UNIVERSITI PUTRA MALAYSIA

ESTABLISHMENT OF HEAT STRESS INDEX TO IMPROVE THERMAL COMFORT AMONG INDUSTRIAL OPERATORS IN MALAYSIA

DAYANA HAZWANI MOHD SUADI NATA

FPSK(p) 2018 1

ESTABLISHMENT OF HEAT STRESS INDEX TO IMPROVE THERMAL COMFORT AMONG INDUSTRIAL OPERATORS IN MALAYSIA

By

DAYANA HAZWANI BINTI MOHD SUADI NATA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December 2017

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

ESTABLISHMENT OF HEAT STRESS INDEX TO IMPROVE THERMAL COMFORT AMONG INDUSTRIAL OPERATORS IN MALAYSIA

By

DAYANA HAZWANI BINTI MOHD SUADI NATA

December 2017

Chairman : Associate Professor Shamsul Bahri Md Tamrin, PhD
Faculty : Medicine and Health Sciences

Malaysia is a tropical climate country with hot and humid condition throughout the year. The hot working environment in the industrial increases the challenges of body homeostasis to induce heat stress and interferes with thermal comfort. For this problem, there is no specific standard or guideline of heat adaptation for the industrial operators in Malaysia to overcome the problems. In addition, no studies have been carried out in Malaysia to model the exposure of heat to workers with thermal comfort. Therefore, the aim of this study is to establish the prediction index of heat stress index in order to improve the thermal comfort among industrial operators in Malaysia. Two phases were conducted, namely (1) Phase 1: Cross-sectional study, and (2) Phase 2: Experimental study. The cross-sectional study was conducted in palm oil mill, steel industry and manufacturing plant in Malaysia to collect the 464 of male industrial workers who were identified exposed to the heat during working. Data collection consisted of the walk-through assessment, questionnaire, environmental monitoring, and personal assessment. The study showed that the mean of WBGTin =30.69±0.99°C, exceeding the ACGIH TLVs which suggested to be 28.2°C for work and rest regime (75% work and 25% rest). In this study, therefore, 100% of operators were identified to suffer heat stress during working y. The perception of comfort checklist showed that 82.1% of operators felt discomfort while working in their workplace. In addition, the variables involved in this study were acute heat symptoms score which recorded as the highest Beta value (B = 0.480, p <0.001), followed by, WBGTin (B = 0.150, p<0.001), metabolic workload (B= 0.1, p=0.11), body core temperature (B=0.087, p =0.015), drinking volumes (B=-0,163, p<0.001) and relative humidity (B = -0.190, p <0.001). An experimental work was conducted between 60 operators in phase 2 for comparison and validation of the predictive index with the existing procedure to determine thermal comfort value, humidex and perception of thermal comfort checklist. The result showed there was a significant positive correlation between the predictive index and humidex, r = 0.754, p = 0.01, and there was no significant correlation with the perception of thermal comfort checklist (r= 0.032).

In addition, the receiver operating characteristic (ROC) curve showed that rule performed more accurately in predictive index (area under the curve = 0.893) compared to perception of thermal comfort checklist (area under the curve = 0.524). All physiological variables exhibited significant difference with predictive index, namely body core temperature ($p<0.001$), heart rate ($p=0.001$), systolic blood pressure ($p<0.001$) and diastolic blood pressure ($p=0.07$). The discriminate function revealed a significant association between groups (comfort and discomfort) with all physiological variables, accounting for 62.41% of between group variability. Moreover, the establishment of heat stress index was integrated into visual basic application (VBA) in Microsoft Excel. The index was found to be able to express comprehensive index which included the individual perception factors, environmental and physiological changes for indoor industries. This index was proved to be more user-friendly and applicable in which the variability of determination of thermal comfort was better than other indexes. In conclusion, the establishment of heat stress index in this study indicated the ability of this index to represent the indoor heat stress condition, as well as applicable and a simple measurement which consisted of all the associated factors (individual, environmental and physiological variables) in heat stress and thermal comfort.

(keywords: thermal comfort, heat stress index, tropical climate, predictive study)

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGUKUHAN INDEKS TEGANGAN HABA UNTUK MENINGKATKAN KESELESAAN HABA DALAM KALANGAN OPERATOR INDUSTRI DI MALAYSIA

Oleh

DAYANA HAZWANI BINTI MOHD SUADI NATA

Disember 2017

Pengerusi : Profesor Madya Shamsul Bahri Md Tamrin, PhD
Fakulti : Perubatan dan Sains Kesihatan

Malaysia adalah sebuah negara yang beriklim tropika, dengan keadaan panas dan lembap sepanjang tahun. Persekitaran kerja yang panas di perindustrian meningkatkan cabaran homeostasis badan yang mendorong kepada tegangan haba dan mengganggu keselesaan haba. Untuk mengatasi masalah ini, tiada standard tertentu atau garis panduan bagi penyesuaian haba untuk operator industri. Di samping itu, tiada kajian yang telah dijalankan di Malaysia untuk memodelkan pendedahan haba terhadap pekerja dengan keselesaan haba. Tujuan utama kajian ini adalah untuk membangunkan ramalan indeks tegangan haba bagi meningkatkan keselesaan haba dalam kalangan operator industri di Malaysia. Terdapat dua fasa yang telah dijalankan iaitu, (1) Fasa 1: Kajian Keratan Rentas, (2) Fasa 2: Kajian Perbandingan. Kajian keratan rentas telah dijalankan di kilang minyak sawit, industri keluli dan kilang pembuatan di Malaysia dengan mengumpul 464 operator industri lelaki yang telah dikenal pasti terdedah kepada haba panas semasa bekerja. Pengumpulan data adalah terdiri daripada penilaian pemerhatian, soal selidik, pemantauan alam sekitar, dan penilaian peribadi. Kajian ini menunjukkan min WBGTin = 30,69 ± 0,99 ° C, melebihi nilai ACGIH TLV yang mencadangkan suhu 28.2 °C untuk bekerja dan rejim rehat (kerja 75% dan rehat 25%). Oleh itu, dalam kajian ini 100% daripada operator telah dikategorikan mengalami tegangan haba semasa bekerja. Persepsi bagi senarai semak keselesaan menunjukkan bahawa 82.1% daripada operator merasakan ketidakselesaan semasa bekerja di tempat kerja merekaDi samping itu, pembolehubah yang terlibat dalam kajian ini adalah simptom haba akut yang telah merekodkan nilai Beta tertinggi (B = 0.480, p <0.001), diikuti oleh WBGTin (B = 0.480, p <0.001), beban kerja metabolik (B= 0.1, p=0.11), suhu teras badan (B=0.087, p =0.015), isipadu minuman (B=-0,163, p<0.001) dan kelembapan relatif (B = -0.190, p <0.001). . Satu kajian eksperimen telah dijalankan antara 60 operator dalam fasa 2 untuk perbandingan dan pengesahan indeks ramalan dengan prosedur sedia ada untuk menentukan nilai keselesaan haba, humidex dan persepsi bagi senarai semakan keselesaan haba. keputusan menunjukkan terdapat korelasi positif yang ketara antara indeks ramalan dan humidex, $r = 0.754$, $p = 0.01$ dan tiada korelasi ketara dengan persepsi bagi senarai semakan keselesaan haba.

Di samping itu, lengkung ciri-ciri penerima operasi (ROC) menunjukkan bahawa peraturan dilakukan dengan lebih tepat dalam indeks ramalan (luas di bawah lengkung = 0.893) berbanding persepsi bagi senarai semakan keselesaan haba (luas di bawah lengkung = 0.524). Semua pembolehubah fisiologi memperlihatkan perbezaan ketara dengan indeks ramalan, iaitu suhu teras badan ($p < 0.001$), kadar jantung ($p = 0.001$), tekanan darah sistolik ($p < 0.001$) dan tekanan darah diastolik ($p = 0.07$). Fungsi diskriminasi menunjukkan hubungan yang signifikan antara kumpulan (keselesaan dan ketidakselesaan) dengan semua pembolehubah fisiologi, menyumbang 62.41% antara kebolehubahan kumpulan. Selain itu, pengukuhan indeks tekanan haba panas telah diintegrasikan ke dalam aplikasi asas visual (VBA) dalam Microsoft Excel. Indeks ini dapat menunjukkan indeks yang komprehensif termasuklah faktor persepsi individu, perubahan alam sekitar dan fisiologi untuk industri yang tertutup. Indeks ini terbukti lebih mesra pengguna dan boleh diguna pakai yang mana variasi penentuan keselesaan haba panas adalah lebih baik daripada indeks-indeks lain. Kesimpulannya, pengukuhan indeks tekanan haba dalam kajian ini menunjukkan keupayaannya untuk mewakili keadaan tegasan panas tertutup, serta pengukuran mudah dan sederhana yang terdiri daripada semua faktor yang berkaitan (pembolehubah individu, alam sekitar dan fisiologi) dalam tekanan haba dan keselesaan haba.

(Kata kunci: keselesaan haba, indeks tegangan haba, iklim tropika, indeks ramalan)

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful.Alhamdulillah all praises to Allah for the strengths and His blessing in completing this thesis.

I would like to thank you dedicated my supervisor, Assoc. Prof. Dr. Shamsul Bahri Hj. Mohd Tamrin, for his supervision, teaching and guidance through all this research. The commitment, dedication and support from him had produced great success for this research. Not to forgotten, a very big thank you also to my supervisory committee, Assoc. Prof. Dr. Samsul Bahari Mohd. Noor and Assoc. Prof. Dr. Goh Yong Meng for their times and valuable feedback on my research.

I owe a debt of gratitude to Ministry of Education (MyBrain PhD) and Long Research Grant Scheme (LRGS) for providing financial assistance and research grant. As well as sincere appreciation for the management and all employee of Palm Oil Mills, Steel Mills and Glass Mills, which had given good cooperation from the approval until the data collection is completed.

Special thanks go to my dearest husband, Muhammad Farith Mohd Jamli and my lovely son, Zayn Akmal Muhammad Farith for their patience, love, and understanding through the good and bad times. Thank you for believing in me throughout my prolonged years of study, which at times seems to be in vain and insurmountable.

I am deeply thankful to my family especially to my beloved parent, (Mohd Suadi Nata Busu and Zawaiah Omar), my parent in laws (Haji Mohd Jamli Ahmad Rasidi and Hajah Hasimah Che Zun) as well as to my siblings (Muhammad Dhiyauddin, Muhammad Danial Hafiz, Dalila Hanani, Nur Hafiza and Muhammad Farhan) for their continuous support, unparalleled love prayers and encouragements.

It is a pleasure to thank my friends at Universiti Putra Malaysia, Hajar Mariah Hashim and Nur Sabrina Mohd Nasir for the wonderful times we shared specially the knowledge and spirit. In addition, I would like to thank all my friends who gave continuous encouragement and motivation throughout my study, Nur Azurinrah Ismail and Noor Diyana Abdul Ranee.

Last but not least, it is a pleasant task to express my thanks to all those who contributed directly, indirectly and in many ways to the success of this study and made it an unforgettable experience for me.

