, Heat-related Symptoms, and Kidney Health Among Kitchen Workers in Kampar	Abigail Koh Shu Hong	Dr Lim Fang Lee Co-supervisor: Dr Nurhanim Binti Abdul Aziz	
3.	Prolonged Standing and Musculoskeletal Discomfort Among UTAR Security Guards	Wong Yi Xun	Dr Putri Anis Syahira Binti Mohamad Jamil	
4.	Level of Traffic Related Air Pollutants (TRAP) and Respiratory Symptoms Among Security Guards	Karthiga Ahnan		
5.	Evaluation of Excessive Noise Exposure Among Construction Workers	Cheong Win Sern	Dr Nurhanim Binti Abdul Aziz	
6.	Fire Emergency Response and Preparedness Among UTAR Kampar Campus	Tan Xin Yee		

Kampar Campus : Jalan Universiti, Bandar Barat, 31900 Kampar, Perak Darul Ridzuan, Malaysia
Tel: (605) 468 8888 Fax: (605) 466 1313
Sungai Long Campus : Jalan Sungai Long, Bandar Sungai Long, Cheras, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Tel: (603) 9086 0288 Fax: (603) 9019 8868

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Professor Ts Dr Faidz bin Abd Rahman

Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, Faculty of Engineering and Green Technology Director, Institute of Postgraduate Studies and Research

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Appendix 2 Questionnaire

Heat stress questionnaire 热应激调查问卷 ***Borang Soal Selidik Tekanan Haba***

Section A: Demographic information 人口统计资料 ***Maklumat Demografi***

1) Workplace 工作地点 ***Tempat kerja*****:**

____

2) Gender 性别 ***Jantina***

☐ **Male 男** ***Lelaki***

☐ **Female 女** ***Perempuan***

3) Age 年龄 ***Umur***

____

4) Height 身高 ***Ketinggian*** **(in cm)**

____

5) Weight 体重 ***Berat badan*** **(in kg)**

____

6) Do you have the following doctor diagnosed disease(s)? Can tick more than one. 您是否患有以下经医生诊断的疾病？可勾选多过一个。***Adakah anda pernah didiagnosis oleh doktor dengan penyakit-penyakit yang berikut? Boleh pilih lebih daripada satu pilihan.***

☐ **Diabetes 糖尿病** ***Kencing manis***

☐ **High blood pressure 高血压** ***Darah tinggi***

☐ **Kidney disease 肾病** ***Penyakit buah pinggang***

☐ **Others 其他疾病** ***Lain-lain*****:**

____

Section B: Living habits 生活习惯 ***Tabiat hidup***

1) How often do you drink alcoholic drinks? 您多久喝一次含酒精饮料？*Berapa kerap anda minum minuman beralkohol (arak)?*

- ☐ **Everyday 每天 *Setiap hari***
- ☐ **Few times a week 一星期几次 *Beberapa kali seminggu***
- ☐ **Few times a month 一个月几次 *Beberapa kali sebulan***
- ☐ **Occasionally (Few times a year) 偶尔（一年几次） *Beberapa kali setahun***
- ☐ **Never 不喝含酒精饮料 *Tidak minum***

2) How often do you smoke? 您多久抽一次烟？*Berapa kerap anda merokok?*

- ☐ **Everyday 每天 *Setiap hari***
- ☐ **Few times a week 一星期几次 *Beberapa kali seminggu***
- ☐ **Few times a month 一个月几次 *Beberapa kali sebulan***
- ☐ **Occasionally (Few times a year) 偶尔（一年几次） *Beberapa kali setahun***
- ☐ **Never 不抽烟 *Tidak merokok***

3) How much water do you drink per day (mL)? 您一天喝多少杯水 (mL)? ***Berapa banyak air yang anda minum sehari (mL)?***

Approximately 300 mL/cup

大概 300 mL/ 杯

Lebih kurang 300 mL/cawan

☐ **1 – 3 cups 杯 (approximately 大概 300 – 900 mL)**

1 – 3 cawan (lebih kurang 300 – 900 mL)

