UNIVERSITI PUTRA MALAYSIA

THE ASSOCIATION BETWEEN HEAT EXPOSURE LEVEL AND HEAT STRESS SYMPTOMS AMONG VULNERABLE POPULATIONS IN THE URBAN AREAS, KUALA LUMPUR

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BY

ADAWIYAH BINTI REDZUAN

Thesis submitted in fulfilment of the requirement for the degree of Bachelor of Science in Environmental and Occupational Health with Honours from the Faculty of Medicineand Health Sciences, Universiti Putra Malaysia.

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ABSTRACT

THE ASSOCIATION BETWEEN HEAT EXPOSURE LEVEL AND HEAT STRESS SYMPTOMS AMONG VULNERABLE POPULATION IN URBAN AREA, KUALA LUMPUR.

ADAWIYAH BINTI REDZUAN

Introduction: Global temperatures have risen steadily since the industrial revolutions and will continue arise. Global temperature increases are a result of climate change. This is become more significant due to greenhouse gases emission (GHG) and rapid urbanization. This has contributed heat stress towards the urban community and causing heat-related illness. It is become more concern as vulnerable groups are at high risk in getting heat-related illness. **Objective:** To determine the association between heat exposure level and heat stress symptoms among vulnerable population in the urban area, Kuala Lumpur. **Methodology**: This study is involved cross sectional comparative study. Cluster random sampling were used for selection of district and then, simple random sampling was used to select the respondents that fulfil the inclusive criteria. Face-to-face interview conducted using adapted questionnaire and heat exposure assessment conducted using WBGT meter to 4 parameter that will be included in UTCI calculation in order to obtain the classification of heat exposure level of individuals. **Results and Discussion:** The study reveals that heat stress symptoms have a mean of 27.42 with standard deviation of 3.69. Overall, 54.80 % of population experienced moderate heat stress while 40.10% experienced strong heat stress. The significant correlation between these number of glasses of water intake, number of E-cigarette intake per day, years living in the house and age of house, time spends during and heat stress symptoms, $p<0.05$. The correlation between time spent inside house during holiday type of wall and type of roof. The association of between glass of water intake and heat stress symptoms have significant association with heat stress symptoms, $p<0.05$. The association of between type of wall and type of roof have significant association with heat stress symptoms, $p<0.001$. The association of between of clothing significant association with heat stress symptoms, $p<0.05$. **Conclusion:** There is correlation be-tween glass of water intake, intake of number of E-cigarette per day, age of house and years living in house. Besides, there also association between glass of water and physical activity, building materials (roof materials and wall materials) and type of clothing during daytime and nigh-time.

Keywords: Heat Exposure, Heat Stress Symptoms, Vulnerable Population, Urban area

ABSTRAK

HUBUNGAN KAIT ANTARA TAHAP PENDEDAHAN HABA DAN GEJALA TEGASAN HABA DI KAWASAN BANDAR, KUALA LUMPUR.

ADAWIYAH BINTI REDZUAN

Pengenalan: Suhu global telah meningkat secara berterusan sejak revolusi perindustrian dan akan terus timbul. Peningkatan suhu global adalah akibat daripada perubahan iklim. Ini menjadi lebih ketara disebabkan oleh pelepasan gas rumah hijau (GHG) dan pembandaran yang pesat. Ini telah menyumbang tekanan haba terhadap masyarakat bandar dan menyebabkan penyakit berkaitan haba. Ia menjadi lebih membimbangkan kerana kumpulan yang terdedah berisiko tinggi untuk mendapat penyakit berkaitan haba. **Objektif:** Kajian ini bertujuan untuk menentukan perkaitan antara tahap pendedahan haba dan gejala tekanan haba dalam kalangan penduduk yang terdedah di kawasan bandar, Kuala Lumpur. **Metodologi:** Kajian ini melibatkan kajian perbandingan keratan rentas. Persampelan rawak kluster digunakan untuk pemilihan daerah dan kemudian, persampelan rawak mudah digunakan untuk memilih responden yang memenuhi kriteria inklusif. Temu bual bersemuka yang dijalankan menggunakan soal selidik yang disesuaikan dan penilaian pendedahan haba yang dijalankan menggunakan meter WBGT kepada 4 parameter yang akan dimasukkan dalam pengiraan UTCI bagi mendapatkan klasifikasi tahap pendedahan haba individu. **Keputusan dan Perbincangan:** Kajian mendedahkan bahawa simptom tekanan haba mempunyai min 27.42 dengan sisihan piawai 3.692. Secara keseluruhan, 54.8% penduduk mengalami tekanan haba sederhana manakala 40.1% mengalami tekanan haba yang kuat. Korelasi yang signifikan antara bilangan segelas pengambilan air ini, bilangan pengambilan E-rokok sehari, tahun tinggal di rumah dan umur rumah, masa yang diluangkan semasa dan gejala tekanan haba, $p<0.05$. Perkaitan antara masa yang dihabiskan di dalam rumah semasa percutian jenis dinding dan jenis bumbung. Perkaitan antara pengambilan segelas air dan gejala tekanan haba mempunyai perkaitan yang signifikan dengan gejala tekanan haba, $p<0.05$. Perkaitan antara jenis dinding dan jenis bumbung mempunyai perkaitan yang signifikan dengan gejala tekanan haba, $p<0.001$. Perkaitan antara perkaitan signifikan pakaian dengan gejala tekanan haba, $p<0.05$. **Kesimpulan:** Terdapat korelasi antara segelas pengambilan air, jumlah pengambilan E-rokok sehari, umur rumah dan tahun tinggal di rumah. Selain itu, terdapat juga perkaitan antara gelas air dengan aktiviti fizikal, bahan binaan (bahan bumbung dan bahan dinding) dan jenis pakaian pada waktu siang dan malam.

Kata kunci: Pendedahan Haba, Gejala Tekanan Haba, Penduduk Terdedah, Kawasan Bandar

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVATIONS

AC	Air- condition
BMI	Body Mass Index
DOSH	Department of Occupational Safety and Health
GHS	Greenhouse gases emission
HRI	Health Related Illness (HRI)
ISO	International Organisation of Standardisation
MOH	Ministry of Health
PHE	Personal Heat Exposure
RH	Relative humidity
SPSS	Statistical Package for the Social Sciences
U.S EPA	Unites States Environmental Protection Agency
UTCI	Universal Thermal Climate Index
UHI	Urban Heat Island
WBGT	Wet Bulb Globe Temperature Meter
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

The Earth has become warmer since pre-industrial era and it is predicted the global temperature will continue arise. Since 1880, the global annual temperature has risen at an average of 0.08 degree Celsius per decade and has grown further double of the value since 1981. The climate change become more significant due to greenhouse gases emission (GHS) and rapid urban development.

Based on United Stated Environmental Protection Agency (EPA), heat island (HI) effect also known as urban heat island effect (UHI) defined as situation where urban area experience high temperature than surrounding rural area results from absorption and re-emit of heat from man-made infrastructure more than green spaces. The ambient temperature become warmer due to heat trapped within and poor air flow across the city. This occurrence causing increase temperature during daylight, reducing night-time cooling and poor air quality.

Human able to cope with the heat stress by regulate the body temperature with surrounding by homeostasis. At certain threshold level, the body able to counteract by cool down the body through sweating. Some studies show increase in heat stress will influence the physiology, behavior and well-being (Arifwidodo & Chandrasiri, 2020). In fact, prolong exposure of extreme heat will strain the human body which lead to heat-related illness. The heat health risk increases among the vulnerable groups.

1.2 Problems Statement

According to the World Health Organization (WHO), the occurrence of extreme heat temperature due to climate change have become more significant and expected to be worsen in the future. In fact, there is rapid growth in prevalence of people exposed to extreme heat. The number of people exposed to heat waves have increase more than 100 million from 2000 to 2016 and nearly 200 million people were exposed to heat within a year (2015) compared to the mean years. High risk group are more vulnerable towards the heat stress. More studies focus on severe health effect that are related to morbidity and mortality and heat-related illness, however only few studies have been done on early physical signs and symptoms of an individual.

This heat stress issue is concerning yet many studies focus more on the workplace instead of homeplace. There are several previous studies conducted on heat stress focus directly on occupational health instead of community health. Thus, this shows that there is lack of research on the effect of heat exposure level towards heat-relates symptoms within the public community. Therefore, this study will be focus on effect heat stress on community health while taking consideration of socio-demographic factor and environmental factor.

An individual to experience heat stress both outdoor environment and indoor environment. This is because outdoor environment influencing indoor environments and other factors in term of building, heat trap and occupant's behaviour may pose health concerns to the occupants (Itani et al., 2020). Majority of unexpected fatalities were seen to occur in home during heat waves. During 2003 European heat, over half of the fatalities in France happened in residencies (Deng et al., 2018). However, many studies focus only outdoor environment as indicator of heat stress. Thus, it is crucial to considered both outdoor and indoor environment as indicator of heat stress and heat-related symptoms.

1.3 Study justification

This research study will be able to provide new information on risk of health when exposed to heat among vulnerable populations of urban area in Kuala Lumpur. This study is crucial as it can focus on residential area as well as identification of contributing factor related to the heat stress to strengthen the association between heat exposure level, heat health risk and the contributing factors.

Besides, the severity of heat-related symptoms experience by the vulnerable population in their homes especially the indoor settings. This is because, most people spend their times outside of working hour inside their homes and this situation are more relatable during the COVID-19 situation.

1.4 Objective

1.4.1 General Objective

To determine the association between heat exposure level and heat stress symptoms among vulnerable population in the urban areas, Kuala Lumpur.

1.4.2 Specific Objective

1. To determine the heat exposure level among vulnerable populations in Kuala Lumpur.
2. To determine the heat stress symptoms among vulnerable populations in Kuala Lumpur.
3. To the correlation between the correlation between the contributing factors and heat stress symptoms among vulnerable population in Kuala Lumpur
4. To determine the association between the contributing factors and heat stress symptoms among vulnerable population in Kuala Lumpur.