I certify that a Thesis Examination Committee has met on 12 December 2017 to conduct the final examination of Dayana Hazwani binti Mohd Suadi Nata on her thesis entitled "Establishment of Heat Stress Index to Improve Thermal Comfort among Industrial Operators in Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Mohd Roslan bin Sulaiman, PhD
Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Zulkifli bin Idrus, PhD
Professor
Institute of Tropical Agriculture and Food Security
Universiti Putra Malaysia
(Internal Examiner)

Amran Ab Majid, PhD
Professor
Universiti Kebangsaan Malaysia
Malaysia
(External Examiner)

Ravindra Stephen Goonetilleke, PhD
Professor
Hong Kong University of Science and Technology
Hong Kong
(External Examiner)

NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 27 February 2018

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Shamsul Bahri Md Tamrin, PhD
Associate Professor
Faculty of Medicine and Health Science
Universiti Putra Malaysia
(Chairman)

Samsul Bahari Mohd Noor, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Goh Yong Meng, PhD
Associate Professor
Faculty of Veterinary Medicine
Universiti Putra Malaysia
(Member)

____
ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: ____________________ Date: ________________

Name and Matric No: Dayana Hazwani Binti Mohd Suadi Nata, GS34629

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

Signature:	
Name of Chairman of Supervisory Committee:	Associate Professor Dr. Shamsul Bahri Md Tamrin

Signature:	
Name of Member of Supervisory Committee:	Associate Professor Dr. Samsul Bahari Mohd Noor

Signature:	
Name of Member of Supervisory Committee:	Associate Professor Dr. Goh Yong Meng

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AHS	Acute Health Score
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
DB	Dry temperature
DOSH	Department of Occupational Safety and Health
FMA	Factories and Machinery Act
GB	Globe temperature
HRD	Human Resources Department
ILO	International Labour Organization
ISO	International Organization for Standardization
MHSI	Malaysian Heat Stress Index
MIDA	Malaysian Investment Development Authority
MLR	Multiple Linear Regression
NIOSH	National Institute of Occupational Safety and Health
NWB	Natural wet bulb temperature
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration; Occupational Health and Safety Act
RH	Relative Humidity
SOSCO	Social Security Organisation
TWA	Time Weighted Average
TLV	Threshold Limit Values

WBGT	Wet Bulb Globe Temperature
WHO	World Health Organization
VBA	Visual Basic Application

CHAPTER 1

INTRODUCTION

Chapter 1 briefly describes the background of this research. It also includes details on the research problem and the justifications. Apart from that, the objectives, hypothesis, conceptual framework and operational definitions were also outlined in this chapter.

1.1 Background

Heat stress is considered as a physical hazard in a working setting. NIOSH, 1986 defined heat stress as a summation of the body's heat production (metabolic load), and environmental temperature minus the heat loss from the body to the environment. Furthermore Barbara (2002) stated that heat stress is the total body's heat load from the combination of the inner and exterior factors. Interior factors include body core temperature, acclimatization, heat tolerance and metabolic load, while the external factors are air temperature, radiant heat, air velocity and relative humidity (Lahey, 1984). Thus, it can be concluded that heat stress is a mixture of the heat capacity of an individual and surrounding environmental factors. This in turn gives negative impacts on operators' performance, safety, and health. (Rasoul et al., 2013). The environmental factors, namely air temperature, radiant temperature, humidity and air movement and personal factors including metabolic load and clothing are the main components that affect the extent of thermal stress imposed on operators. Examples of operations that involved heat stresses are iron and steel foundries, glass mills, rubber factories, boiler places, food industries, and steam tunnels. (OSHA Technical Manual, 1999; Azlis S. J. et al., 2007). Next, heat strain is defined as the response of the human body towards total heat stress. In ideal situation, thermoregulation mechanism of a human body responds well to heat exposures. However, injuries, low productivity and heat related illness takes place when the heat load (environmental and metabolic) is beyond the ability of the body to maintain normal body function. Nevertheless, repeated exposures to heat contributes to physiological adaptation called acclimatization, whereby the body will be able to maintain its performance despite heat denudation.

Figure 1.1 describes the mechanisms of heat exposure. According to Barbara (2002), as the heat storage increases, body temperature will relative rise. In response to this, blood circulation dilates the cutaneous vascular bed which further increases the blood flow to the skin. Thus, sweating mechanism will be activated to sustain the temperature if required. However, this physiological reaction causes an increase in the core body temperature, heat rash and loss of water and salt. The physiological reaction is the increase in skin temperature that results in excess sweating.

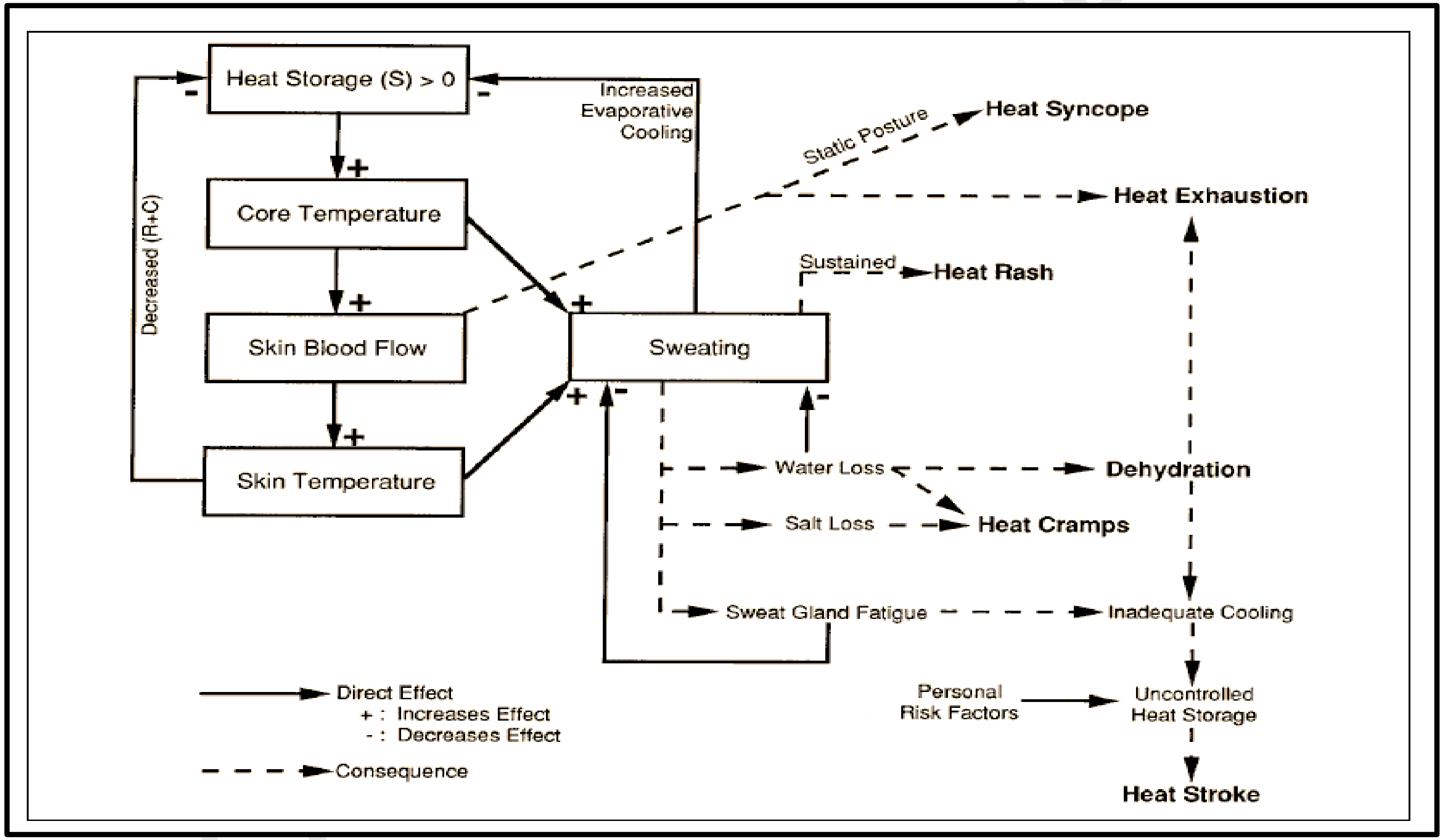

Figure 1.1 : Mechanism due to heat exposure
(Source : Barbara, 2000)

Heat Stress Index is a metric widely applied for heat used as a guideline to measure the six fundamental factors in human heat stress, as a result ensuring safe condition in a working environment. (Parson et al. 2000). The current development of heat stress index was mostly related to the heat disorders and productivity compared to the thermal comfort.

1.2 Problem Statement

Although there are more than 20 indices available to evaluate heat stress at global scale (Moran et al., 2000), however none of those were regarded as a universal heat stress index. There were many literatures that reported on the researches and methods conducted to evaluate array of heat indices for heat stress assessment. Although many indices are proposed, but none of the indices can be utilized by operators within a tropical region, most notably in Malaysia.

Although ample of researches and discussions were carried out to report on the outstanding and universal heat stress indices, however most does not include all the necessary fundamental factors (Goldman, 1988). Theoretically, these indices are of poor quality, but sufficient to be used by specific applications based on experiences in a particular industry. Additionally, the existing index is incapable of measuring the thermal comfort experienced from heat stress by the employees within the tropical region. In addition, no studies were conducted to generate measurable scale of thermal comfort in tropical climate countries (Hassan & Ramli, 2010).

Besides that, enormous researches that were conducted among operators of different workplaces demonstrated significant association between high environmental temperature and negative impact on operators' performance, attitude and satisfaction level (Lee S.Y. et al., 2005). In other word, frequent exposure to heat within a work environment induced physiological and psychological stresses, which led to sensitivity, irritation, and anxiety. These outcomes exerted a direct impact on the performance, health, and safety of the operators (Parson et al. 2000). The notable industries that had high exposure to heat stress are ceramic plants, steel foundries, rubber product factories, bakeries and steam tunnels (Azlis S. J. et al., 2007).

Figure 1.2 depicts the workforce of different industries in Malaysia for the year of 2011. It can be concluded that manufacturing industry holds the highest number of employees. The reports published by the Labour Department, and Social Security Organisation (SOCSO), 2008-2013 exhibited that highest number of accident occurred in the manufacturing industry compared to rest. Most notably, 422 cases of those reported in 2012 were related to exposure or contact with extreme temperatures in the workplace. Along these lines, as the number of operators increased, the possibilities of increment in the number of accidents are also highly viable.

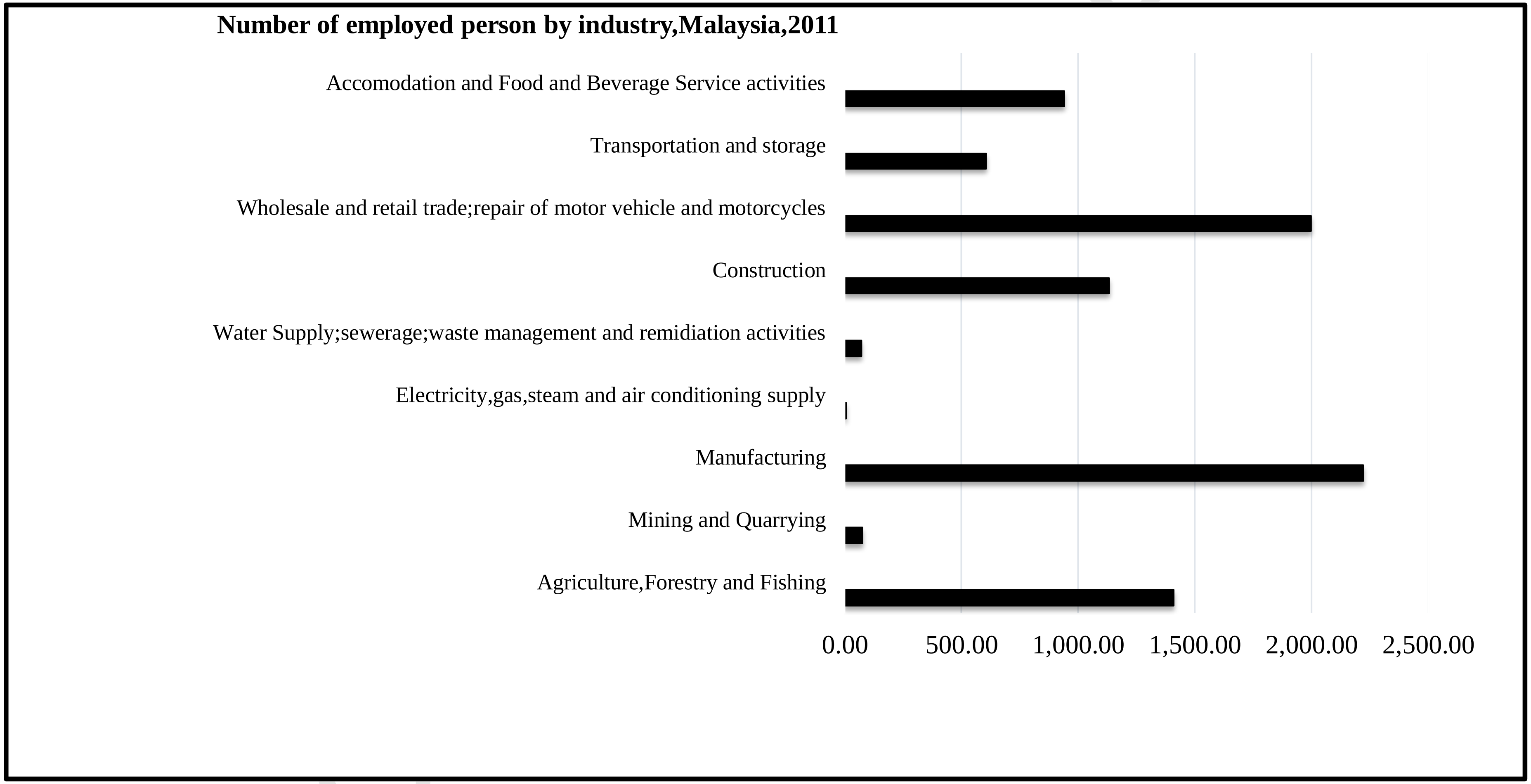

Figure 1.2 : Number of employees relative to industries within Malaysia
(Source : Ministry of Human Resource, 2012)