☐ **4 – 6 cups 杯 (approximately 大概 900 – 1800 mL)**

4 – 6 cawan (lebih kurang 900 – 1800 mL)

☐ **7 – 9 cups 杯 (approximately 大概 1800 – 2700 mL)**

7 – 9 cawan (lebih kurang 1800 – 2700 mL)

☐ **10 cups or more 杯或更多 (>2700 mL)**

10 cawan atau lebih (>2700 mL)

4) How often do you drink caffeinated drinks (eg. Coffee, tea, Coca-Cola)? 您多久喝一次含咖啡因饮料（如：咖啡，茶，可乐）? ***Berapa kerap anda minum minuman berkafein (contoh: kopi, teh, Coca-Cola)?***

☐ **Everyday 每天** ***Setiap hari***

If everyday, how many cups per day? 如果每天喝的话，每天多少杯? ***Jika setiap hari, berapa cawan sehari?***

——————— Cups 杯 ***cawan***

☐ **Few times a week 一星期几次** ***Beberapa kali seminggu***

☐ **Few times a month 一个月几次** ***Beberapa kali sebulan***

☐ **Occasionally (Few times a year) 偶尔（一年几次）** ***Beberapa kali setahun***

☐ **Never 不喝** ***Tidak minum***

Section C： Work-related information 与工作相关的信息 ***Maklumat berkaitan pekerjaan***

1) Occupation 职业 ***Pekerjaan*****：**

____

2) How long have you been working? (months / years) 您工作多久了？（月/年） ***Berapa lama anda telah bekerja? (bulan / tahun)***

____

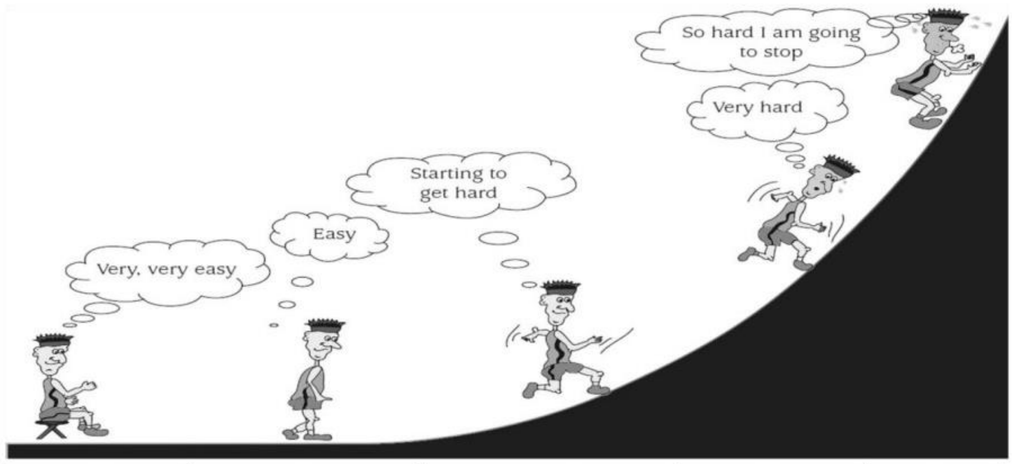
3) How many days do you work per week? 您每周工作多少天？ ***Berapa hari anda bekerja setiap minggu?***

____

4) How many hours do you work per day? 您每天工作几个小时？ ***Berapa jam anda bekerja sehari?***

____

5) How do you feel about your work? 您对自己的工作有何感想？ ***Bagaimana perasaan anda tentang pekerjaan anda?***



0	1	2	3	4

☐ **0 Very easy 非常轻松** ***Sangat senang***

☐ **1 Easy 轻松** ***Senang***

☐ **2 Hard 辛苦** ***Susah***

☐ **3 Very hard 非常辛苦** ***Sangat susah***

☐ **4 So hard I am going to stop 太辛苦了我想要停下来** ***Sangat susah, dan ingin berhenti kerja***

Section D: Heat-related illness symptoms 与热相关的疾病症状 ***Simptom penyakit yang berkaitan dengan haba***

Please ✓ tick the following relevant option for each heat-related illness symptom. In the **past 1 year**, have you experienced these symptoms?