1.5 Study hypothesis

1. There is significant correlation the contributing factors and heat stress symptoms among vulnerable population in Kuala Lumpur.
2. There is a significant association between the contributing factors and heat stress symptoms among vulnerable population in Kuala Lumpur.

1.6 Definition

1.6.1 Heat Exposure

1.6.1.1 Conceptual Definition

Heat exposure is referred as situation where there is an actual interaction of heat between a person and indoor or outdoor environment at the present location which combination of air temperature, radiation, atmospheric humidity and air velocity cause increase in body core temperature or feeling unpleasant or both (Kuras et al., 2017).

1.6.1.2 Operational Definition

Heat exposure level will be assess using Wet Bulb Globe Temperature meter (WBGT meter), and calculation of Universal Thermal Climate Index (UTCI).

1.6.2 Heat Stress

1.6.2.1 Conceptual Definition

Heat stress is defined as the perceived discomfort and physiological strain associated with exposure to a hot environment, especially during physical work (Wills, 2015).

1.6.2.2 Operational Definition

A questionnaire consists of a heat stress checklist adapted which consist of Guidelines on Heat Stress Management at Workplace 2016 that been released by the Department of Occupational Safety and Health Malaysia (DOSH)

1.6.3 Socio-demographic

1.6.3.1 Conceptual Definition

Socio-demographic factors represent the characteristics of a population. The factors include age, gender, ethnicity, education level, income, etc. (Dobronte, 2013)

1.6.3.2 Operational Definition

Socio-demographic factors included are age, citizenship, races, marital status, level of education, monthly salary, number of households, height, and weight will be included in the survey questionnaire.

1.6.4 Environmental Factors

1.6.4.1 Conceptual Definition

The urban heat island (UHI) intensity influences by external factors (e.g., climate, weather, and season) and urban intrinsic factors (e.g., city size, building density, and land-use distribution)

1.6.4.2 Operational Definition

Environmental factors will be included are the types of building material of the house and roof, number of households and availability of air conditioning in the house will be included in the questionnaire.

1.7 Conceptual framework

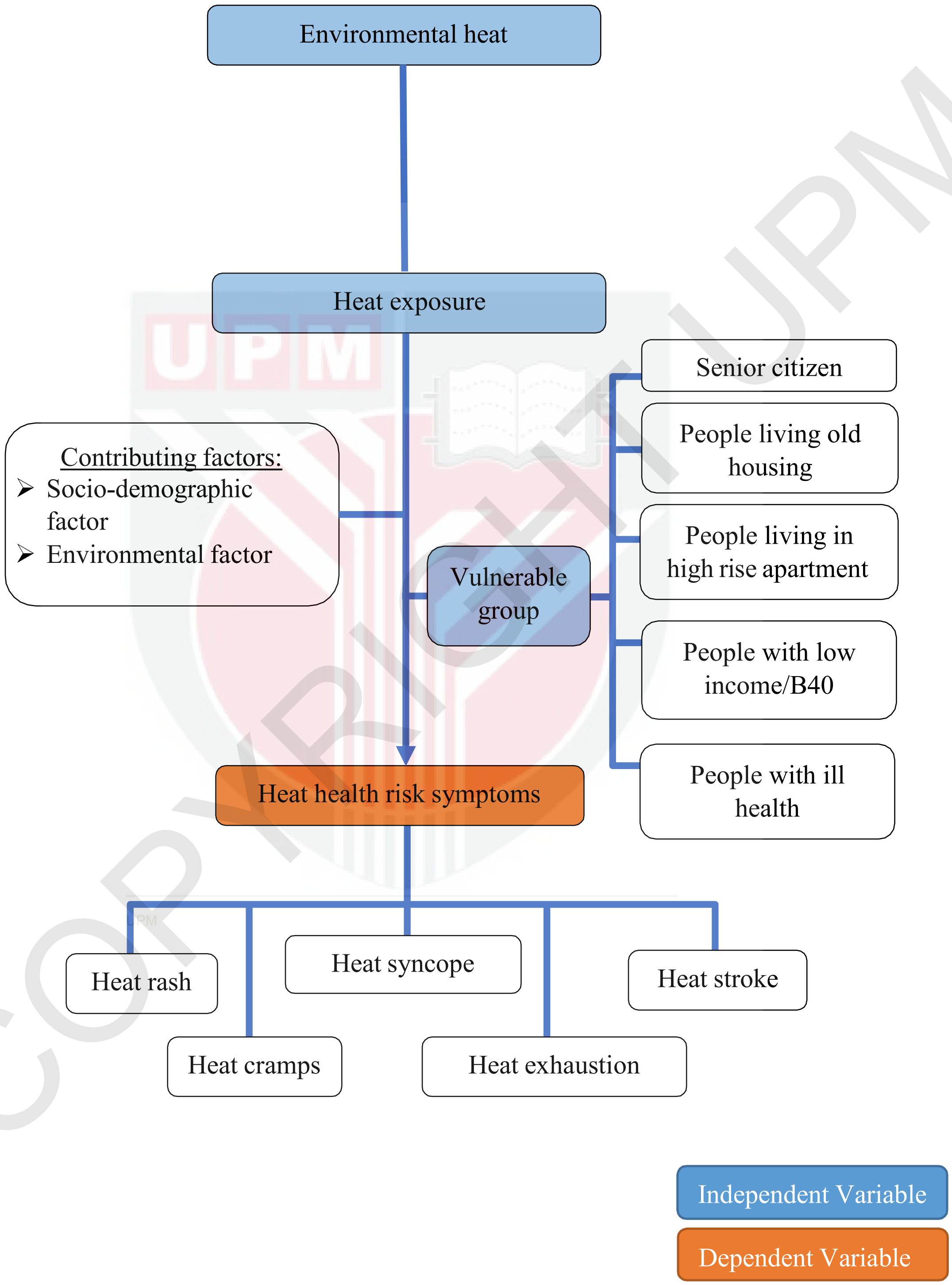

Figure 1.1: Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Environmental Heat Exposure

Atmospheric temperature, radiation and ventilation and humidity are main component influence the heat stress. Cumulative effects of between those 4 components contribute to the personal heat exposure (PHE). Thus, PHE is key component related to climate change factors, indoor and outdoor settings and severity of health (McGregor & Vanos, 2018).There is study mentions that heat build-up is caused by a combination of external exposure, metabolic loads, and restricted or inefficient cooling processes (Muth, 2020) while some studies mentions that health impacts is in connection to temperature alone or in combination with high humidity, while other taking into account the potentially synergistic effects of various meteorological parameters such as air pressure, wind speed, and cloud cover (Hajat et al., 2010)

Urban regions are more vulnerable to climate change due urban heat island (UHI) effect and it is expected that people in cities would be twice as vulnerable to heat rises as individuals in rural regions (Zander et al., 2018). In fact, it is important to assess heat stress both outdoor and indoor environment. This is because outdoor environment strongly influencing indoor environment and it is found that people in developed countries spend time mostly indoor (Walikewitz et al., 2015). Itani et al., (2020) revealed a study from Wong et al. (2009) that indoor temperature and relative humidity can reach up to 31°C and 72% respectively which beyond the thermal comfort threshold. Thermal comfort threshold indicates maximum temperature of 27°, relative humidity of 50% and air velocity of 0.4m/s according to ISO 7730.

2.2 Exposure of Heat Toward Vulnerable Groups

In older and chronically sick people, particularly people with cardiovascular, respiratory and renal disasters, the rate of heat-related mortality and morbidity is considerable. Swain et al. (2019) found that chronic diseases increase the risk of heat illness by 2–4 times due to a person's fragility and low heat tolerance. Medication is one of the contributors to the complexity risk of heat related. Certain medicines might increase the risk of heat-related illness as they can affect thermoregulation mechanisms such as anticholinergics, antihistamines, non-steroidal anti-inflammatory drugs (NSAIDs) etc. (Paterson & Godsmark, 2020). Hajat et al. (2010) stated that heat exposure can lead to the deterioration of several pre-existing health issues. The majority of heat-related fatalities in high-income nations are expected to be from cardiovascular or respiratory causes.

It is proved that senior citizens unable to withstand heat and this group populations have higher risk to heat-related mortality compared to younger citizens. The body cooling mechanism can be reduced in elderly or other vulnerable populations such people with illness or been prescribed with medication. Diminished heat tolerance might be driven by low aerobic fitness, variation in body composition, chronic health issues instead of the increase in age. (Hajat et al., 2010). (Chindapol et al., 2017) conclude that deterioration in thermoregulation in the elderly results in sweat control failure, a reduction in body heat conservation, and a decrease in heat sensitivity. Paterson & Godsmark (2020) conclude that heat-related mortality in the elderly is most likely attributable to self-neglect, social isolation, and typical behaviour.

Studies have proved that air-conditioning (AC) system able to relieve heat stress during night time; however, it is insufficiently given desired cooling effect (Zander et al., 2018). Swain et al. (2019) conclude that the usage of cooling technologies reduced the risk of heat sickness by 60%. In addition, It is predicted that habituation to air-conditioned homes, workplaces, and motor vehicles will jeopardise physiological acclimatisation and may also jeopardise behavioural adaption (Hajat et al., 2010). AC system also only aids in sleeping (Arifwidodo & Chandrasiri, 2020). Besides, the ineffectiveness of AC system is due to urban morphology where the air circulation is closely related to overpopulation in the particular areas. This results in elevation of heat and moisture level and decline in air quality within that area causing AC system less efficient.