The American Conference of Governmental Industrial Hygienists (ACGIH) and Table of Threshold Limit Values (TLVs) are the underlying mechanisms that supports Wet Bulb Globe Temperature (WBGT) index, which is commonly used to measure heat stress. Nevertheless, the studies by Siti Fawziah (2000), Goh (2001), Hidayah (2004), and Izzah (2007), Azlis et al. (2007), and Ainun et al. (2011) revealed that heat exposure to operators in Malaysia exceeded the TLVs. In addition, the problem of WBGT index is the index only take account the environmental factors without take consideration others factors such as physiological and psychological factors only (Dehghan, et al., 2011; Mortazavi, Maracy, Dehghan & Jafari, 2012)). A study conducted by Rastoogi, et al. (1992) showed that the exposed workers towards heat would show noticeable physiological strain. Besides, heat stress also leads to increase in the basal body temperature, increased heart rate, and extreme sweating. Therefore, continuous heat exposure will result in heat oedema, fatigue, heat rashes, heat cramps, heat exhaustion and heat stroke (Khogali, 1992). Thus, it showed that the importance of including others factor than environmental factors.

Humidex that is widely used in the measurement of thermal comfort were found to overestimate the actual comfort situation, as being reported by the employees. This situation testified the poor reliability of the tool in determining indoor level of comfort (Rainham, et al., 2003; D'Ambrosio Alfano, et al., 2011).

1.3 Justification of Study

Studies related to heat stress were conducted and published internationally. However, in Malaysia particularly, no specific research was conducted on heat stress index in order to improve thermal comfort. Research into this area would help to reduce the effect and impact of heat stress among operators. Therefore, the present study aims to investigate the establishment of heat stress index to determine the thermal comfort among the operators in Malaysia. The aim of this study is to determine the thermal comfort as well as able to reduce the effect and impact of heat. In addition, the prediction index was designed to increase the efficiency, user friendly, and as a cost saving measure in a workplace. As a result, the management and the operators will be well versed on effective occupational health and safety measures related to heat stress.

Despite the proposal, a major downfall that need to be stressed is the law and regulation. The regulations were supposed to reinforce and increase the awareness among the workers. To date, Department of Occupational Safety and Health Malaysia (DOSH), 2016 had released a guideline entitled "Guidelines on Heat Stress Management at Workplace." This guideline was aimed to educate employees on the recognition, estimation, prevention, and treatment of heat stress at workplace. However, the guideline still uses the existing WBGT index with ACGIH TLVs as underlying references, which led to overestimation of heat stress and thermal comfort values. Therefore, our research functions as a preliminary study, aspiring to provide important information and guideline to DOSH, Malaysia.

1.4 Objectives

1.4.1 General Objective

The general objective of this study is to establish the prediction index for heat stress index in order to improve the thermal comfort among industrial operators in Malaysia.

1.4.2 Specific Objectives

The specific objectives of this research are:

Phase 1 : Cross-Sectional Study

i. To determine the individual risk factor of operators.
ii. To determine health-related symptoms and the proportion of Acute Heat Symptoms Score (AHS) that are experienced by operators in industries.
iii. To determine the heat stress factors (WBGTin, relative humidity, air velocity, clothing and metabolic workload).
iv. To determine the physiological changes (Body core temperature, Heart Rate, Systolic Blood Pressure and Diastolic Blood Pressure).
v. To determine the perception of thermal comfort among industrial operators.
vi. To determine the relationship between Individual Risk Factors, Acute Health Symptoms Score, Heat Stress Factors (WBGTin, Relative Humidity, Air Velocity, Clothing and Metabolic Workload), Physiological Measurement (Systolic Blood Pressure, Diastolic Blood Pressure, Body Core Temperature, and Heart Rate) with the Perception of Thermal Comfort in order to establish heat stress index among industrial operators.

Phase 2 : Comparative Study

i. To compare the thermal comfort value between the predictive index with selected existing procedure among the operators.
ii. To determine the relationship between the prediction heat stress index of thermal comfort with accessible physiological data of the industrial operators.

1.5 Research Hypothesis

The hypotheses of this research are:

i) There is a significant association between Individual Risk Factors, Acute Health Symptoms Score, Heat Stress Factors (WBGTin, Relative Humidity, Air Velocity, Clothing and Metabolic Workload), Physiological Measurement (Systolic Blood Pressure, Diastolic Blood Pressure, Body Core Temperature, and Heart Rate) with the Perception of Thermal Comfort, where the goal is to establish the Heat Stress Index.

ii) There is a significant relationship of thermal comfort value between the predictive index with selected existing procedure among the operators among the operators.

iii) There is significant relationship between the prediction index of thermal comfort with accessible physiological data of the industrial operators

1.6 Definition of Terms

1.6.1 Heat Stress

Conceptual Definition

Heat stress is a combination of the heat load from the individual and environmental factors imposed on operators' bodies, which affected the operators' performance, safety, and health. (Rasoul Hemmatjo et al., 2013).

Operational Definition

Heat stress is determined by using Questemp°34 Thermal Environmental Monitor to measure environmental temperature in degree Celsius and relative humidity in percentage, while for the ACGIH index will be used as the reference.

1.6.2 Thermal Comfort

Conceptual Definition

Thermal comfort is a subjective assessment defined as satisfaction of mind with the surrounding thermal environment. (ASHRAE, 1992).

Operational Definition

Thermal comfort is determined by using ASHRAE Scale to measure the perception among the operators.

1.6.3 Heat Stress Index

Conceptual Definition

Heat stress index is defined as the integration of effects of all basic parameters in any individual thermal environment into a single value (Parson, 2003).

Operational Definition

The heat stress index is established by applying multiple linear regression on individual risk factors, Acute Heat Symptoms Score for heat related symptoms, physiological, and environmental factors in order to improve the thermal comfort by establish heat stress index among industrial operators.

1.6.4 Physiological Changes

Conceptual Definition

Physiological changes are adaptations of the body when being exposed to high temperature, which includes an increase in the basal body temperature, heart rate, and blood pressure. (Barbara, 2002).

Operational Definition

Body core temperature was measured using Omron MC-510 Gentle Temperature Ear Thermometer, while OMRON Blood Pressure Monitor Model T3 was used to measure blood pressure. Apart from that, heart rate was measured by using POLAR Heart Rate Monitor Watch.

1.6.5 Acute Health Symptoms Score

Conceptual Definition

Heat related symptoms occurred after an exposure to high temperature and the resultant symptoms include profuse sweating, headache, nausea and extremely fatigue. Apart from symptoms, the impact of heat can also cause illness, namely heat syncope, heat rashes, heat cramps, heat stroke or heat exhaustion (Barbara, 2000).

Operational Definition

Heat related symptoms were measured by using self-constructed questionnaire. The questionnaire includes all the symptoms related to heat stress experienced by the operators in their working environment. Acute Health Symptoms score based on the heat related symptoms which cumulated based on seven symptoms, namely profuse sweating, extremely fatigue, heat collapse, dizziness, heat cramp, heat rashes, and heat stroke.

1.6.6 Natural Wet Bulb Temperature

Conceptual Definition

Natural wet bulb temperature measurement allowed air to flow over the sensor naturally rather than by force. When air flow is less than 3 m/s (meter per second), the temperature reduces to absolute humidity. Therefore, natural wet bulb temperature has high sensitivity to both humidity and air movement (Barbara, 2002).

Operational Definition

Wet Bulb temperature is measured using the thermometer that is enclosed by moistened cotton wick and exposed only to the natural air movement (NIOSH, 1986).

1.6.7 Globe Bulb Temperature

Conceptual Definition

Globe temperature originates from the radiant heat of the solid surroundings and convectional heat of the ambient air. The globe temperature is used to estimate the average wall temperature of the surroundings (Barbara, 2002).

Operational Definition

The globe temperature is measured by using a six inch, thin-walled, and sphere black colour on the outside, and the temperature sensor is placed at the centre of the globe (Barbara, 2002).

1.6.8 Dry Bulb Temperature

Conceptual Definition

Dry bulb temperature is the measurement of air temperature, where the sensor is surrounded by free air. (Barbara, 2002).

Operational definition

Dry Bulb Temperature is measured by using a thermal sensor that is protected from direct radiant energy sources (OSHA, 1999).

1.7 Conceptual Framework

This research defines the relationship between dependent and independent variables. It is known to all that operators of our industries suffered complications from heat stress in their working environment. Heat stress is a physical hazard that were found to cause thermal discomfort among the operators. (Bell, 1981). Figure 1.3 shows the conceptual framework of this study. The establishment of heat stress index is based on the dependent variables, thermal comfort. The independent variables of this study were divided into 4 groups, namely:

1. Risk Factors including individual, job and lifestyle characteristic.
2. Heat stress (Ramphal, 2000; Epstein and Moran, 2006; Kjellstrom et al., 2009)
3. Physiological changes (Moran et al., 1998; Bernard&Cross, 1999; Chen et., 2011)
4. Acute Heat Symptoms Score (AHSS) (Hunt et al., 2005; Harshal et al., 2006; Joseph et al., 2007; Bethel et al., 2014)

The regression of 4 independent variables were established and integrated into single value in order to predict the thermal comfort. Consequently, the interaction between the perception of thermal comfort, physiological changes, and environment are the substantiation based on the assessment in terms of environmental, physiological and psychological. (Epstein and Moran, 2006, (Simson, Kurnitski & Kuusk, 2017). The interaction vice-versa between perception thermal comfort and physiological changes was related to mechanism of the physiological thermal adaptation towards heat exposure (Lin, de Dear & Hwang, 2011).