请在以下每个与热相关的症状勾选 ✓ 相关的选项。在过去的一年里，您是否经历过以下症状？

Sila tanda ✓ symptom penyakit yang anda alami semasa bekerja dalam tempoh ***setahun*** *yang lalu.*

Symptoms **症状** ***Simptom***	**Everyday** **每天** ***Setiap hari***	**Often** **(1-6 times / week)** **时常** **（1-6 次/星期）** ***Selalu (1-6 kali seminggu)***	**Sometimes** **(1-3 times / month)** **偶尔** **（1-3 次/月）** ***Kadang kala (1-3 kali sebulan)***	**Rarely** **(1-3 times / year)** **很少** **（1-3 次/年）** ***Jarang (1-3 kali setahun)***	**Never** **从来没有** ***Tidak pernah***
Heavy sweating **大量出汗** ***Kerap berpeluh***					
Weakness/fatigue **虚弱/疲劳** ***Lesu/letih***					
Dizziness **头晕** ***Pening kepala***					
Muscle cramps **肌肉抽筋** ***Kejang otot***					
Headache **头痛** ***Sakit kepala***					

Rash on skin 皮疹 ***Ruam pada kulit***					
Irritability 烦躁 ***Rasa marah dan tidak sabar***					
Nausea 恶心想吐 ***Rasa ingin muntah***					
Dry and cracking skin 皮肤干燥龟裂 ***Kulit kering***					
Vomiting 呕吐 ***Muntah***					
Swelling hands and feet 手脚肿胀 ***Tangan dan kaki bengkak***					
Blisters on skin 皮肤起水泡 ***Kulit melecur***					
Fainting 晕倒 ***Pengsan***					
Thirst 口渴 ***Dahaga***					

Section E： Kidney-related symptoms 肾脏相关症状 *Simptom berkaitan buah pinggang*

Please ✓ tick the following relevant option for each kidney-related symptom. In the **past 1 year**, have you experienced these symptoms?

请在以下每个与肾脏相关的症状勾选 ✓ 相关的选项。在过去的一年里，您是否经历过以下症状？

*Sila tanda ✓ symptom penyakit yang anda alami semasa bekerja dalam tempoh **setahun** yang lalu.*

Symptoms 症状 ***Simptom***	**Everyday** 每天 ***Setiap hari***	**Often (1-6 times / week)** 时常 （**1-6** 次/星期） ***Selalu (1-6 kali seminggu)***	**Sometimes (1-3 times / month)** 偶尔 （**1-3** 次/月） ***Kadang kala (1-3 kali sebulan)***	**Rarely (1-3 times / year)** 很少 （**1-3** 次/年） ***Jarang (1-3 kali setahun)***	**Never** 从来没有 ***Tidak pernah***
Pain / burning sensation when urinating 小便时疼痛或烧灼感 ***Rasa sakit ketika buang air kencing***					
Blood in urine 尿中带血 ***Darah dalam air kencing***					
Cloudy urine 尿液混浊 ***Air kencing keruh***					

Urinary tract infections / inflammation 尿道感染 / 发炎 ***Jangkitan saluran air kencing***					
Kidney stones 肾结石 ***Batu karang***					
Urinating frequently but very little urine each urination 排尿频繁，但每次排尿的尿量很少 ***Kerap buang air kencing tetapi sedikit kuantitinya***					

Section F： Contact information 联络资料 ***Maklumat untuk dihubungi***

1) Name 姓名 ***Nama*****：**

——————————————————————————————————————

2）Contact number 联络号码 ***Nombor telefon***

(to inform the result of urine test 用于告知尿检结果 ***untuk memaklumkan keputusan ujian air kencing*****)：**

——————————————————————————————————————