Low-income households are more vulnerable to heat than higher income households. This is because of lack access on services on protecting themselves against heat stress and also seek for medicals service or treatment. Some findings agreed air conditioning relate with income level. Gao et al., (2020) agrees that economic condition is a major determinant of ownership and use of home air conditioners as those who have lowest educational level, those who are unemployed, those who live in public housing, and those with the lowest household income are less likely to purchase and use home air conditioners. People with low income are reluctant to use AC to relief their discomfort due to inability in managing the cost of electricity consumption (Chan et al., 2012; López-Bueno et al., 2020). Study conducts by Swain et al. (2019) in India found that adaptive behavior towards extreme heat connected to income level, water availability and cultural practices. This means that people tend to find other alternative cooling methods in combating extreme heat according to their own budget.

Economic growth, as well as migratory factors, have contributed to fast urbanisation, which has resulted in an increase in the development rate of multi-story and high-rise structures in cities. The increased density of residential structures in metropolitan areas may exacerbate the urban heat island effect and limit natural ventilation potentials (Chen, 2019). In fact, exposure of solar radiation towards the exterior surfaces of the buildings rises the temperature of the surface buildings, which varies substantially from the external air temperature. This creates convection heat flow within the buildings (Giyasov & Giyasova, 2018). A study conducted by Zheng et al. (2016) shows that the height of a structure buildings affects the thermal comfort of its occupants since the top floor has the greatest indoor temperature due to the roof's ability to absorb heat from solar radiation. Besides, the sunshade from trees did not help to reduce the indoor temperature of ground floors. Other elements to consider in understanding building overheating include living arrangements, home type, housing quality, date of construction, and air conditioning status (M Sc, 2016; White-Newsome et al., 2012). However, these studies are primarily concerned with thermal comfort, and there is lack of studies of high-rise buildings that are directly connected to heat-related illness.

2.3 Heat Stress Symptoms

Heat-related illness occur due inability of body to regulate internal temperature at optimum level when exposed to extreme hot temperature. The decrease efficiency in thermoregulation as the temperature rises will directly or indirectly impact the health in term of cardiovascular, respiratory, renal, pancreatic, digestive, cerebrovascular, and cognitive functions which lead to significant morbidity and mortality (Williams et al., 2019).

The severity of heat illness varies from minor disease (heat oedema, heat rash, heat cramps, and heat syncope) to heat exhaustion and potentially fatal heat stroke (Muth, 2020). According to Ministry of Health Malaysia (MOH), 200 cases related to hot weather have been reported which is 52 cases of heat cramps (hyperthermia, spasms of large muscle), 126 cases of heat exhaustion (fatigue, collapse) and 22 cases of heat stroke (hot red or flushed dry skin, nausea or vomiting, coma) includes two deaths reported as a result of heat stroke (Suparta & Yatim, 2017).

Fatality in an individual with heatstroke can be escalated within hours and 15% of heatstroke are deadly cases even with immediate medical treatment. However, heat-related illness is underreported since heat exposure might not be proven as underlying cause of mortality. People who survive from heatstroke suffered from irreversible organs dysfunction will results in functional impairment and have high risk of premature death (Kovats & Hajat, 2008)

2.4 Thermoregulation function

Thermoregulation is one of the homeostasis processes which help regulating theinternal body temperature as our body temperature are independently toexternal temperature. This means that human body are unable to adapt when there is increase fluctuations from the external temperature. Behavioral responses aid in human adaption to cold conditions while heat adaptation is relied on the body's capacity to function as a natural cooling mechanism (Hajat et al., 2010). Heat stress is situation where our body are exposed to external heat, and it becomes a burden to our body. Then, heat strain happens when therate of heat gains in our body exceeds the heat loss due to faulty in thermoregulation causing body core temperature gradually to increase. This ledto sequence of heat-related symptoms from mild symptoms such as headacheand fatigue to severe symptoms such as heatstroke or death (Muth, 2020; Pantavou et al., 2015;

Zander et al., 2018).

2.5 Contributing Factors of Heat Stress

Age is considered major determinants of heat stress as heat tolerance diminished as we age. It also concludes that female is more susceptible to heat stress compared to male due to body size. Smaller body size has high surface area; therefore, female have high adaptability towards heat compared to female (Arifwidodo & Chandrasiri, 2020). Chan et al., (2012) in their study revealed a rise of 1.08°C in the mean temperature over 28.2°C on given day was related with a 1.8 percent increase in mortality and deaths in women were more susceptible to high temperatures than in men. A findings of Humans populations are able adapt to local weather physiologically, behaviourally and culturally. Even though, an individual has ability adapt in broad range of temperatures and conditions, there is still defined limitations of how much each individual able to withstand (Kovats & Hajat, 2008). To gain a better understanding of the health risks during and after extreme heat events, it is necessary to assess the indoor temperature exposures while accounting for building characteristics. Although the community is exposed to the same ambient temperatures, each residential building either exacerbates or mitigates the thermal exposures (Williams et al., 2019)

CHAPTER 3

METHODOLOGY

3.1 Study design

In this study, cross sectional comparative study was conducted to determine the association between heat exposure level and heat health risk symptoms among vulnerable population in urban area, Kuala Lumpur.

3.2 Study location

This study was conducted in the selected urban area in Kuala Lumpur. Kuala Lumpur is the capital city of Malaysia and had been known as the largest urban city in Malaysia. The city covering an area of 243 km2 with population density of 7,299 per kilometre square according to the 2010 Population and Housing Census of Malaysia. There are 8 districts in Kuala Lumpur consist of Ampang, Bandar Kuala Lumpur, Batu, Cheras, Kuala Lumpur, Petaling, Setapak and Ulu Klang.

3.3 Study population

The target population of this study was all the vulnerable population from the urban area which is Kuala Lumpur consist of these five groups of people.

- Senior citizens – seniors over the age of 60 years old and. They are considered as heat-sensitive group as they very intolerable heat towards extreme hot temperature due to effects of comorbidities, decreased mobility, diminished ability to care for themselves, and a weakened immune system.

- People living in old house buildings- old building have poor maintenance in term of ventilation system and have degrading quality of building materials which exposed more heat stress to the people who living in old building.
- People living in multi-storey or high-rise building apartment buildings- people who live on the upper floors of high-rise buildings having greater health risks than those who live in older housing.
- People with low income group (B40) - Low-income people are at higher risk due to high expenditure cost services which lead to limitations options in overcome the extreme hot temperature and have more comorbidities if compared to other income groups.
- People with ill health- people having medical problems as well as those who are self-neglect or reduced in mobility are at higher risk which focuses more on metabolic disorder, respiratory problem, cardiovascular problem and etc.

3.4 Sampling

3.4.1 Sampling frame

The sampling frame consists of a list of a vulnerable population who reside in the urban area of Kuala Lumpur. The list of people with health problem, people with low income (B40), people living in multi storey or high-rise buildings, people living in old housing and senior citizens will be included in the study's vulnerable populations

3.4.2 Selection Criteria

Table 3.1: Inclusive Criteria & Exclusive Criteria

	Inclusive criteria			Exclusive criteria
Vulnerable groups	Has been living in residential area for more than 1 year	Above 12 years old or attended secondary school	Physically present during face-to-face interview session	Pregnant women
Senior citizens (60 years old and above)	/	/	X	/
B40 Groups	/	/	/	/
Old house residents (30 years and above)	/	/	/	/
Multi-storey or high-rise buildings	/	/	/	/
People with ill-health	/	/	/	/

3.4.3 Sampling Method

The cluster random sampling will be used in selecting certain districts in Kuala Lumpur. As a result, only urban areas in the selected district will be used for this study. Then, simple random sampling to obtain number of respondents of vulnerable populations in the previously selected district.

3.4.4 Sampling Unit

The vulnerable population in urban areas of Kuala Lumpur that met the inclusive criteria were selected as the sampling unit.

3.4.5 Sampling Size

Table 3.2: Sample Size Calculation

Objectives	Formula
1. To determine the heat exposure level among the vulnerable populations in Kuala Lumpur.	The samples size for the objectives will be calculated using the Rubinson & Neutens formula (2002) $N = \left(\frac{Z}{e}\right)^2 P(1-P)$ where, N= sample size Z = standard score for significant level P=Expected proportion of population based on previous study For 95% significant level, z= 1.96, e = 0.1, Since there is limitation in obtained the reference value, we assumed the P= 50%.
2. To determine the heat stress symptoms among the vulnerable populations in Kuala Lumpur	

	$$N = \left(\frac{1.96}{0.1}\right)^2 (0.5)(0.5)$$ The sample size, N is 96 samples.
3. To determine the correlation between heat exposure level and heat stress symptoms among vulnerable population in Kuala Lumpur.	$$N = \frac{2\sigma^2\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{(\mu1 - \mu2)^2}$$ where, σ = Estimated standard deviation (assumed to be equal to each group) μ1 = Estimated mean (larger) μ2 = Estimated mean (smaller) Z1-α = Standardized value for confidence interval, 95% CI=1.96 Z1-β = Standardized value for power, 80% of power =0.84 The reference value were obtained from previous study (Hamerezaee, M et.al, 2017): σ = 6.10 μ1 = 44.24 μ2 = 27 $N = \frac{2(6.10)^2[1.96+0.84]^2}{(44.24-27)^2}$ N= 1.96304 *N*= 1.96304 The sample size, N is 1 sample in each vulnerable groups. Thus, total sample size for 5 vulnerable groups is 5 sample.
4. To determine the association between the contributing factors and heat stress symptoms	

Based on the sample size calculation above, 96 respondents needed for this study. The number of respondents was increased by 20% for the strength of analysis of the study and to consider on non-responsive respondents, missing data, and errors. Therefore, the total number of samples that were included in this study was 115 respondents were selected from urban area of Kuala Lumpur. Thus, at least 23 participants were recruited from each of the vulnerable group.

3.4.6 Sampling Procedure

This study was conducted after receiving approval from The University Ethics Committee Involving Human Subjects of University Putra Malaysia, JKEUPM. After receiving ethic approval and JKEUPM and the permission from the property management company to conduct the study on the three districts of Kuala Lumpur that been randomly selected previously.