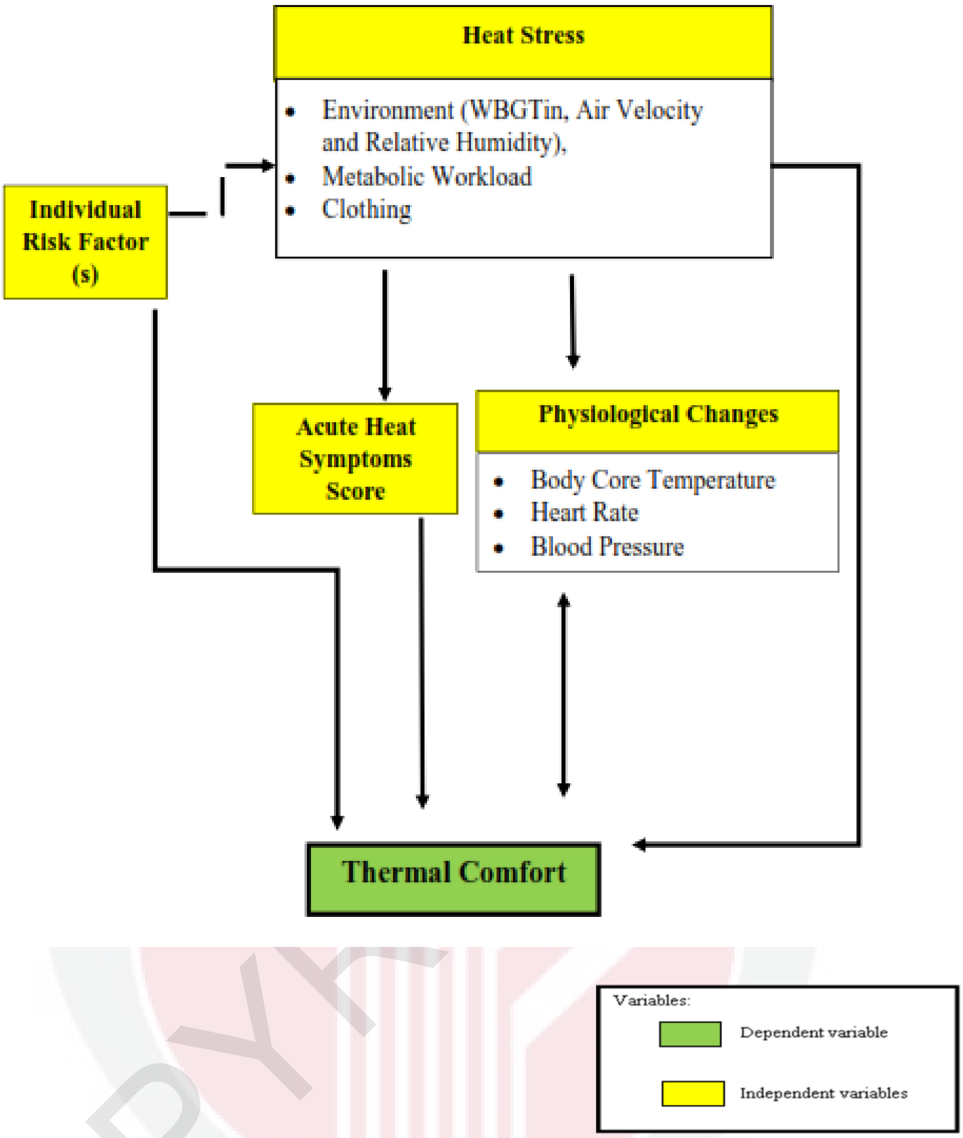

Figure 1.3 : Conceptual framework of research

REFERENCES

Abdul Rahman, A.M. (1995). Housing design in relation to environmental comfort. *Build. Res. Inform.*, *23*, 49-54.

Abidin, I.Z., Azid, A., Mustapha, A.D., and Azaman, F. and Juahir, H. (2015). Application of excel-VBA for computation of water quality index and air pollutant index. *Malaysian Journal Of Analytical Sciences*, 1056-1066.

Abu Bakar, R., Jusoh, N., Rasdan Ismail, A., & Zanariah Shamshir Ali, T. (2016). Effect on human metabolic rate of skin temperature in an office occupant. *MATEC Web of Conferences*, 90, 01070. http://dx.doi.org/10.1051/matecconf/20179001070

Ahasan, M.R., Tarvainen, H., Virokannas, H., and Mohiuddin, G. (2001). Evaluation of heat stress and physical effort of workers in a re-rolling steel mill. *Journal of Physiological Anthropology*.

Ajimotokan, H.A., Oloyede, L.A., and Ismail, M.E. (2009). Influence of indoor environment on health and productivity. *New York Science Journal, 2*(4), 46-49.

Akerman, A.P., Tipton, M., Minson, C.T., and Cotter, J.D. (2016). Heat stress and dehydration in adapting for performance: Good, bad, both, or neither? *Temperature (Austin), 3*(3), 412-436.

Ali, M.M., and Salih, S.K. (2013). A visual basic-based tool for design of stand-alone Solar Power Systems. *Energy Procedia*, *36*, 1255-1264. Doi: 10.1016/j.egypro.2013.07.142.

American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE). (1985). *Handbook of Fundamental*. Atlanta, Ga.

American College of Sport Medicine (1987). American College of Sport Medicine position stand on the prevention of thermal injuries during distance running. *Med. Sci. Sports Exerc.*, *19*(5), 539-533.

American Conference of Governmental Industrial Hygienists (ACGIH) (1992). *1992-1993 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.* Cincinnati: American Conference of Governmental Industrial Hygienists.

American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), Standard 55. (1992). *Thermal Environmental Conditions for Human Occupancy*. Atlanta, GA.

American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE). (1997). *Fundamentals*. SI edition. Atlanta, GA.

American Conference of Governmental Industrial Hygienist. (ACGIH). (1998). *TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents. Thermal Stress.* Cincinnati OH: American Conference of Governmental Industrial Hygienist. 170-182.

American Conference of Governmental Industrial Hygienist (ACGIH). (2001). *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.* Cincinnati: American Conference of Governmental Industrial Hygienist.

American Conference of Governmental Industrial Hygienists (ACGIH). *Heat Stress and Strain: TLV® Physical Agents 7th Edition Documentation (2017)*. TLVs and BEIs with 7th Edition Documentation, CD-ROM. Cincinnati, OH, 2017.American Academy of Paediatrics (AAP). (2011). Policy statement - Climatic heat stress and exercising children and adolescents. *PEDIATRICS, Volume 128,* NO.3. Doi:10.1542/peds.2011-1664

American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), Standard 55. (2010). *Thermal Environment Conditions for Human Occupancy.* Atlanta, GA.

Anderson, H.M. (2014). *Effects of passive heat stress on thermoregulation in smokers versus non-smokers* (Bachelor's dissertation, University of Arkansas, Fayetteville). Retrieved from http://scholarworks.uark.edu/cgi/viewcontent.cgi?article=1010&context=hhpruht.

ANSI/ASHRAE Standard 55 (2010). Thermal Environmental Conditions for Human Occupancy ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers Atlanta.

Arens, E., and Zhang, H. (2006). The skin's role in human thermoregulation and comfort. *Thermal and moisture transport in fibrous materials*. DOI:10.1201/9781439824351.ch16

Armstrong, L.E., and Maresh, C.M. (1991). The induction and decay of heat acclimatisation in trained athletes. *Sports Medicine*, *12*(5), 302-312.

Armstrong, L.E. (1998, March 10). Heat acclimatization. Retrieved from http://www.sportsci.org/encyc/heataccl/heataccl.html

Armstrong, L.E. (2000). Performing in extreme environments. *Champaign, IL: Human Kinetics*. DOI: http://dx.doi.org/10.1580/1080-6032(2002)013[0287:]2.0.CO;2

Attwood, D.A., Deeb, J.M., and Danz-Reece, M.F. (2004). Ergonomics solution for the process industries. Retrieved from http://www.sciencedirect.com/science/book/9780750677042

Avellini, B.A., Kamon, E., and Krajewski, J.T. (1980). Physiological responses of physically fit men and women to acclimatization to humid heat. *J. Appl. Physiol. Respir. Environ. Exerc. Physiol.*, *49*(2), 254–61.

Axelson, O. (1974). Influence of heat exposure on productivity. *Work Environ. Health*, *11*(2), 94-99.

Backer, H.D., Shopes, E., Collins, S.L., and Barkan, H. (1999). Exertional heat illness and hyponatremia in hikers. *The American Journal of Emergency Medicine, 17*(6), 532-539.

Barbieri, R. (2004). A point-process model of human heartbeat intervals: new definitions of heart rate and heart rate variability. AJP: *Heart and Circulatory Physiology, 288(1)*, H424-H435. http://dx.doi.org/10.1152/ajpheart.00482.2003

Basu, R., and Samet, J.M. (2002). An exposure assessment study of ambient heat exposure in an elderly population in Baltimore, Maryland. *Environmental Health Perspectives*, *110*(12), 1219–1224.

Bedford T. (1946). Environmental warmth and its measurement. *Academic Medicine, 21*(5).

Belding, H.S., and Hatch, T.F. (1955). Index for evaluating heat stress in terms of resulting physiological strain. *Heating, Piping and Air Conditioning, Vol.27*, No.8, 129-136.

Bell, P.A. (1981), Physiological, comfort, performance, and social effects of heat stress. *Journal of Social Issues*, *37*, Issue 1, 71–94. DOI:10.1111/j.1540-4560. 1981. tb01058.

Bernadette M. Marriott. (1993). *Nutritional Needs in Hot Environments.* National Academies Press.

Bernhard, M.C., Kent, S.T., Sloan, M.E., Evans, M.B., McClure, L.A. and Gohlke, J.M. (2015). Measuring personal heat exposure in an urban and rural environment. *Environ Res*., *137*, 410-8. DOI: 10.1016/j.envres.2014.11.002.

Bethel, J.W., and Harger, R. (2014). Heat-related illness among Oregon farmworkers. *International Journal of Environmental Research and Public Health*, *11*(9), 9273–9285. DOI: 10.3390/ijerph110909273

Billett, S., Harteis, C., and Gruber, H. (2014). *International handbook of research in professional and practice-based learning*. Dordrecht: Springer.

Bissonnette,B., Sessler, D.I, LaFlamme, P. (1989). Intraoperative temperature monitoring sites in infants and children and the effect of inspired gas warming on esophageal temperature. *Anesth Analg*. 1989, *69(2*):192-6.

Bouchama, A, and Knochel. J.P. (2002). Heat stroke. *N. Engl. J. Med.*, *346*(25), 1978–1988.

Brahmapurkar, K.P., Lanjewar, A.G., Zodpey, S.P., Brahmapurkar, V.K., Khakse, G.M., Thakre, S.B., Giri, V.C., (2012). Heat stress and its effect in glass factory workers of Central India. *International Journal of Engineering Research & Technology (IJERT), l*(8), 2278-0181.

Brandelik, A. (2009). CALCMIN – an EXCEL™ Visual Basic application for calculating mineral structural formulae from electron microprobe analyses. *Computers & Geosciences, 35(7),* 1540-1551. http://dx.doi.org/10.1016/j.cageo.2008.09.011

Brake, R., and Bates, G. (2001). A valid method for comparing rational and empirical heat stress indices. *Ann. Occupational Hygiene*, 46(2), 165-174.

Bridger, R.S. (2003). *Introduction to ergonomics*. London: Taylor & Francis.

Brotherhood, J.R. (1987). *The practical assessment of heat stress. Heat stress: Physical exertion and environment*. New York: Elsevier Science Publishing.

Brown-Brandl, T.M, Jones, D.D. and Woldt, W.E. (2005). Evaluating modelling techniques for cattle heat stress prediction. *Biosystems Engineering*, *91*(4), 513–524. https://doi.org/10.1016/j.biosystemseng.2005.04.003

Bruce, L. SS, Cotterrell, D, Jones, G.E. (2006). Heart rate variability during high ambient heat exposure. *Aviat Space Environ Med 77:* 915–920.

Bulcao, C.F., Frank, S.M., Raja, S.N., Tran, K.M., and Goldstein, D.S. (2000). Relative contribution of core and skin temperatures to thermal comfort in humans. *Journal of Thermal Biology*, *25*(1-2), 147-150. DOI: 10.1016/s0306-4565(99)00039-x

Budd, G. (2008). Wet-bulb globe temperature (WBGT)—its history and its limitations. *Journal of Science and Medicine In Sport, 11(1)*, 20-32. http://dx.doi.org/10.1016/j.jsams.2007.07.003

Budd, G. (2016). How should we measure occupational heat stress? *Temperature, 3(3),* 369-370. http://dx.doi.org/10.1080/23328940.2016.1218992

Byass, P., Twine, W., Collinson, M., Tollman, S., and Kjellstrom, T. (2010). Assessing a population's exposure to heat and humidity: an empirical approach. *Global Health Action*, *3*. http://doi.org/10.3402/gha.v3i0.5421

Cabanac, A., & Guillemette, M. (2001). Temperature and heart rate as stress indicators of handled common eider. *Physiology & Behavior, 74(4-5)*, 475-479. http://dx.doi.org/10.1016/s0031-9384(01)00586-8

Carmichael, K., Mindy, M., and Murray, V. (2011). *Overheating and health: a review into the physiological response to heat and identification of indoor heat thresholds.* London: Health Protection Agency.

Charles, S.T., and Almeida, D.M. (2006). Daily reports of symptoms and negative affect: Not all symptoms are the same. *Psychology and Health*, *21*(1), 1-17.

Chase, B., Karwowski, W., Benedict, M.E., and Queseda, P.M. (2005). Effects of thermal stress on dual task performance and attention allocation. *Journal of Human Performance in Extreme Environments*, 8(1).

Chen, M.L., Chen, C.J, Yeh, W.Y., Huang, J.W., and Mao I.F. (2003). Heat stress evaluation and worker fatigue in a steel plant. *J. Am. Ind. Hyg. Assoc.*, *64*, 352–359.

Chen,C. P., Hwang, R.L., Chang, S.Y., Lu, Y.T., (2011). Effect of temperature steps on human physiology and thermal sensation response. *Build. and Environ.*, *46*, 2387–2397. https://doi.org/10.1016/j.buildenv.2011.05.021

Chen, X., Li, X., Stanton, B., Fang, X., Lin, D., Cole, M., and Yang, H. (2004). Cigarette smoking among rural-to-urban migrants in Beijing, China. *Preventive Medicine*, *39*(4), 666-673. DOI:10.1016/j.ypmed.2004.02.033

Cheung, S.S., and Mclellan, T.M.. (1998). Influence Of hydration status and short-term aerobic training on tolerance during uncompensable heat stress. *Medicine & Science in Sports & Exercise*, *30*(Supplement), 285. DOI:10.1097/00005768-199805001-01621

Cheung, S.S., McLellan, T.M., and Tenagalia, S. (2000). The thermophysiology of uncompensable heat stress. Physiological manipulations and individual charateristics. *Sport Medicine*, *29*(5), 329-359.

Chindapol, S., Blair, J., Osmond, P., & Prasad, D. (2017). A Suitable Thermal Stress Index for the Elderly in Summer Tropical Climates. *Procedia Engineering, 180*, 932-943. http://dx.doi.org/10.1016/j.proeng.2017.04.253

Choi, J.H., Loftness, V., and Lee, D.W. (2012). Investigation of the possibility of the use of heart rate as a human factor for thermal sensation models. *Building and Environment*, *50*, 165–75.

Craig. F.N. (1950). Relation between heat balance and physiological strain in walking men clad in ventilated impermeable envelope. *Fed. Proc.*, *9*(1), 26.

Crandall, C. (2008). Heat Stress and Baroreflex Regulation ofBlood Pressure. Medicine & Science in Sports & Exercise, 40(12), 2063-2070. http://dx.doi.org/10.1249/mss.0b013e318180bc98

Crandall, C.G., Shibasaki, M, and Wilson, T.E. (2010). Heart due to either the baroreflexes or a global hyperadrenergic state. *Am J Physiol Heart Circ Physiol. 299(4):*168-73.

D'Ambrosio Alfano, F.R., Palella, B.I., and Riccio, G. (2011). Thermal environment assessment reliability using temperature - Humidity indices. *Industrial Health*, *49*(1), 95–106. https://doi.org/10.2486/indhealth.MS1097

D'Ambrosio Alfano, F., Malchaire, J., Palella, B., & Riccio, G. (2014). WBGT Index Revisited After 60 Years of Use. *The Annals of Occupational Hygiene*. http://dx.doi.org/10.1093/annhyg/meu050

Daniel, W.W. (2014). *Biostatistics: a foundation for analysis in the health sciences*. 10th Edition. New York: John Wiley.

Dang, B.N., and Dowell, C.H. (2014). Factor associated with heat strain among workers at an aluminium smelters in Texas. *Journal of Occupational and Environmental Medicine, 56*(3), 313-318. DOI: 10.1097/JOM.0000000000000095.

Daud, A., Abdin, E., Aziz, A., Naing, L., and Nordin, R. (2010). *Assessment of indoor air quality and heat stress exposure in an automotive assembly plant*. *Air Quality.* DOI: 10.5772/9765

de Dear, R.J., Leow, K.G. and Foo, S.C. (1991). Thermal comfort in the humid tropics: Field experiments in air conditioned and naturally ventilated buildings in Singapore. *International Journal of Biometeorology, Vol.34,* Issue 4, pp.259 – 265.

de Dear, R.J., and Fountain, M.E. (1994). Field experiments on occupant comfort and office thermal environments in a hot-humid climate. *ASHRAE Transactions, Vol. 100,* No.2, pp. 457–475.

DeMaio, T.J., and Bates, N. (2012). New relationship and marital status questions: A reflection of changes to the social and legal recognition of same- sex couples in the U.S. Research Report Series. Retrieved from https://www.researchgate.net/profile/Nancy_Bates/publication/267557424_New_Relationship_and_Marital_Status_Questions_A_Reflection_of_Changes_to_the_Social_and_Legal_Recognition_of_SameSex_Couples_in_the_US/links/552fb4790cf2f2a588a8ced0/New Relationship-and-Marital-Status-Questions-A-Reflection-of-Changes-to-the-Social-and-Legal-Recognition-of-Same-Sex-Couples-in-the-US.pdf

Dehghan, H., Mortazavi, S.B., Jafari, M.J., Maracy, M.R. (2011). Construct validation of a heat strain score index with structural equation modeling. *Health System Res*. *6*(4), 601-612.

Dehghan, H., Mortazavi, S. B., Jafari, M. J., & Maracy, M. R. (2012). Evaluation of wet bulb globe temperature index for estimation of heat strain in hot/humid conditions in the Persian Gulf. *Journal of Research in Medical Sciences : The Official Journal of Isfahan University of Medical Sciences, 17(12),* 1108–1113.

Department of Occupational Safety and Health (2016). Guidelines on Heat Stress Management at Workplace. Retrieved from http://www.dosh.gov.my/index.php/en/legislation/guidelines/industrial hygiene-1/2017-guidelines-heat-stress-management-at-workplace/file.

Department of Statistic Malaysia. (2016). *Selected Agricultural Indicator Malaysia 2016*. Malaysia: Department of Statistic Malaysia. Retrieved from https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=72&bul_id=T2Z3NkhLSFk2VjZ5dkdUL1JQUGs4dz09&menu_id=Z0VTZGU1UHBUT1VJMFlpaXRRR0xpdz09

Dutta, P., Rajiva, A., Andhare, D., Azhar, G.S., Tiwari, A., Sheffield, P., and Ahmedabad Heat and Climate Study Group. (2015). Perceived heat stress and health effects on construction workers. *Indian Journal of Occupational and Environmental Medicine*, *19*(3), 151–158. http://doi.org/10.4103/0019-5278.174002

DiCorleto, R., , Coles, G., and Firth, I. (Eds.) (2003). *Heat stress standard and documentation developed for use in the Australian environment*. Tullamarine, Vic: The Australian Institute of Occupational Hygienists.

Dimri, G., Malhotra, M., Sen Gupta, J., Sampath Kumar, T., & Arora, B. (1980). Alterations in aerobic-anaerobic proportions of metabolism during work in heat. *European Journal of Applied Physiology and Occupational Physiology, 45(1),* 43-50. http://dx.doi.org/10.1007/bf00421200

Draper, N.R. and Smith, H. (2003). *Applied Regression Analysis. Third Edition*. New York: Wiley.

Environmental Quality Act (Act 127) (1974). Retrieved from https://www.env.go.jp/en/recycle/asian_net/Country_Information/Law_N_Regulation/Malaysia/Malaysia_mal13278.pdf

Elgstrand, K., and Petersson, N.F. (2009). *OSH for development: Occupational safety and health for development*. Stockholm, Sweden: Industrial Ecology, Royal Institute of Technology.

Epstein, Y, and Moran, D.S. (2006). Thermal comfort and the heat stress indices. *Industrial Health*, *44*(3), 388-398.

Erlandson, T., Cena, K., De Dear, R., and Havenith, G. (2003). Environmental and human factors influencing thermal comfort of office occupants in hot—humid and hot—arid climates. *Ergonomics*, *46*(6), 616-628.

Erlichman, J., Kerbey, A.L., and James, W.P. (2002). Physical activity and its impact on health outcomes. Paper 2: Prevention of unhealthy weight gain and obesity by physical activity: an analysis of the evidence. *Obesity Reviews*, *3*(4), 273-287.

Factories and Machinery Act 1967 and Regulations. (2011). Kuala Lumpur: MDC Publishers.

Fanger, P.O. (1970). *Thermal comfort: An analysis and applications in environmental engineering*. New York: McGraw-Hill.

Fanger, P.O. (1973). Assessment of man's thermal comfort in practice. *British Journal of Industrial Medicine*, *30*(4), 313-324.

Feriadi, H. and Wong, N.H. (2004). Thermal comfort for naturally ventilated houses in Indonesia. *Energy and Buildings*, *36*(7), 614-626. https://doi.org/10.1016/j.enbuild.2004.01.011

Frank, S.M., Raja, S.N., Bulco, C.F., and Goldstein, D.S. (1999). Relative contribution of core and cutaneous temperatures to thermal comfort and autonomic responses in humans. *Journal of Applied Physiology*, 86(5), 1588-1593.

Frost, J. (2013, May 30). Regression analysis: How do I interpret R-squared and assess the goodness-of-fit? Retrieved from http://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess the-goodness-of-fit.

Fruehan, R. (1998). *The making, shaping and treating of steel.* Pittsburgh, Pa: AISE Steel Foundation.

Gagge, A.P., Stolwijk, J.A.J., and Hardy, J.D. (1967). Comfort and thermal sensations and associated physiological responses at various ambient temperatures. *Environmental Research, 1*(1), 1-20. DOI:10.1016/0013-9351(67)90002-3

Gagge, A.P., Fobelets, A.P., and Berglund, L.G. (1986). A standard predictive index of human response to the thermal environment. *ASHRAE Trans., 92,* No.1, 709-731.

Gagge, A.P., and Gonzalez, R.R. (2011). Mechanism of heat exchange: Biophysics and physiology. Comprehensive Physiology. Retrieved from DOI: 10.1002/cphy.cp040104

Ghani, S., Bialy, E.M., Bakochristou, F., Gamaledin, S.M.A., Rashwan, M.M., and Hughes, B. (2017). Thermal comfort investigation of an outdoor air-conditioned area in a hot and arid environment. *Science and Technology for the Built Environment*, *23*(7), 1-19. DOI:10.1080/23744731.2016.1267490

Gilani, S.I., Khan, M.H., and Ali, M. (2016). Revisiting Fanger's thermal comfort model using mean blood pressure as a bio-marker: An experimental investigation. *Applied Thermal Engineering*, *109*, Part A, 35-43. DOI:10.1016/j.applthermaleng.2016.08.050

Givoni, B. (1964). The influence of work and environmental conditions on the physiological responses and thermal equilibirium of man. Paper presented at Proceedings of UNESCO Syposium on Environmental Physiology and Psychology in Arid Condition (pp. 199-204). Lucknow.

Glazer, J.L. (2005). Management of heatstroke and heat exhaustion. *American Family Physician*, *71*(11), 2133-2140.

Goh, S.B., Hashim, Z., and Rosnan H. (2003). Heat stress among workers in a plastics industry *Malaysian Journal of Public Health, Vol.3*, Issue 1, 1.

Golbabaie, F., Esmaieli, M.R.M., Hemmatjou, R, Nasiri, P., Yaaghoub G.R.P., Hosseini, M. (2012). Comparing the heat stress (DI, WBGT, SW) indices and the men physiological parameters in hot and humid environment. *Iran J. Health Environ.*, *5*(2), 245-252.

Gonzales-Alonso, J., Teller, C., Andersen, S.L., Jensen, F.B., Hyldig, T., and Nielsen, B. (1999). Influence of body temperature on the development of fatigue during prolonged exercise in the heat. *Journal Applied Physiology*, *86*, 1032-1039.

Gonzalez, R.R., Levell, C.A., Strochein, L.A., Gonzalez, J.A., and Pandolf, K.B. (1993).Copper Manikin and Heat Strain Model Evaluations of Chemical Protective Ensembles for the Technical Cooperation Program (TTCP). Natick, MA:US Army Research Institute of Environmental Medicine. (Technical Report T94-4).

Grandjean, A.C., and Grandjean, N.R. (2007). Dehydration and cognitive performance. *Journal of the American College of Nutrition*, *26*(Sup5), 549S-554S. DOI:10.1080/07315724.2007.10719657

Greenleaf, J.E. (1992). Problem: Thirst, drinking behavior, and involuntary dehydration. *Medicine and Science in Sport and Exercise*, *24*(6), 645-656.

Guyton, A.C. and Hall, J.E. (2000). *Textbook of Medical Physiology*. London New York: W.B. Saunders Company.