Next, the consent form and questionnaire will be distributed to the selected respondent in the selected study location which matches all the inclusive criteria of the study sample. An interview face-to-face will be conducted between researcher and respondents.

For heat exposure assessment, WBGT meter were used. The WBGT meter were placed in the living room of the respondent's house during middle of the day for 1 hour where the measurement will be taken every 5 minute interval comply with ISO 7243.

The collected data will be analysed using SPSS Software version 26.0 and universal climate index (UTCI) will be calculated and will be categorized based on the stress category. Precautionary steps will be taken during the COVID-19 situation according to the Standard Operation Procedure (SOP) from Ministry Health of Malaysia (MOH).

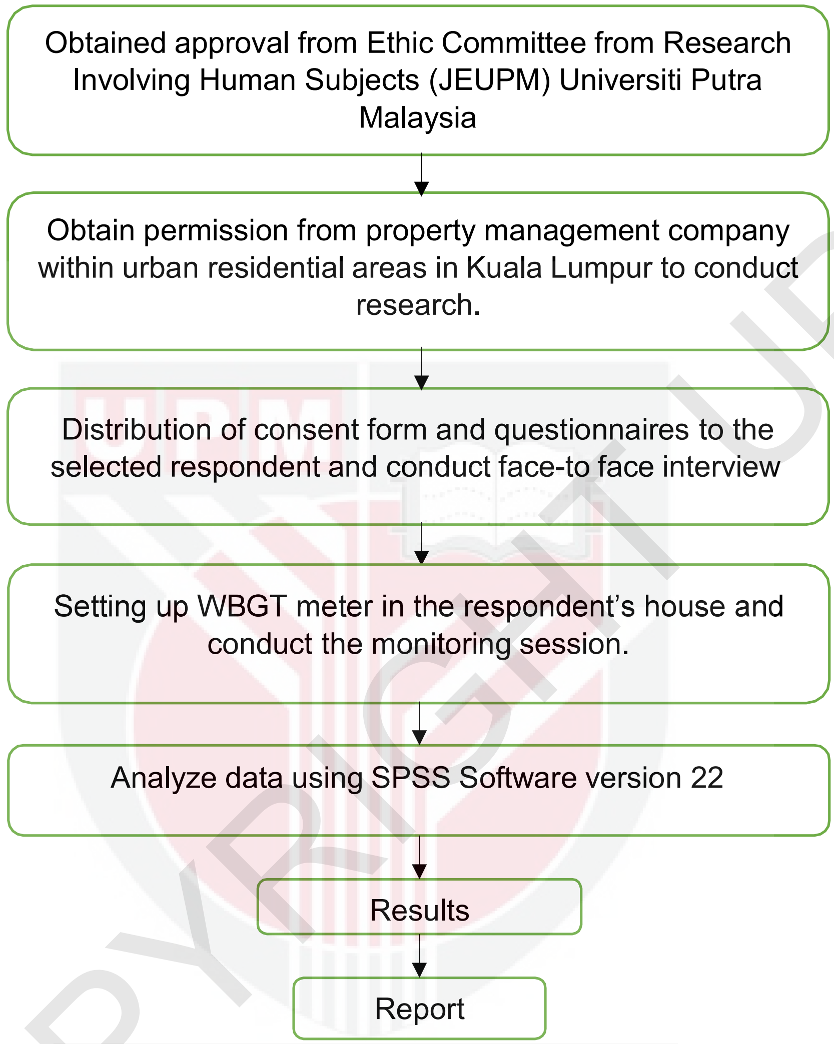

Figure 3.1: Flowchart of data collection

3.5 Instrumentation

3.5.1 Questionnaires

A questionnaire was used to collect information based on study objectives. The items in the questionnaire were adapted from Guidelines on Heat Stress Management at workplace 2016, United Kingdom's Health and Safety Executive (HSE) website and other validated questionnaire from previous studies (Coris et. al, 2007) and modified according to the study of interest. This study instruments are accessible in English version as well as Malay's version as there might be some residents prefer the national language for a better understanding. The questionnaire consists of 5 sections that are:

Part A: Sociodemographic information

Part B: Residential information

Part C: Health information

Part D: Heat stress checklist

Part E: Heat health-related symptoms

3.5.2 Wet Bulb Globe Temperature Meter (WBGT Meter)

Wet Bulb Globe Temperature Meter (WBGT Meter) with a data logging software, is utilized to determine potential heat stress conditions in a quick and precise manner ((TSI / Quest QT range | Heat stress meter, 2021). It can be utilised as an indoor thermal comfort monitor by simultaneously monitoring the air velocity probe, temperature, and relativehumidity sensors. The WBGT Meter simplifies attempts to control heat stress by providing real-time information for wet/dry bulb, globe, WBGT indoor/outdoor, relative humidity and heat index on stay lengths and work/rest balance (Air-Met Scientific, 2021).

WBGT comes with four different types of sensors which are as below:

1) Dry Bulb Sensor: To determine the air temperature using a thermometer that is not insulated from radiation or moisture but is fully exposed to the air.
2) Natural Wet Bulb Sensor: To take the temperature of the air using a conventional thermometer, with the exception that the thermometer's bulb is covered by the wet cloth/wick.
3) Globe Temperature Sensor: A black globe with a thermometer put in the centre is used to measure air temperature.
4) Air Velocity Sensor: To measure the air velocity by sensing the pressure produced by the air movement

Figure 32: QUESTemp o36 WBGT Thermal Environmental Monitor
Source: (QUEST Technologies, 2008)

3.5.3 Universal Thermal Climate Index (UTCI)

Universal thermal climate index (UTCI), introduced in 1994, considers dry temperature, relative humidity, solar radiation, and wind speed into account and is regarded as the reference environmental temperature causing strain (K). UTCI is the equivalent temperature for the environment derived from a reference environment. It is defined as the air temperature of the reference environment which produces the same strain index value in comparison with the reference individual's response to the real environment. It is regarded as one of the most comprehensive indices for calculating heat stress in outdoor spaces. The parameters that are taken into account for calculating UTCI involve dry temperature, mean radiation temperature, the pressure of water vapour or relative humidity, and wind speed (at the elevation of 10 m). The wind speed should range from 0.5 to 17 m/s in order to calculate UTCI.

For the calculation part of UTCI index in this study (Błazejczyk et al., 2013):

$$UTCI = f\,(T\ a;\ TMRT;\ V\ a;\ R\ H)$$

where, Ta is air temperature,

TMRT is mean radiant temperature,

Va is wind speed,

RH is relative humidity.

3.5 Quality Control

Quality control was done to ensure the result of the data that was obtained throughout the study is reliable and validated. A validated questionnaire was adapted from Guidelines on Heat Stress Management in Workplace 2016. Test-retest reliability will be conducted before the distribution of questionnaire. The content of questionnaires will be evaluated to ensure the questions included are relevant to this study and align with the objectives and appropriate for the respondent selected in the study. Wet Bulb Globe Temperature (WBGT) and hot-wired anemometer will be calibrated before taking the measurement. The measurement of WBGT, hot-wired anemometer and non-contact infrared thermometer will be repeated three times and the average will be taken.

3.6 Data Analysis

All the data collected from questionnaire, measurement and test were analysed by using IBM SPSS Version 26 Software and Microsoft Excel. The assumption of normality for significant was ($p>0.05$).

Table 3.3: Data Analysis

Specific Objective	Hypothesis	Statistical Analysis
1. To determine the heat stress level among the vulnerable populations in Kuala Lumpur	No hypothesis	Descriptive analysis
2 To determine the heat stress symptoms among the vulnerable population in Kuala Lumpur.	No hypothesis	Descriptive analysis and independent t-test
3. To determine the correlation between the contributing factors and heat stress symptoms among the vulnerable population in Kuala Lumpur	There is significant correlation the contributing factors and heat stress symptoms among vulnerable population in Kuala Lumpur.	Pearson's correlation
4. To determine the association between the contributing factors	There significant association between the contributing	Independent t-test

and heat stress symptoms among vulnerable populations in Kuala Lumpur.	factors and heat stress symptoms among vulnerable population in Kuala Lumpur.	One-way ANOVA test

3.8 Study Ethic

This study had obtained approval by the Ethics Committee for Research involving Human Subjects (JKEUPM) and school administration. Besides, the respondent's consents were also obtained, and they were given a brief explanation regarding the questionnaire and written consent need to be filled by the respondents before proceeding to complete the questionnaire. All personal information and responses from the respondents will be kept confidential for their own privacy.

CHAPTER 4

RESULT

4.1 Data of Respondent

4.1.1 Socio-Demographic Data of Respondent

Table 4.1 shows the distribution of respondents by age, gender, nationality, ethnicity, level of education, total household monthly income and numbers of member in the house. A total of 277 respondents has been recruited in this study where the majority of the respondents was among B40 groups (35.70%), followed by old building residents (23.50%), multi-storey building residents (16.20%), people with health problems (13.00%) and senior citizen (11.60%).