Habibi, P., Momeni, R., and Dehghan, H. (2016). The effect of body weight on heat strain indices in hot and dry climatic conditions. *Jundishapur J. Health Science*, 8(2), E34303.

Hakansson, A., Höjer, M., Howlett, R., & Jain, L. (2013). *Sustainability in Energy and Buildings*. Berlin, Heidelberg: Springer Berlin Heidelberg.

Haldane, J.S. (1905). The influence of high air temperature. *Journal Hygiene*, *5*(4), 494-513.

Hancock, P.A., and Vasmatzidis, I. (1998). Human occupational and performance limits under stress: the thermal environment as a prototypical example. *Ergonomics*, *41*(8), 1169-1191. DOI:10.1080/001401398186469

Hall, J.F.J, and Polte, J.W. (1960). Physiological index of strain and body heat storage in hyperthermia. *Journal Applied Physiological*, *15*, 1027-1030.

Hassan, A.S., and Ramli, M. (2010). Natural ventilation of indoor air temperature: A case study of the traditional Malay house in Penang. *American Journal of Engineering and Applied Sciences*, *3*(3), 521-528. doi:10.3844/ajeassp.2010.521.528

Havenith, G., Holmér, I., & Parsons, K. (2002). Personal factors in thermal comfort assessment: clothing properties and metabolic heat production. *Energy and Buildings, 34(6),* 581-591. http://dx.doi.org/10.1016/s0378-7788(02)00008-7

Havenith, G., and van Middendorp, H. (1990). The relative influence of physical fitness, acclimatization state, anthropometric measures and gender on individual reactions to heat stress. *Europ. J. Appl. Physiol.*, 61, 419. DOI: 10.1007/BF00236062

Havenith, G. (2001). An individual model of human thermoregulation for the simulation of heat stress response. *Journal of Applied Physiology*, *90*, 1943-1954.

Hayashi, K. (2007). Environmental Impact of Palm Oil Industry in Indonesia. In *International Symposiumon EcoTopia Science 2017*. Japan.

Helman, R.S., and Habal, R. (2017, May 18). Heatstroke. Retrieved from http://emedicine.medscape.com/article/166320-overview

Hemmatjo, R., Zare, S., Heydarabadi, A.B., and Hajivandi, A. (2013). Investigation of heat stress in workplace for different work groups according to ISO 7243 standard in Mehr Petrochemical Complex, Assaluyeh, Iran. *Journal of Paramedical Science, Vol.4*, No.2, ISSN 2008-4978.

Hill, L, Griffith, O., and Flack, M. (1916). The measurement of the heart loss at body temperature by convection, radiation and evaporation. *Phil. Trans. Royal Soc*., *207*(B), 183-220.

Hoffman, J. (2014). *Physiological aspects of sport training and performance*. Champaign, IL: Human Kinetics

Holopainen, R. (2012). *A human thermal model for improved thermal comfort* (Doctoral Dissertation). Retrieved from https://www.researchgate.net/publication/257377375_A_human_thermal_model_for improved_thermal_comfort.

Hooper, V. (2006). Accuracy of Noninvasive Core Temperature Measurement in Acutely Ill Adults: The State of the Science. *Biological Research for Nursing, 8(1),* 24-34. http://dx.doi.org/10.1177/1099800406289151

Hoppe P (2002) Different aspects of assessing indoor and outdoor thermal comfort. Energy and Buildings 34 (6):661-665.

Houghton, F.C., and Yaglo, C.P. (1923). Determining equal comfort lines. *Journal of the American Society of Heating and Ventilating Engineers, 29*, 165-176.

Hu, Y.F. (2006). Application of Excel in hydrologic frequency analysis. *Jilin Water Resources*, pp.1-2.

Huberty CJ, Olejnik S (2006) *Applied manova and discriminant analysis*. Wiley, Hoboken

Huizenga, C., Hui, Z., and Arens, E. (2001). A model of human physiology and comfort for assessing complex thermal environments. *Building and Environment*, *36*(6), 691-699.

Hunt, P.A., and Smith, J.E. (2005). Heat illness. *Journal of the Royal Army Medical Corps*, *151*(4), 234-242.

Hunt, A.P. (2013). Heat strain, hydration status, and symptoms of heat illness in surface mine workers. *Industry Economic Journal*, *2*(1), 1-10.

Hussein, I., and Rahman, M.H.A. (2009). Field study on thermal comfort in Malaysia. *European Journal of Scientific Research*, *Vol.37*, No.1, pp.134-153.

Hyde, K., & Maier, H. (2006). Distance-based and stochastic uncertainty analysis for multi-criteria decision analysis in Excel using Visual Basic for Applications. *Environmental Modelling & Software, 21(12*), 1695-1710. http://dx.doi.org/10.1016/j.envsoft.2005.08.004

Iduseri, A., & Osemwenkhae, J. (2015). An Efficient Variable Selection Method for Predictive Discriminant Analysis. *Annals of Data Science, 2(4),* 489-504. http://dx.doi.org/10.1007/s40745-015-0061-9

Inaba, R., and Mirbod, S.M. (2007). Comparison of subjective symptoms and hot prevention measures in summer between traffic control workers and construction workers in Japan. *Industrial Health, 45*, 91-99.

Indraganti, M., and Rao, K.D. (2010). Effect of age, gender, economic group and tenure on thermal comfort: A field study in residential buildings in hot and dry climate with seasonal variations. *Energy and Buildings*, *42*(3), 273-281. doi:10.1016/j.enbuild.2009.09.003

International Organisation for Standardisation. (2004). ISO 9886: Ergonomics – Evaluation of Thermal Strain by Physiological Measurements. Geneva: International Organisation for Standardisation.

Intergovernmental Panel on Climate Change (IPCC). (2007) Chapter 18. Adaptation to climate change in the context of sustainable development and equity. Retrieved from http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=641

Intergovernmental Panel on Climate Change (IPCC) (2014). Retrieved from http://www.ipcc.ch/.

ISO 7933. (1989). Hot environments - Analytical determination and interpretation of thermal stress using calculation of required sweat rate. *ISO, Geneva*.

Ismail, A.R., Rani, M.R.A., Makhbul, Z.K.M., Nor, M.J.M. and Rahman, M.N.A. (2009). A study of relationship between WBGT and relative humidity to worker performance. *World Academy of Science, Engineering and Technology,Vol.3*, No.3, 257-262. .

Ismail, A.R., Shashi Kumar, S., Karagaratnan, A., and Kadirgama, K. (2013). Thermal comfort findings: Scenario at Malaysian automotive industry. *Thermal Science*, *17*(2), 387-396. doi:10.2298/tsci111111015.

ISO 7933. (1989). Hot environments-analytical determination and interpretation of thermal stress using calculation of required sweat rates. *International Standard Organization.* Geneva

Izzate, M.S. (2011). *Association between occupational heat exposure with physiological changes among palm oil mill workers*. (Unpublished doctoral/master's thesis), Universiti Putra Malaysia, Selangor, Malaysia.

Izzate, M.S, Shamsul, B.M.T., Karmegam, K. and Guan, N.Y. (2015). Study on physiological effects on palm oil mill workers exposed to extreme heat condition. *Journal of Scientific and Industrial Research, Vol.74*, 406-410.

Jalil, A.S., Dor, Z., Yahya, M.S., Batcha, M.F.M., and Hasnan, K. (2007). Heat stress investigation on laundry workers. Paper presented at International Conference on Ergonomics (ICE07), Kuala Lumpur.

Jay, O., & Kenny, G. (2010). Heat exposure in the Canadian workplace. *American Journal of Industrial Medicine, n/a-n*/a.http://dx.doi.org/10.1002/ajim.20827

Kamaruzzaman, K., and Tazilan, A.S.M. (2013). Thermal comfort assessment of a classroom in tropical climate conditions. Recent Advances in Energy, Environment and Development; *SEAS Press*: Rhodes Island, Greece, 88-91.

Karyono, T.H. (2000). Report on thermal comfort and building energy studies in Jakarta, Indonesia. *Building and Environment*, *Volume 35*, Issue 1, pp. 77-90.

Kawada, T. (2012). Sample Size in Receiver-Operating Characteristic (ROC) Curve Analysis. *Circulation Journal*, *76(3)*, 768. http://dx.doi.org/10.1253/circj.cj-11-1408

Kim, J.H.,Min, Y.K., . and Kim, B. (2013). Is the PMV index an indicator of human thermal comfort sensation?. *International Journal of Smart Home*,*7*(1), 27-34.

Kjellstrom, T. (2009). Climate change, direct heat exposure, health and well-being in low and middle-income countries. *Global Health Action*, *2*. DOI: 10.3402/gha.v2i0.1958

Kjellstrom, T., Gabrysch, S., Lemke, B., and Dear, K. (2009a). The 'Hothaps' programme for assessing climate change impacts on occupational health and productivity: An invitation to carry out field studies. *Global Health Action*, *2*. DOI: 10.3402/gha.v2i0.2082

Kjellstrom, T., Holmer, I., and Lemke, B. (2009b). Workplace heat stress, health and productivity–an increasing challenge for low and middle-income countries during climate change. *Global Health Action, 2*.

Kjellstrom, T., Kovats, R.S., Lloyd, S.J., Holt, T., and Tol, R.S. (2009c). The direct impact of climate change on regional labor productivity. *Archives of Environmental & Occupational Health*, *64*(4), 217-227. http://dx.doi.org/10.1080/19338240903352776

Knez I, Thorsson S (2006) Influences of culture and environmental attitude on thermal, emotional and perceptual evaluations of a public square. *Int J Biometeorol 50:*258–268

Kool, M., Hoeks, AL, Boundier, H., Reneman, R. (1993). Short and long term effects of smoking on arterial wall properties in habitual smokers. *J. Am. Coll. Cardiol.*, *22*(7), 1881-1886.

Kruszelnicki, K.S. (2012, February 28). Why does drinking alcohol cause dehydration? Retrieved from http://www.abc.net.au/science/articles/2012/02/28/3441707.htm

Kujanpää, T, Soukka R, Heinimo J, Linnanen L (2009) *Sustainability of Palm Oil Production and Opportunities for Finnish Technology and Know-how Transfer.* Lappeenranta University of Technology, Faculty of Technology LUT Energy, Finland.

Kutner, M. H., Nachtsheim, C., Neter, J., and Li, W. (2005). *Applied linear statistical models*. Boston, Massachusett: McGraw-Hill Irwin.

Kwok, G. (1998). Thermal comfort in tropical classrooms. ASHRAE Transactions, Vol. 104, N°1B, pp. 1031 – 1047.

Lahey, J.W. (1984). What to do when the heat's on?. *National Safety News*, *130*(3), 60-64.

Lam, M., Krenz, J., Palmández, P., Negrete, M., Perla, M., Murphy-Robinson, H., amd Spector, J.T. (2013). Identification of barriers to the prevention and treatment of heat-related illness in Latino farmworkers using activity-oriented, participatory rural appraisal focus group methods. *BMC Public Health*, *13*, 1004. http://doi.org/10.1186/1471-2458-13-1004

Larry K.W. (2011, March 16).Physiological responses to the thermal environment. Retrieved from http://www.ilocis.org/documents/chpt42e.htm

Lee, S.Y. and Brand, J.L. (2005). Effect of control over office workspace on perceptions of the work environment and work outcomes. *Journal of Environmental Psychology*,, 323-333.

Leger, K.A., Charles, S.T., Ayanian, J.Z., and Almeida, D.M. (2015). The association of daily physical symptoms with future health. *Social Science & Medicine*, *143*, 241-248. DOI: 10.1016/j.socscimed.2015.08.050

Lemaire, C., & Murphy, E. (1977). Heart rate and core temperature as indicators of heat stress during deep underwater activity. *Aviat Space Environ Med., 48(2),* 146-8.

Lemeshow, S., Hosmer, D.W., Klar, J., and Lwanga, S.K. (1990). *Adequacy of sample size in health studies*. Chichester, New York: John Wiley & Sons.

Lenzuni, P., & Del Gaudio, M. (2007). Thermal Comfort Assessment in Comfort-Prone Workplaces. *The Annals of Occupational Hygiene, 51(6),* 543-51. http://dx.doi.org/10.1093/annhyg/mem032

Leon, L.R. and Kenefick, R. (2012). Pathophysiology of heat–related illnesses. In Paul Auerbach (Ed.), Wilderness Medicine Textbook (pp.113-140). Retrieved from https://pdfs.semanticscholar.org/e916/528ca235e07ea30f0837a56ca5faed5f88b1.pdf

Li, W. (2010). *Research of human's thermal comfort based on physiology-psychology in building environment indoors* (PhD). Chongqing University.

Liang, C., Zheng, G., Zhu, N., Tian, Z., Lu, S., and Chen, Y. (2011). A new environmental heat stress index for indoor hot and humid environments based on Cox regression. *Building and Environment*, 46, 2472-2479. https://doi.org/10.1016/j.buildenv.2011.06.013

Lin, T., de Dear, R., & Hwang, R. (2011). Effect of thermal adaptation on seasonal outdoor thermal comfort. *International Journal of Climatology, 31(2),* 302-312. http://dx.doi.org/10.1002/joc.2120

Lin, Y., Yang, L., Zheng, W., & Ren, Y. (2015). Study on Human Physiological Adaptation of Thermal Comfort Under Building Environment. *Procedia Engineering, 121*, 1780-1787.http://dx.doi.org/10.1016/j.proeng.2015.09.157

Liu, W., Lian, Z., and Liu, Y. (2008). Heart rate variability at different thermal comfort levels. *European Journal of Applied Physiology*, *103*(3), 361-366. DOI:10.1007/s00421-008-0718-6

Liu, H., Liao, J., Yang, D., Du, X., Hu, P., Yang, Y., & Li, B. (2014). The response of human thermal perception and skin temperature to step-change transient thermal environments. *Building and Environment, 73, 232-238.* http://dx.doi.org/10.1016/j.buildenv.2013.12.007

Luurila, O.J. (1992). The sauna and the heart. *Journal of Internal Medicine*, *231*(4), 319–320.

Lu, Y.D., and Huo, Z.H. (2003). *Special environmental physiology*. Beijing: Military Medicine Science Press.

Ma, X.X., Wang, F.M., and Ma, Q.H. (2003). Application of VBA in the optimal selection of hydrologic statistic parameters. *Journal of Zhengzhou University of Technology*, pp.67-69

MacAuley, J.D., McCrum, E.E, Stott, G., Evans, A.E., McRoberts, B, Boreham, A. (1996). Physical activity, physical fitness, blood pressure, and fibrinogen in the Northern Ireland health and activity survey. *J. Epidemiol. Community Health*, *50*(3), 258–263.

Makaremi, N., Salleh, E., Jaafar, M.Z., Hoseini, A.H.G. (2012). Thermal comfort conditions of shaded outdoor spaces in hot humid climate of Malaysia. *Building Environment, 48*, 7- 14.

Malaysian Employment Act 1955 (1957, June 1). Retrieved from http://www.ilo.org/dyn/natlex/docs/WEBTEXT/48055/66265/E55mys01.htm

Malaysian Labour laws: with regulations & rules. (2001). Employment Act 1955. Petaling Jaya, Selangor Darul Ehsan: International Law Book Services.

Malaysia Palm Oil Council (MPOC) (2013). Malaysia Palm Oil Industry. Retrieved from http://www.mpoc.org.my/Industry_Overview.aspx.

Malaysian Investment Development Authority (MIDA) (2015). Industries. Retrieved from http://www.mida.gov.my/home/industries/posts/.

Manu, S., Shukla, Y., Rawal, R., Thomas, L. E., and de Dear, R. (2016). Field studies of thermal comfort across multiple climate zones for the subcontinent: India Model for Adaptive Comfort (IMAC). *Building and Environment, 98*, 55-70.

Marino, D. (2005). Physiologically Based Pharmacokinetic Modeling Using Microsoft Excel and Visual Basic for Applications. *Toxicology Mechanisms and Methods, 15(2),* 137-154.http://dx.doi.org/10.1080/15376520590918810

Marino, F. (2002). Methods, advantages, and limitations of body cooling for exercise performance. *British Journal of Sports Medicine, 36(2),* 89-94. http://dx.doi.org/10.1136/bjsm.36.2.89

Masterson, J.M., and Richardson, F.A., (1979). *Humidex, A Method of quantifying human discomfort due to excessive heat and humidity*. Downsview, Ontario: Environment Canada.

Matsumura, T., Hiramatsu, T., Shirakashi, T., & Muramatsu, T. (2005). A Study on Cutting Force in the Milling Process of Glass. *Journal Of Manufacturing Processes, 7(2),* 102-108. http://dx.doi.org/10.1016/s1526-6125(05)70087-6

Mchorney, C.A., and Tarlov, A.R. (1995). Individual-patient monitoring in clinical practice: are available health status surveys adequate? *Quality of Life Research*, *4*(4), 293-307. DOI:10.1007/bf01593882

McKinnon, M. (2005). *Climate Change and Labour: Impacts of Heat in the Workplace pdf*. International Labor Organization. Retrieved 14 November 2013, from http://www.ilo.org/wcmsp5/groups/public/---ed_emp/---gjp/.../wcms_476194.pdf

Meyer, W.B. (2002). Why indoor climates change: A case study. *Climatic Change, 55*(3), 395 - 407.

Miller, V.S., and Bates, G.P. (2007). The thermal work limit is a simple reliable heat index for the protection of workers in thermally stressful environments. *Ann. Occupational Hygiene,* 51(6), 553-561.

Ministry of Human Resource. (2012). Labour and human resource statistic. Retrieved from http://www.mohr.gov.my/index.php/ms/.

Mohanty, P., Panigrahi, D., & Acharya, M. (2014). MissRF: A Visual Basic Application in MS Excel to Find out Missing Rainfall Data and Related Analysis. *Intelligent Information Management*, *06(02*), 38-44. http://dx.doi.org/10.4236/iim.2014.62006

Moran, D., & Mendal, L. (2002). Core Temperature Measurement. *Sports Medicine, 32(14)*, 879-885. http://dx.doi.org/10.2165/00007256-200232140-00001

Moran, D.S., Shitzer, A. and Pandolf, K.B. (1998). A physiological strain index (PSI) to evaluate heat stress. *Am. J. Physiol*., 275(44), R129-R134.

Moran, D.S. and Pandolf, K.B. (1999). Wet bulb globe temperature (WBGT) - to what extent is GT essential? *Aviat. Space Environ. Med*., *70*(5), 480-484.

Moran, D.S., Pandolf, K.B., Shapiro, Y., Heled, Y., Shani, Y., Matthew, W.T., and Gonzalez, R.R. (2001). An environmental stress index (ESI) as a substitute for the wet bulb globe temperature (WBGT*). Journal of Thermal Biol*ogy, *Vol.26*, Issue 4-5, 427-431.

Mortazavi, S., Maracy, M., Dehghan, H., & Jafari, M. (2012). Combination of wet bulb globe temperature and heart rate in hot climatic conditions: The practical guidance for a better estimation of the heat strain. *International Journal Of Environmental Health Engineering, 1(1),* 18.http://dx.doi.org/10.4103/2277-9183.96006

Nadel, E.R., Pandolf, K.B., Roberts, M.F., and Stolwijk, J.A. (1974). Mechanisms of thermal acclimatisation to exercise and heat. *Journal of Applied Physiology*, *37*(4), 515-520.

Nakamura, S., and Aruga, T. (2013). Epidemiology of heat illness. *J. Med. Assoc. Japan*, *56*(3), 162–166.

Naley, L. (2012). Screening for heat stress in workers and athletes. *Proc (Bayl Univ Med Cen),* 25(3)(3), 224–228.

National Institute for Occupational Safety and Health (NIOSH). (1986). Criteria for a recommended standard: Occupational exposure to heat and hot environments. Revised 1986. USDHEW, Cincinnati, OH.

National Institute for Occupational Safety and Health. (1986). Occupational exposure to hot environments. *Department of Health and Human Services*, Report No. DHHS86-113, Washington, DC.

National Institute for Occupational Safety and Health (NIOSH) (2013). Heat stress. Retrieved from http://www.cdc.gov/niosh/topics/heatstress/.

Natural Resources Defense Council (NRDC). (2011) Climate Change and Health Preparedness in India: Protecting Local Communities in Ahmedabad, Gujarat from Extreme Heat. Summary Report, Kick-off Workshop on Climate Change: Heat and Health, Addressing Vulnerability.

Näyhä, S., Rintamäki, H., Donaldson, G., Hassi, J., Jousilahti, P., & Laatikainen, T. et al. (2013). Heat-related thermal sensation, comfort and symptoms in a northern population: The National FINRISK 2007 study. *European Journal of Public Health, 24(4)*, 620-626. http://dx.doi.org/10.1093/eurpub/ckt159

Nguyen, A.T., Singh, M.K., and Reiter, S. (2012). An adaptive thermal comfort model for hot humid South-East Asia. *Building and Environment, Vol.56*, 291-300.

Nicol, J., Raja, I., Allaudin, A., & Jamy, G. (1999). Climatic variations in comfortable temperatures: the Pakistan projects. *Energy and Buildings, 30(3)*, 261-279. http://dx.doi.org/10.1016/s0378-7788(99)00011-0

Nielsen, B. (1994). Heat stress and acclimation. Ergonomics, 37(1), 49-58. http://dx.doi.org/10.1080/00140139408963622

Noordin, S., and Hashim, J.H. (2006). A prevalence study on the effect of heat stress among a steel plant employee in Selangor Darul Ehsan,. *Jurnal Kesihatan Masyarakat, 12*(1), 1663-1675.

Nurulhuda (2009). Separation technique of crude palm oil at clarification area via optimum parameters. (Unpublished master's dissertation). Universiti Malaysia Pahang, Malaysia.

Nurul, H., Shamsul, B.M.T., Sharifah, I., and Ahmad, A. (2014). The evaluation of heat stress on steel mill workers through monitoring environmental and acute physiological changes. *Advances in Environmental Biology, 8*(15), 177-183.

Nutter, J.F.W., and Gleason, M. (1993). Assessing the accuracy, intra-rater repeatability, and inter-rater reliability of disease assessment systems. *Phytopathology, 83*(8), 806. DOI:10.1094/phyto-83-806

Occupational Safety and Health Administration (1999). OSHA Technical Manual Section III Chapter 4: Heat Stress. Retrieved October 25, 2013 from https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html.\

Occupational Safety and Health Act 1994 and regulations (2012). MDC Publishers. Kuala Lumpur.

Ogbonna, A.C. and Harris, D.J. (2008). Thermal comfort in sub-Saharan Africa: Field study report in Jos-Nigeria. *Applied Energy*, 85(1), 1–11.

Okamoto-Mizuno, K., and Mizuno, K. (2012). Effects of thermal environment on sleep and circadian rhythm. *Journal of Physiological Anthropology*, *31*(1), 14. http://doi.org/10.1186/1880-6805-31-14

Olesen, B., and Parsons, K. (2002). Introduction to thermal comfort standards and to the proposed new version of EN ISO 7730. *Energy and Buildings*, *34*(6), 537-548. doi:10.1016/s0378-7788(02)00004-x

Ormandy, D., and Ezratty, V. (2015). Thermal discomfort and health: protecting the susceptible from excess cold and excess heat in housing. *Advances in Building Energy Research, 10*(1), 84-98.

Jay, O. and Kenny, G.P. (2010) Heat exposure in the Canadian workplace. *American Journal of Industrial Medicine, 53*(8), 842-853.

Johansson, E., Yahia, M., Arroyo, I., & Bengs, C. (2017). Outdoor thermal comfort in public space in warm-humid Guayaquil, Ecuador. *International Journal of Biometeorology*. http://dx.doi.org/10.1007/s00484-017-1329-

Ormandy, D. and Ezratty, V. (2012). Health and thermal comfort: From WHO guidance to housing strategies. *Energy Policy*, *Vol.49*, 116-121.