Table 4.1: Respondents' Socio-Demographic Information (N=277)

Variables		N	%	Mean ± S.D.
Vulnerable group	Senior citizen	32	11.60	3.17 ± 1.22
	Old building	65	23.50	
	High rise building	45	16.20	
	B40 group	99	35.70	
	Ill people	36	13.00	
Age		-	-	48.98 ± 21.84
Gender	Male	147	53.10	
	Female	130	46.90	
Nationality	Malaysian	266	96.00	
	Non-Malaysian	11	4.00	
Ethnicity	Malay	240	86.60	
	Chinese	10	3.60	

	Indian	16	5.80	
	Others	11	4.00	
Level of education	No formal education	4	1.40	2.08 ± 0.86
	Primary school	58	20.90	
	Secondary school	150	54.20	
	Pra U/STPM/Diploma	43	15.50	
	Bachelor	22	7.90	
	Master/ PhD	0	0.00	
Total household monthly income	B40	269	97.10	1.03 ± 0.17
	M40	8	2.90	
	T20	0	0.00	
No. of members in the house		-	-	4.71 ± 3.14
BMI	Normal (<25)	145	52.30	0.48 ± 0.50
	Overweight (≥25)	132	47.70	

4.1.2 Health Information

Table 4.2 shows the distribution of respondents based on the medical history, medicine history, smoking status, type of cigarette, glass of water and alcohol use. Approximately half of the total respondents have medical history (50.50%) while 48.7% of respondents were prescribed with medicine. Only 25.30 % of respondent smokers where majority of them use conventional cigarette (20.20%), followed E-cigarette user (4.30%) and both (0.70%). There were none of the respondent consumed alcohol.

Table 4.2: Respondents' Health Information (N=277)

Variables		N	%	Mean ± S.D.
Medical history	Yes	140	50.50	0.51 ± 0.50
	No	137	49.50	
Medicine history	Yes	135	48.70	0.55 ± 0.81
	No	140	50.50	
Smoking	Yes	70	25.30	0.25 ± 0.44
	No	207	74.70	
Type of cigarette	Conventional cigarette	56	20.20	
	E-cigarette	12	4.30	
	Both	2	0.70	
Alcohol	Yes	0	0.00	0.00 ± 0.00
	No	277	100.00	
Glass of water	< 8	133	48.00	0.52 ± 0.50
	≥ 8	144	52.00	

4.1.3 Residence Information

Table 4.3 illustrate the distribution of respondents of type of residence, type of wall material, type of roof material according to vulnerable groups. More than half of the respondents live in multi-storey building (53.40%) while 46.60% of other respondents live in landed house. Majority of respondent's house are made of concrete wall (61.00 %) where 20.20% out of overall percentage for concrete wall are among B40 group while 15.20% of them are among high-rise buildings. Number of respondents having concrete ceiling roof materials were recorded the highest (45.50%) where majority of them among B40 groups (15.20%) followed by high rise-building residents(11.20%).

Table 4.4 and Table 4.5 summarize the availability of ventilation and the perception of the ventilation in the living room, bedroom, dining area, kitchen and toilet according to different vulnerable groups. Majority of respondents of have a ventilation system in living room 92.40%), bedroom (98.20%), dining area (78.30%), kitchen (88.80%) and toilets (70.80%). Minor of respondents informed having poor ventilation in living room (8.30%), in bedroom (24.50%), dining area (16.60%), kitchen (25.60%) and toilet (26.70%) where most of them are among the B40 groups and old house residents.

Table 4.3 Respondents' Residence Information (N=277)

Variables		N (%)					
Group		Overall	Senior citizen	Old house resident	High-rise building residents	B40 group	People with health problem
Type of residence	Landed house	129 (46.60)	14 (5.10)	46 (16.60)	-	51 (18.40)	18 (6.50)
	Multi-storey building	148 (53.40)	18 (6.50)	19 (6.90)	45 (16.20)	48 (17.30)	18 (6.50)
Type of wall	Concrete	169 (61.00)	20 (7.20)	31 (11.20)	42 (15.20)	56 (20.20)	20 (7.20)
	Brick with/without plaster	66 (23.80)	8 (2.90)	19 (6.90)	2 (0.70)	28 (10.10)	9 (3.20)
	Wooden planks	39 (14.10)	4 (1.40)	14 (5.10)	1 (0.40)	14 (5.10)	6 (2.20)
	Zinc/metal	3 (1.10)	0 (0.00)	1 (0.40)	0 (0.00)	1 (0.40)	1 (0.40)
Type of roof	Zinc/metal roof	65 (23.50)	6 (2.20)	19 (6.90)	11 (4.00)	29 (10.50)	10 (3.60)
	Ceramic/clay roof	57 (20.50)	10 (3.60)	11 (4.00)	0 (0.00)	17 (6.10)	9 (3.20)
	Concrete roof	29 (10.50)	2 (0.70)	11 (4.0)	3 (1.10)	11 (4.00)	2 (0.70)
	Concrete ceiling	126 (45.50)	14 (5.10)	24 (8.70)	31 (11.20)	42 (15.20)	15 (5.40)

Table 4.4: Ventilation status in house among vulnerable group (N=277)

Variables		N (%)					
Group		Overall	Senior citizen	Old house resident	High-rise building residents	B40 group	People with health problem
Living room	Available	256 (92.40)	28 (10.10)	59 (21.30)	43 (15.50)	93 (33.60)	33 (11.90)
	Not available	21 (7.60)	4 (1.40)	6 (2.20)	2 (0.70)	6 (2.20)	3 (1.10)
Bedroom	Available	272 (98.20)	32 (11.60)	63 (22.70)	45 (16.20)	97 (35.00)	35 (12.60)
	Not available	5 (1.80)	0 (0.00)	2 (0.70)	0 (0.00)	2 (0.70)	1 (0.40)
Dining area	Available	217 (78.30)	30 (10.80)	51 (18.40)	32 (11.60)	83 (30.00)	4 (12.30)
	Not available	60 (21.70)	1 (0.40)	14 (5.10)	14 (5.10)	16 (5.80)	2 (0.70)
Kitchen	Available	246 (88.80)	31 (11.20)	58 (20.90)	40 (14.40)	84 (30.30)	32 (11.60)
	Not available	31 (11.20)	2 (0.70)	7 (2.50)	5 (1.80)	14 (5.10)	4 (1.40)
Toilet	Available	196 (70.80)	26 (9.40)	37 (13.40)	34 (12.30)	71 (25.60)	28 (10.10)
	Not available	81 (29.20)	5 (1.80)	28 (10.10)	12 (4.30)	28 (10.10)	8 (2.90)

Table 4.5: Ventilation perception in house among vulnerable group (N=277)

Variables		N (%)					
Group		Overall	Senior citizen	Old house resident	High-rise building residents	B40 group	People with health problem
Living room	Poor	23 (8.30)	1 (0.40)	2 (0.70)	0 (0.00)	8 (2.90)	3 (1.10)
	Good	254 (91.70)	31 (11.20)	63 (22.70)	45 (16.20)	91 (32.90)	33 (11.90)
Bedroom	Poor	68 (24.50)	8 (2.90)	18 (6.50)	7 (2.50)	27 (9.70)	8 (2.90)
	Good	209 (75.50)	24 (8.70)	47 (17.00)	38 (13.70)	72 (26.00)	28 (10.10)
Dining area	Poor	46 (16.60)	3 (1.10)	11 (4.00)	5 (1.80)	20 (7.20)	7 (2.50)
	Good	231 (83.40)	29 (10.50)	54 (19.50)	40 (14.40)	79 (28.50)	29 (10.50)
Kitchen	Poor	71 (25.60)	6 (2.20)	20 (7.20)	6 (2.20)	30 (10.80)	9 (3.20)
	Good	206 (74.40)	26 (9.40)	45 (16.20)	39 (14.10)	69 (24.90)	27 (9.70)
Toilet	Poor	74 (26.70)	6 (2.20)	25 (9.00)	5 (1.80)	28 (10.10)	10 (3.60)
	Good	203 (73.30)	26 (9.40)	40 (14.40)	40 (14.40)	71 (25.60)	26 (9.40)

4.1.4 Heat Exposure Information

Table 4.6 shows the type of work, green spaces, type of clothing during daytime and during night-time and physical activity. Type of work categorize into 7 type that are work from home- refer to housewife and retiree person; work from office; work from non-office setting (indoor) –e.g., cleaner, factory worker, café workers; work from non-office setting (outdoor) –e.g., gardeners, farmer; remote workstation; student that study from home; and student that attending. Majority of the respondents are working from home (55.60%), followed by working in office (10.50%), working in non-office (indoor) (6.10%), working in non-office (outdoor) (6.50%), remote workstation (3.20%), study from home (5.40%) and attending school (12.60%). More thanhalf (68.60%) the green space around the respondent's residential area are exhibit more on poorly. During daytime, majority of respondents wearing normal clothing (65.70%) followed by light clothing (23.10%) and thick clothing (11.20%). More than half of respondents are physical active (63.20%) while the others are physical inactive (36.8%).

Table 4.6: Heat exposure information

Variables		Frequency, *f* (%)					
Group		Overall	Senior citizen	Old house resident	High-rise building residents	B40 group	People with health problem
Type of work	Work from home	154 (55.60)	28 (10.10)	29 (10.50)	23 (8.30)	46 (16.60)	28 (10.10)
	Office	29 (10.50)	1 (0.40)	5 (1.80)	6 (2.20)	13 (4.70)	4 (1.40)
	Non-office (indoor)	17 (6.10)	2 (0.70)	5 (1.80)	2 (0.70)	6 (2.20)	2 (0.70)
	Non-office (outdoor)	18 (6.50)	0 (0.00)	5 (1.80)	4 (1.40)	8 (2.90)	1 (0.40)
	Remote work station	9 (3.20)	0 (0.00)	4 (1.40)	1 (0.40)	4 (1.40)	0 (0.00)
	Study from home	15 (5.40)	0 (0.00)	7 (2.50)	0 (0.00)	7 (2.50)	1 (0.40)
	Attending school	35 (12.60)	0 (0.00)	10 (3.60)	10 (3.60)	15 (5.40)	0 (0.00)
Green spaces	Poor	190 (68.60)	18 (6.50)	53 (19.10)	29 (10.50)	65 (23.50)	25 (9.00)
	Good	87 (31.40)	13 (4.70)	12 (4.30)	17 (6.10)	34 (12.30)	11 (12.30)
Type of clothing (daytime)	Light	48 (17.30)	6 (2.20)	7 (2.50)	11 (4.00)	18 (6.50)	6 (2.20)
	Normal	218 (78.70)	24 (8.70)	56 (20.20)	32 (11.60)	78 (28.20)	28 (10.10)

	Thick	11 (4.00)	1 (0.40)	2 (0.70)	3 (1.10)	3 (1.10)	2 (0.70)
Type of clothing (nightime)	Light	64 (23.10)	7 (2.50)	12 (4.30)	13 (4.70)	24 (8.70)	8 (2.90)
	Normal	182 (65.70)	23 (8.30)	44 (15.90)	26 (9.40)	64 (23.10)	26 (9.40)
	Thick	31 (11.20)	1 (0.40)	9 (3.20)	7 (2.50)	11 (4.00)	2 (0.70)
Physical activity	Physical inactive	102 (36.80)	14 (5.10)	20 (7.20)	17 (6.10)	33 (11.90)	18 (6.50)
	Physical active	175 (63.20)	17 (6.10)	45 (16.20)	29 (10.50)	66 (23.80)	18 (6.50)

4.2 Heat Stress Symptoms and Personal Heat Exposure Level

Table 4.7 and table 4.8 shows the distribution of heat stress symptoms and personal heat exposure level according to classification UTCI level. Heat stress symptoms have a mean of 27.42 with standard deviation of 3.69. Based on table 4.8, 54.80% of respondents experienced moderate heat stress where majority respondents are among B40 groups (20.20%), followed by high-rise buildings residents (10.60%), old house resident (8.60%), senior citizen (7.90%) and people with health problem (7.50%). On the other hand, about 40% of respondent experience strong heat stress where both B40 groups and old house residents have the same percentage (13.70%) which are majority, followed by high-rise residents (5.10%), people with health problem (4.80%) and senior citizen (2.70%).

Table 4.7: Heat stress symptoms

Variables	Mean ± S.D.	Median	Range
Heat stress symptoms	27.42 ± 3.69	27.00	13

Table 4.8: UTCI classification.

Variables	Frequency, N (%)					
Group	Overall	Senior citizen	Old house residen t	High-rise building residents	B40 group	Peopl e with health proble m
Moderate heat stress	160 (54.80)	23 (7.90)	25 (8.6)	31 (10.60)	59 (20.20)	22 (7.50)
Strong heat stress	117 (40.10)	8 (2.70)	40 (13.70)	15 (5.10)	40 (13.70)	14 (4.80)

4.3 Correlation of Contributing Factors with Heat Stress Symptoms

Correlation analysis was used to assess the direction of linear relationship between contributing factors and heat stress symptoms. Thus, a bivariate Pearson's Correlation (r) was calculated Based on the Table 4.9, the bivariate correlation between these number of glass of water intake was positive and poor, r= 0.15, p<0.001. The correlation between number of E-cigarette intake per day and heat stress symptoms was positive and strong, r=0.93, p<0.01. The correlation between years living in the house and age of house with heat stress symptoms was positive and poor, r=0.13, p<0.05 and was positive and poor, r=0.13, p<0.05 respectively. The correlation between time spends during and heat stress symptoms was positive and strong, r=0.93, p<0.01. The correlation between time spent inside house during holiday with heat stress symptoms was positive and poor, r= 0.19, p<0.001.

Table 4.9: Correlation of variables and heat stress symptoms

	Heat Stress Symptoms	
Variables	(r)	p-value
Age[a]	0.12	0.06
Number of houses members[b]	0.10	0.10
BMI[b]	0.08	0.20
Glass of water[a]	0.15	0.00*
Number of conventional cigarettes per day[b]	0.04	0.76
Number of E-cigarette per day[a]	0.93	0.00*
Living in house (year)[b]	0.13	0.03*
Age of house (year)[b]	0.13	0.04*
Time spends during off work[b]	0.19	0.07
Time spends during workday[b]	0.06	0.34

[a] *Pearson correlation*
[b] *Spearman correlation*
**p-value significant at value <0.05*

4.4 Association between Contributing Factors and Heat Stress Symptoms

Table 4.10 shows the association between selected contributing factors (gender, BMI, medical history, medicine intake, smoking status, number of glasses of water intake, type of residence, green spaces and physical activity. There is association between number of glass water intake and heat stress symptoms where people who drink more than 8 glasses of water have higher mean (27.00 ± 5) compared to people who drink less than 8 glass of water (24.00 ±6). There is association between physical activity and heat stress symptoms where people who physically active higher mean (28.00 ±5) compared to people who drink less than 8 glass of water (25.00 ± 4).

Table 4.10: Association of variables and heat stress symptoms (N=277)

Variables		Mean ± SD Median ± IQR	t-value[a]/ z-value[b]	p-value
Gender[b]	Male	27.00 ± 6	-0.72	0.47
	Female	24.00 ± 1		
BMI[b]	Normal	27.00 ± 5	-0.11	0.92
	Overweight	24.00 ± 4		
Medical history[b]	No	27.43 ± 4.03	0.07	0.95
	Yes	27.40 ± 3.34		
Medicine intake[a]	No	27.51 ± 3.86	0.47	0.64
	Yes	27.30 ± 3.55		
Smoking[a]	No	27.71 ± 3.68	2.31	0.96
	Yes	26.54 ± 3.63		
Glass of water[b]	<8	24.00 ±6	-2.83	0.01*
	≥8	27.00 ± 5		
Type of residence[a]	Landed house	26.98 ± 3.60	- 1.82	0.26
	Multi-storey building	27.79 ± 3.75		
Green spaces[a]	Poor	27.56 ± 3.93	1.08	0.28
	Good	27.09 ± 3.09		
Physical activity[b]	Physical inactive	25.00 ± 4	2.98	0.003*
	Physical active	28.00 ±5		

[a] *Independent t-test*
[b] *Mann-Whitney*
*****_p-value significant at value <0.05_

Table 4.11 illustrate the association between selected contributing factors and heat stress. There is association between type of wall materials and heat stress symptoms, where zinc/metal (30.00 ± 0.00) have the highest followed by brick with/ without plaster (29.46 ± 2.98), concrete (26.81 ± 3.72) and wooden plank (26.15 ± 3.44). There is association between type of roof materials and heat stress symptoms, where concrete roof (30.41 ± 4.15) has the highest mean followed by concrete ceiling (27.15 ± 3.949), ceramic/clay roof (27.07 ± 2.46) and zinc/metal roof (26.71 ± 3.29). There is association between type of clothing during daytime and nightime with heat stress symptom, where thick clothing has the highest mean (30.73 ± 2.49), (29.26 ± 3.076), followed by normal clothing (27.42 ± 3.58), (27.12 ± 3.47) and light (26.65 ± 4.06), (27.36 ± 4.33).

Table 4.11: Association between contributing factors and heat stress symptoms

Variables		Mean ± SD Median ± IQR	F	P values
Levels of education	No formal education	27.00 ± 0.00	2.28	0.06
	Primary school	28.00 ± 3.64		
	Secondary school	27.71 ± 3.93		
	Pra U/ STPM/ Diploma	26.28 ± 3.31		
	Bachelor	26.18 ± 2.44		
Type of cigarettes	Conventional cigarettes	26.50 ± 3.77	2.38	0.10
	E-cigarettes	26.23 ± 2.65		
	Both	32.00 ± 0.00		
Type of wall[a]	Concrete	26.81 ± 3.72	11.80	0.00*
	Brick with/ without plaster	29.46 ± 2.98		

	Wooden plank	26.15 ± 3.44		
	Zinc/metal	30.00 ± 0.00		
Type of roof[a]	Zinc/metal roof	26.71 ± 3.29	6.911	0.00*
	Ceramic/clay roof	27.07 ± 2.46		
	Concrete roof	30.41 ± 4.15		
	Concrete ceiling	27.15 ± 3.95		
Type of work[a]	Work from home	26.99 3.93	1.854	0.89
	Office	27.41 2.77		
	Non- office (indoor)	28.35 3.41		
	Non-office (outdoor)	28.72 ± 2.99		
	Remote work station	26.67 ± 4.42		
	Student from home	26.53 ± 2.56		
	Attending school	28.71 ± 3.65		
Type of clothing (day)[a]	Light	26.65 ± 4.06	5.65	0.004*
	Normal	27.42 ± 3.58		
	Thick	30.73 ± 2.49		
Type of clothing (night)[a]	Light	27.36 ± 4.33	4.56	0.01*
	Normal	27.12 ± 3.47		
	Thick	29.26 ± 3.08		

[a] One-way ANOVA
[b] Kruskal Wallis test
*** p-value is significant at 0.001 level; * p-value is significant at 0.05 level*

CHAPTER 5

DISCUSSION

5.1 Heat Stress Symptoms and Personal Heat Exposure Level

The heat exposure level that experienced may be different every individual. There are individual factors and environmental factors that need to be considered. Hajat et al. (2010) that mention some studies mentions that health impacts is in connection to temperature alone or in combination with high humidity, while other taking into account the potentially synergistic effects of various meteorological parameters such as air pressure, wind speed, and cloud cover. Based on the observation, most of respondents that live in poor green spaces reported experience less heat stress symptoms which contradict with the heat exposure assessment that been conducted in the respondent's house. This is due to body adaptability towards heat stress. Zander et al., (2018) mentions that individual's response towards heat depends on their body temperature threshold and physiological ability to endure the heat.

5.2 Correlation of Contributing Factors with Heat Stress Symptoms

According to the findings, it shown that the amount of fluid intake correlate with the heat stress symptoms. The body thermoregulation mechanism is important in optimize the internal body temperature. Thus, increase in heat stress exposure may cause our body sweating which give cooling effect to our body. Over prolong period of time, this may cause dehydration as there's no water replenishment due to electrolyte imbalance. Mansor et al., (n.d.) states that excessive perspiration can cause electrolyte imbalances, which can lead to heat cramps. Heat exhaustion arises due to water dominance or salt depletion caused by a lack of fluid replenishment, which causes the sensation of thirst.

Besides, there is strong correlation between number of conventional of E-cigarette per day and heat stress symptoms. This is in line with. Zhu et al (2021) where the experimental study is conducted on mouse by exposing the nicotine vapour in order to examine the acute effects and chronic effect on cellular and behavioral. This study concludes that nicotine vaping able to alter homeostasis such as thermoregulation and locomotion.

It is found that age of house and years of living in house have correlation with heat stress symptoms. This is in line with date of construction building factors can contribute to overheating of building (M Sc 2016; White Newsome et al., 2012). The study mentions that Due to the large thermal mass of many structures, which absorbs and retains heat and efficiently warms the internal environment, buildings without sufficient climate controls may magnify heat exposure above outside levels, raising the risk of heat-related illness and mortality. Based on the observation, most of old house buildings have poorly maintenance in term of the ventilation system and the building materials which may contribute to prevention of high heat exposure.

5.3 Association between Contributing Factors and Heat Stress Symptoms

It is found that people who are physically active tend likely to have heat stress symptoms. It is contradicted with previous study that where people engaged in strenuous physical activity tend to have healthy body which able regulate body temperature more efficiently. This indirectly reduce the chance of having Heat Related Illness (HRI). While other studies McGregor & Vanos, (2018) mentioned that excessive physical activity in hot environments can cause heat strain.

There is association between building materials in term of type of wall and type of roof with heat stress symptoms. This is in line previous study which mention increase of indoor temperature varies based on type of exterior surface of buildings (Giyasov& Giyasova, 2018; Zheng et al., 2016).

The findings also shown that type of clothing during day-time and night-time have association with heat stress symptoms where people who wear thick clothing are likely to experience heat stress symptoms. This is in line Havenith et al., (2002) that mention the thickness of cloth contribute the individual heat stress level. The study mentions that clothing may influence the air flow between inside and out-side cloth which can cause the heat to retain within the clothing. Besides, one of the factors of clothing heat resistance based on the thickness of cloth.

CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Conclusion.

In conclusion, the is found that there is correlation be-tween glass of water intake, intake of number of E-cigarette per day, age of house and years living in house. Besides, there also association between glass of water and physical activity, building materials (roof materials and wall materials) and type of clothing during daytime and nigh-time.

6.2 Recommendation

For the future research, it is recommended to use cohort study design in order to study the heat stress effects on human annually especially in understanding the heat stress contributing factor in depth. . Besides, it is recommended to obtain equal samples from each of vulnerable group so that, none of vulnerable groups are underrepresented and it present as a whole. The study related to heat stress are more suitable to conduct during the hottest month of the year which are from April to June in Malaysia. Thus, the heat stress findings are more clear and significant. It is also recommended for the community to always conduct maintenance on ventilation system and improve the building materials, when necessary, as this are able to reduce the exposure of heat stress.

6.3 Study limitation

There are few study limitation that the researcher encountered throughout this study. The cross-sectional study design was conducted to identify the potential contributing factors toward heat stress. However, this study design may not be suitable to conduct to study each heat stress contributing factors in depth as the heat stress effect experienced by a person may differ from time to time.

Besides, the data collection was conduct between November and December which are during Northeast monsoon which are associated with rainfall season. Therefore, the study findings unable to compare with other studies as the heat stress effect on human been conducted outside of the hottest months of the year in Malaysia.

It also need to be stressed that the study findings generalize the every vulnerable groups as a whole. This due to the sample selection are of vulnerable populations are selected whoever fulfils the inclusive and exclusive criteria. Therefore, the findings regarding heat stress contributing factors are unable to represent for each different vulnerable groups.

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RESPONDENT ID: ☐☐☐

SECTION A: SOCIODEMOGRAPHIC INFORMATION

Please fill in or mark (/) the space provided.

1.1 Mobile No. : ____________________

1.2 Age : ______years

1.3 Gender : ☐ Male ☐ Female

1.4 Nationality : ☐ Malaysian ☐ Non-malaysian

1.5 Ethnicity : ☐ Malay ☐ Chinese ☐ Indian ☐ Others
Please state: ____________

1.6 Level of education : ☐ No formal education ☐ Primary school ☐ Secondary school ☐ Pre-Uni/STPM/Diploma ☐ Bachelor ☐ Master/PhD

1.7 Total household monthly incomes : ☐ Below RM4,851 (B40) ☐ RM 4, 851 - RM 10,970 (M40) ☐ RM 10,971 and above (T20)

1.8 No. of members in the house : ______ people

1.9 Height : ______ cm

1.10 Weight : ______ kg

1.11 State area of your home
(e.g.: Flat Sri Kundang, Kg. Batu 13) : ____________________

SECTION B: HEALTH INFORMATION

2.1 Do you suffer from any of the following disease(s) that have been diagnosed by a doctor in the **last 6 months**?
(Answers can be marked with more than one option)

1.	Hypertension	☐	10.	Asthma	☐
2.	Diabetes	☐	11.	Pneumonia	☐
3.	Obesity	☐	12.	Tuberculosis (TB)	☐
4.	Liver/ Hepatic disease	☐	13.	Influenza *(Viral infection that attacks the respiratory system)*	☐
5.	Cancer	☐	14.	Bronchitis	☐
6.	Kidney/ Renal disease	☐	15.	Chronic Obstructive Pulmonary Disease (COPD) *(Airflow blockage and breathing-related problems)*	☐
7.	Cardiovascular disease *Please specify:* ________________	☐	16.	Cystic fibrosis *(Inherited disorder that causes severe damage to the lungs and other organs in the body)*	☐
8.	Skin disease/ infection *(e.g.: eczema)* *Please specify:* ________________	☐	17.	Brain disease/ damage *(e.g.: encephalopathy)*	☐
9.	Rhabdomyolysis *(Damaged or injured skeletal muscle)*	☐	18.	**None of the above**	☐

2.2 Are you currently taking any medication under doctor's supervision?
(If 'No', please proceed to question 2.3)

Yes ☐ No ☐

2.2.1 If 'Yes', state the type of medicine you are taking.

____

2.3 Please state how many glasses of water you drink in a day? (1 glass = 250ml)

________glasses

2.4 Do you smoke?
(If 'No', please proceed to the question 2.5)

Yes ☐ No ☐

2.4.1 What type(s) of cigarette do you smoke?
(Answers can be marked with more than one option)

☐ Conventional cigarette *(e.g.: cigarette/cigar)*

☐ E-cigarette *(e.g.: vape, port, shisha)*

2.4.2 If 'Yes', please state how many times do you smoke in a day?

Conventional cigarette:_____ cigarette in a day

E-cigarette:_____time(s) in a day

2.5 Do you regularly consume alcoholic drinks (at least once a day)?
(If 'No', please proceed to the next section)

Yes ☐ No ☐

2.5.1 If 'Yes', how many can(s) do you consume alcoholic drinks in a day?

______ can(s) in a day

SECTION C : RESIDENTIAL INFORMATION

Please fill in or mark (/) in the space provided.

3.1 What is the type of your residence?

☐ Landed house *(e.g.: Terrace house, Semi D, Banglow)*

☐ Multi-story/high rise building *(e.g.: Apartment, Condominium, SoHo)*
Please state which floor (e.g.: LG, G, L22): ______

3.2 How long have you been living here?

________year(s)

3.3 How old is your house since it was built?

________year(s)

3.4 What is the type(s) of ventilation system available in your house and where it is(are) located? *(Answers can be marked with more than one option)*

Type(s) of ventilation system	**Available area(s)**					
	Living room	Bedroom	Dining area	Kitchen	Toilet	Not available
Operable fan *(e.g.: wall/ceiling/portable fan)*	☐	☐	☐	☐	☐	☐
Openable window	☐	☐	☐	☐	☐	☐
Air-conditioner *(e.g.: wall/portable/ceiling mounted type of air conditioner)*	☐	☐	☐	☐	☐	☐
Wind hole	☐	☐	☐	☐	☐	☐
Residential exhaust fan *(e.g.: wall mount propeller, stainless steel roof ventilator)*	☐	☐	☐	☐	☐	☐

3.4.1 When do you commonly use the available ventilation system in your house?
(Answers can be marked with more than one option)

Type(s) of ventilation system	**Period of using ventilation system**					
	Whole day	In the morning	In the afternoon	In the evening	At night	Never
Operable fan	☐	☐	☐	☐	☐	☐
Openable window	☐	☐	☐	☐	☐	☐
Air-conditioning	☐	☐	☐	☐	☐	☐
Residential exhaust fan *(e.g.: wall mount propeller, stainless steel roof ventilator)*	☐	☐	☐	☐	☐	☐

3.5 What is the type(s) of wall building materials of your house?
(Answers can be marked with more than one option)

☐ Concrete

☐ Brick with/without plaster

☐ Wooden planks

☐ Zinc/metal

3.6 What is the type(s) of roof or roof building material of your house?
(Answers can be marked with more than one option)

☐ Zinc/metal roof  

☐ Ceramic/clay roof  

☐ Concrete roof/ceiling  

☐ Asphalt shingle roof 

☐ Thatch roof 

3.7 How do you perceive your house ventilation according to the specific areas as stated?
(Please answer for every house area)

House area	Good ventilation	Poor ventilation
Living room	☐	☐
Bedroom	☐	☐
Dining room	☐	☐
Kitchen	☐	☐
Toilet	☐	☐

SECTION D: HEAT EXPOSURE INFORMATION

Please fill in or mark (/) in the space provided.

4.1 How many hours do you spend at home in a day **during off work** ?

________hour(s)

4.2 How many hours do you spend at home in a day **during working day** ?

________hour(s)

4.3 How would you describe your current job?

- ☐ Work from home (including housewife and retiree person)
- ☐ Work at the office
- ☐ Work at the non-office setting (indoor) *e.g.: cleaner, factory worker, café workers*
- ☐ Work at the non-office setting (outdoor) *e.g.: gardener, farmer*
- ☐ Remote workstation
- ☐ Student (Study from home)
- ☐ Student (attending school/ study institution)

4.4 Which of the following home appliances make you feel hot during usage? *(Answers can be marked with more than one option)*

- ☐ Cooking stove (without exhaust fan)
- ☐ Cooking stove (without exhaust fan)
- ☐ Electrical stove
- ☐ Oven
- ☐ Iron
- ☐ Steamer
- ☐ Air fryer
- ☐ Microwave
- ☐ Rice cooker
- ☐ Pressure cooker
- ☐ Washing machine
- ☐ Dryer machine
- ☐ Refrigerator
- ☐ Vacuum
- ☐ PC/laptop
- ☐ Television (TV)
- ☐ Humidifier
- ☐ Hair dryer
- ☐ Water heater
- ☐ Other hot objects (if any) *Please state:* ________________

4.5 Which of the following can be found in your neighborhood area?
(Answers can be marked with more than one option)

- ☐ Road tar
- ☐ Highway
- ☐ Passing vehicle
- ☐ High-rise building
- ☐ Public transport *(e.g.: KTM, Rapid KL)*
- ☐ Industrial area
- ☐ Public plaza
- ☐ Higher education campuses
- ☐ Others
  *Please state:*_______________
- ☐ Water features *(e.g.: pond, lake, river)*
- ☐ Sea
- ☐ Natural landscape
- ☐ Forest/ Trees
- ☐ Plantation *(e.g.: oil palm trees)*
- ☐ Recreational area
- Community parks/garden
- ☐ Cemeteries

4.6 What type of clothing do you commonly wear at home according to the specified time?
(Choose only one(1) answer for daytime and night-time)

Clothing types	Daytime	Night-time
Light clothing *(e.g.: not wearing shirt/ singlet/ light t-shirt + short pants/ thin long pants)*	☐	☐
Normal clothing *(e.g.: short sleeve t-shirt + long pants/ skirt/ batik skirt)*	☐	☐
Thick clothing *(e.g.: long sleeve shirt/ sweater/ sweatshirt + long pants/ sweatpants)*	☐	☐

4.7 During the **last 7 days**, on how many days did you do **vigorous physical activities** for at least 10 minutes? *(e.g.: heavy lifting, digging, aerobics, running or fast bicycling)*
Vigorous physical activities = activities that take hard physical effort and make you breathe much harder than normal.

_____ days per week

☐ No vigorous physical activities *(Please proceed to question 4.8)*

4.7.1 How much time did you usually spend doing **vigorous physical activities** on one of those days?

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

4.8 During the **last 7 days**, on how many days did you do **moderate physical activities** for at least 10 minutes at a time?
(e.g.: carrying light loads, bicycling at a regular pace, or doubles tennis) **Do not include walking**.
Moderate activities = activities that take moderate physical effort and make you breathe somewhat harder than normal

_____ days per week

☐ No moderate physical activities *(Please proceed to question 4.9)*

4.8.1 How much time did you usually spend doing **moderate physical activities** on one of those days?

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

4.9 During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time? (Including at work and at home, walking to travel from place to place, and any other walking that you have done)

_____ days per week

☐ No walking *(Please proceed to question 4.10)*

4.9.1 How much time did you usually spend **walking** on one of those days?

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

4.10 During the **last 7 days**, how much time did you spend **sitting** on a **weekday**?
Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

_____ hours per day

_____ minutes per day

☐ Don't know/Not sure

4.11 Please indicate (/) if you experience any of the following symptoms or sensations while doing physical activities **during last 7 days.**
(Answers can be marked with more than one option)

Symptoms/ sensations	**Vigorous activities** *(e.g.: heavy lifting, digging, aerobics, running or fast bicycling)*		**Moderate activities** *(e.g.: carrying light loads, bicycling at a regular pace, or doubles tennis)*	
	Yes	No	Yes	No
a. Sweating				
b. Heat rash (itchy red bumps/ cluster of pimples/ small blister at the body parts)				
c. Flushed skin (Skin turn red)				
d. Nausea or vomiting				
e. Dizziness				
f. Headache				
g. Thirst				
h. High body temperature (>38^{O}C)				
i. Faint				
j. Rapid, shallow breathing				
k. Muscle cramps				
l. Light-headedness during prolonged standing or suddenly rising from a sitting or lying position				
m. Cool, moist skin with goose bumps when in the heat				
n. Weak or rapid pulse				
o. Racing heart rate				
p. Weakness/Fatigue				
q. Slurred speech				
r. Irritability				
s. Confusion				
t. Agitation				
u. Seizure				

SECTION E: HEAT HEALTH-RELATED SYMPTOMS

5.1 Please indicate (/) if you experience any of the following symptoms or sensations while living in your house. *(Answers can be marked with more than one option)*

Heat stress symptoms	**Never**	**1-2 times in a week**	**3-4 times in a week**	**Once everyday**	**Several times everyday**
a. Sweating					
b. Heat rash (itchy red bumps/ cluster of pimples/ small blister at the body parts)					
c. Flushed skin (Skin turn red)					
d. Nausea or vomiting					
e. Dizziness					
f. Headache					
g. Thirst					
h. High body temperature (>38^{O}C)					
i. Faint					
j. Rapid, shallow breathing					
k. Muscle cramps					
l. Light-headedness during prolonged standing or suddenly rising from a sitting or lying position					
m. Cool, moist skin with goose bumps when in the heat					
n. Weak or rapid pulse					
o. Racing heart rate					
p. Weakness/Fatigue					
q. Slurred speech					
r. Irritability					
s. Confusion					
t. Agitation					
u. Seizure					

DATE: 24 SEPTEMBER 2021
JKEUPM-2021-384 VERSION 2

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR, MALAYSIA

FORM 2.4: RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. STUDY TITLE :
The Association between Heat Exposure Level and Heat Stress Symptoms among Vulnerable Population in Urban Area, Kuala Lumpur.

2. INTRODUCTION:
This study is to determine the association between the heat exposure level and the stress symptoms among vulnerable population in urban area, Kuala Lumpur. The study include senior citizen, people living old buildings, people living in multi-storey or high rise building, people with low income (B40) and people with health problem.

3. WHAT WILL YOU HAVE TO DO?
The questionnaire consist of 5 section, that are:

- Section A: Sociodemographic information
- Section B: Residential information
- Section C: Health information
- Section D: Heat stress information
- Section E: Heat stress symptoms

1. You are required to answer all of the questions listed in the questionnaire.
2. Please complete all the questionnaire by providing answer in spaces provided.
3. This questionnaire must be returned back to the researcher after answering all of the questions.
4. All information obtained will be kept confidential and will only be used for learning purpose only.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?
Pregnant women

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

The respondent able to understand the impact of heat exposure on their heat stress symptoms especially towards the vulnerable population and able to identify early heat-related symptoms to overcome the issue.

(b) TO THE INVESTIGATOR?

The investigator able to associate the heat exposure level and heat heat stress symptoms among thevulnerable populations in urban residential areas.

6. WHAT ARE THE POSSIBLE RISKS?
There is no possible risk.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?
Yes. All of the information that will be obtained remained confidential and only be used for learning puposes only.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If your require further information or have any problems related to this study, you can contact the Chief Researcher:

Dr Vivien How

Department of Environmental & Occupational Health.

Faculty of Medicine and Health Sciences,

Universiti Putra Malaysia

Emel: vivien@upm.edu.my

Tel no.:

You can also contact the members of the researcher team:

Adawiyah binti Redzuan

Bachelor of Science Environmental & Occupational Health,

Faculty of Medicine and Health Sciences,

Universiti Putra Malaysia.

Emel: 196156@student.upm.edu.my

Tel no.:

*Please initial here if you have read and understood the contents of this page*________

9. CONSENT

I …………………………………… Identity Card No. …………………………… address………………………………………………………………………………………………….. …………………………………………………….hereby voluntarily agree to take part in the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature …………………………………… (Respondent)

Signature …………………………………… (Witness)

Date :……………………………………….

Name :……………………………………….

I/C No. :……………………………………….

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ……………………………………

Signature …………………………………… (Researcher)

ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS (JKEUPM)
UNIVERSITI PUTRA MALAYSIA

Research title	:	**Association Between Heat Exposure Level and Heat Health Risk Among Vulnerable Population in the Urban Areas, Kuala Lumpur.**
Study Site	:	**Kuala Lumpur**
JKEUPM Ref No.	:	**JKEUPM-2021-384**
Researcher	:	**Adawiyah Binti Redzuan**
Supervisor	:	**Dr. Vivien How**

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 14/6/2021
2. Respondent Information Sheet & Consent (English), Version 2 dated 24/9/2021
3. Proposal (English), Version 2 dated 24/9/2021
4. Questionnaire/Interviews (English), Version 2 dated 24/9/2021
5. Questionnaire/Interviews (Malay), Version 2 dated 24/9/2021
6. Curriculum Vitae of:
    a. Assoc. Prof. Dr. Hazizi Abu Saad

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

[X] Approved

[X] **Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research**

[ ] Disapproved

Please note that the approval is **VALID UNTIL 27 OCTOBER 2022**

Researchers should comply with the following:

I. Complete a Study Final Report upon study completion (Form 3.2).

II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.

III. Applicable for Clinical Trial Studies and Clinical interventional Studies only: Progress Report has to be submitted to JKEUPM at every 6 months from the date of approval (Form 3.1). Report occurrences of all Serious Adverse Events (SAEs), Suspected Unexpected Serious Adverse Reaction (SUSARs) and Protocol Deviation/ Violation at all JKEUPM approved sites to JKEUPM. SAEs are to be reported within 15 calendar days from awareness of event by investigator. Initial report of SUSARs are to be reported as soon as possible but not later than 7