Ozturkoglu, O., Saygılı, E. E., and Ozturkoglu, Y. (2016). A manufacturing-oriented model for evaluating the satisfaction of workers – Evidence from Turkey. *International Journal of Industrial Ergonomics*, *54*, 73-82. DOI:10.1016/j.ergon.2016.05.002

Palm Oil Mill Processing. (n.d.). Retrieved May 12, 2014, from http://www.fao.org/DOCrEP/005/Y4355E/y4355e04.htm

Pananapaan V, Helin T, Kujanpää , Soukka R, Heinimo J, Linnanen L (2009) *Sustainability of Palm oil Production and Opportunities for Finnish Technology and Know-how Transfer.* Lappeenranta University of Technology, Faculty of Technology LUT Energy, Finland.V, Helin

Pandolf, K.B. (1998). Time course of heat acclimatisation and its decay. *International Journal of Sports Medicine*, 19 Suppl 2, S157-160.

Pantzar, M., Dahl, J., Wester, K. and Ian, L.U. (1995). *Smoke free life: thinking about quitting?* Uppsala, Konsultforl: Landstinget.

Parameswarappa, S., & Narayana, J. (2014). Assessment of dust level in working environment and study of impact of dust on health of workers in steel industry. *International Journal Of Current Microbiology And Applied Sciences, 3(11),* 166-172.

Parsons, K.C. (1995). International heat stress standards: a review. *Ergonomics, 38*(1), 6-22.

Parsons, K.C. (2000). Environmental ergonomics: a review of principles, methods and models. *Applied Ergonomics, 31*(6), 581-594.

Parsons, K.C. (2003). *Human thermal environments: the effects of hot, moderate, and cold environments on human health, comfort, and performance. Third Edition*. Boca Raton: CRC Press.

Passe, D. (2015). Effect of dehydration on cognitive function, perceptual responses, and mood. *Fluid Balance, Hydration, and Athletic Performance*, 155-198. doi:10.1201/b19037-12

Patel, T., Mullen, S., & Santee, W. (2013). Comparison of Methods for Estimating Wet-Bulb Globe Temperature Index from Standard Meteorological Measurements. *Military Medicine, 178(8),* 926-933. http://dx.doi.org/10.7205/milmed-d-13-00117

Persinger, M.A. (1980). *The weather matrix and human behavior*. New York: Praeger.

Philpott, C.J., and Singh, J.R. (1999). Health, comfort and productivity in buildings. *Indoor and Built Environment*, *8*(4), 269-271. DOI:10.1159/000024650

Pilch, W., Szyguła, Z., Palka, T., Pilch, P., Cison, T., Wiecha, S., & Tota, Ł. (2014). Comparison of Physiological Reactions And Physiological Strain In Healthy Men Under Heat Stress In Dry And Steam Heat Saunas. *Biology of Sport*, 31(2), 145-149. http://dx.doi.org/10.5604/20831862.1099045

Plog, B.A., and Quinlan, P.J. (2002). Fundamentals of Industrial Hygiene 5th Edition. Part III: Thermal Stress. United States of America, USA: NSC Press.

Pradhan, B., Shrestha, S., Shrestha, R., Pradhanang, S., Kayastha, B., and Pradhan, P. (2013). Assessing climate change and heat stress responses in the Tarai region of Nepal. *Industrial Health, 51*(1), 101-112.

Popkin, B.M., D'Anci, K.E., and Rosenberg, I.H. (2010). Water, hydration and health. *Nutrition Reviews, 68*(8), 439–458. http://doi.org/10.1111/j.1753-4887.2010.00304.x

Pormahabadian, M., Adelkhah, M. and Azam, K. (2008). Heat exposure assessment in the working environment of a glass-manufacturing unit. *Journal Environmental Health Science Engineering*, *5*(2), 141-147.

Quest Technologies (2004). Thermal Environmental Monitor. Instruction for QUESTemp 34. Retrieved from http://www.quest-technologies.com.

Rainham, D.G.C., & Smoyer-Tomic, K.E. (2003). The role of air pollution in the relationship between a heat stress index and human mortality in Toronto. *Environmental Research*, *93*(1), 9–19. https://doi.org/10.1016/S0013-9351(03)00060-4

Ramphal, L. (2000). Heat stress in the workplace. *Proceedings (Baylor University. Medical Center)*, *13*(4), 349–350.

Rana, R., Kusy, B., Jurdak, R., Wall, J., and Hu, W. (2013). Feasibility analysis of using humidex as an indoor thermal comfort predictor. *Energy and Buildings*, *64*, 17–25. https://doi.org/10.1016/j.enbuild.2013.04.019

Rastogi, S., Gupta, B., & Husain, T. (1992). Wet-bulb globe temperature index: a predictor of physiological strain in hot environments. *Occupational Medicine, 42(2)*, 93-97. http://dx.doi.org/10.1093/occmed/42.2.93

Rawlings, J.O., Pantula, S.G., and Dickey, D.A. (2014). *Applied regression analysis: a research tool.* Second Edition. New York: Springer.

Rey, G., Jougla, E, Fouillet, A., Pavillon, G., et al., (2003). The impact of major heat waves on all-cause and cause-specific mortality in France from 1971 to 2003. *Int. Arch. Occup. Environ Health.*, *80*(7), 615–626.Roaf, S., Crichton, D., and Nicol, F. (2009). *Adapting buildings and cities for climate change: a 21st century survival guide.* Amsterdam: Architectural Press.

Rodahl, K. (2003). Occupational health conditions in extreme environments. *The Annals of Occupational Hygiene*, 47(3), 241–252.

Rowell, L.B. (1990). Hyperthermia: a hyperadrenergic state. *Hypertension,* 15(5), 505–507.

Saw, S.H. (1988). *The population of Peninsular Malaysia*. Singapore: Singapore University Press, National University of Singapore.

Sawka, M.N., Latzka, W.A., Matott, R.P., and Montain, S.J. (1998). Hydration effects on temperature regulation. *International Journal of Sports Medicine*, 19(S2), S108-10. DOI:10.1055/s-2007-971971

Schuster, C., Honold, J., Lauf, S., & Lakes, T. (2017). Urban heat stress: novel survey suggests health and fitness as future avenue for research and adaptation strategies. *Environmental Research Letters, 12(4)*, 044021. http://dx.doi.org/10.1088/1748-9326/aa5f35

Sessler, D. (2008). Temperature Monitoring and Perioperative Thermoregulation. *Anesthesiology, 109(2),* 318-338. http://dx.doi.org/10.1097/aln.0b013e31817f6d76

Shapiro, Y., Pandolf, K.B., and Goldman R.F. (1982). Predicting sweat loss response to exercise, environment and clothing. *European Journal Applied Physiological Occuppational Physiological*, 48, 83-96.

Shibasaki, M., Wilson, T.E., and Crandall, G.C. (2006). Neural control and mechanisms of eccrine sweating during heat stress and exercise. *Journal of Applied Physiology*, *100*(5), 1692-1701. DOI: 10.1152/japplphysiol.01124.2005

Shrout, P.E., and Fleiss, J.L. (1979). Intraclass correlations: uses in assessing rater reliability. *Psychological Bulletin*, *86*(2), 420-428. DOI:10.1037//0033-2909.86.2.420

Simson, R., Kurnitski, J., & Kuusk, K. (2017). Experimental validation of simulation and measurement-based overheating assessment approaches for residential buildings. *Architectural Science Review*, *60*(3), 192-204. http://dx.doi.org/10.1080/00038628.2017.1300130'

Singh, M.K, Mahapatra, S., and Atreya,S.K. (2009). Thermal performance study and evaluation of comfort temperatures in vernacular buildings of North-East India. *Build. and Environ.*, 45, 320-329. DOI: 10.1016/j.buildenv.2009.06.009

Snodgrass, J.J., Leonard,W.R., Sorensen,M.V., Tarskaia, L.A., and Mosher, M.J. (2008). The influence of basal metabolic rate on blood pressure among indigenousSiberian. *Am. J. Phys. Anthropol*., 137, 145-155.

Spector, J.T., and Sheffield, P.E. (2014). Re-evaluating occupational heat stress in a changing climate. *Annals of Occupational Hygiene*, *58*(8), 936–942. http://doi.org/10.1093/annhyg/meu073

Srivastava, A., Kumar, R., Joseph, E., and Kumar, A. (2000). Heat exposure study in the workplace in a glass-manufacturing unit in India. *The Annals of Occupational Hygiene*, *44*(6), 449-453. DOI: 10.1016/s0003-4878(00)00003-x

Stellman, J.M. (1998). *Encyclopedia of Occupational Health and Safety (4th Edition Volume (2)*. Geneva: International Labor Organization (ILO).

Stoecklin-Marois, M., Hennessy-Burt, T., Mitchell, D., and Schenker, M. (2013). Heat-related illness knowledge and practices among California hired farm workers in The MICASA Study. *Industrial Health*, *51*(1), 47-55. DOI:10.2486/indhealth.2012-0128

Stolwijk, J.A. (1980). Mathematical models of thermal regulation. *Annals of the New York Academy of Sciences*, *335*(1), 98-106.

Stress Smoking: Coping with Stress. (2017, June 14). Retrieved from https://my.clevelandclinic.org/health/articles/stress-stress-management-and-smoking

Strom, G. (1960). *Handbook of Physiology, Section 1: Neurophysiology* (pp. 1173–96). Washington (DC): Waverly Press.

Sueyoshi T (1999) DEA-discriminant analysis in the view of goal programming. *Eur J Opl Res 115:*564–582

Siti Fawziah, M.N. (2002). Tegasan Haba dan Perubahan Fisiologi Pekerja Kilang Besi Jabatan Kesihatan Komuniti, Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia

Social Security Organisation (SOCSO). (2009). Annual Report. Ministry of Human Resources, Malaysia. Retrieved from http;//www. Perkeso.gov.my

Social Security Organisation (SOCSO). (2010). Annual Report. Ministry of Human Resources, Malaysia. Retrieved from http; //www. Perkeso.gov.my

Social Security Organisation (SOCSO). (2011). Annual Report. Ministry of Human Resources, Malaysia. Retrieved from http; //www. Perkeso.gov.my

Sun, D.Z., and Oort, A.H. (1995). Humidity–temperature relationships in the tropical troposphere. *Journal of Climate*, *8*(8), 1974-1987. DOI:10.1175/1520-0442(1995)008<1974: hrittt>2.0.co;2

Suzuki, E., Itomine, I., Saito, M., Katsuki, T., and Sato, C. (2008). Factors affecting the turnover of novice nurses at university hospitals: A two year longitudinal study. *Japan Journal of Nursing Science*, *5*(1), 9-21. doi:10.1111/j.1742-7924.2008.00095.x

Taki, A., Ealiwa, M., Howarth, A., & Seden, M. (1999). Assessing thermal comfort in Ghadames, Libya: Application of the adaptive model. *Building Services Engineering Research and Technology, 20(4),* 205-210. http://dx.doi.org/10.1177/014362449902000408

Tawatsupa, B., Lim, L.L.Y., Kjellstrom, T., Seubsman, S., Sleigh, A., and the Thai Cohort Study team. (2010). The association between overall health, psychological distress, and occupational heat stress among a large national cohort of 40,913 Thai workers. *Global Health Action*, *3,* 10.3402/gha.v3i0.5034. http://doi.org/10.3402/gha.v3i0.5034

Tawatsupa, B., Yiengprugsawan, V., Kjellstrom, T., Berecki-Gisolf, J., Seubsman, S.A., and Sleigh, A. (2013). Association between heat stress and occupational injury among Thai workers: findings of the Thai Cohort Study. Industrial Health, 51(1), 34-46. doi:10.2486/indhealth.2012-0138

Taylor, N.A.S. (2006). Ethnic difference in thermoregulation genotypic versus phenotypic heat adaptation. *Journal of Thermal Biology*, 31, 90-104.

The significance of core temperature – Pathophysiology and measurement methods. (2015).

Thirakomen, K. (2001). Humidity control for tropical climate. Retrieved from http://www.ashraethailand.org/download/ashraethailand_org/pub_20010908humidity_control.pdf

Thom, E.C. (1959). The discomfort index. *Weatherwise, 12,* 57-60.

Teodoreanu, E. (2016). Thermal Comfort Index. *Present Environment And Sustainable Development, 10(2).* http://dx.doi.org/10.1515/pesd-2016-0029

Tilaki,, K. (2013). Receiver Operating Characteristic (ROC) Curve Analysis for Medical Diagnostic Test Evaluation. *Caspian J Intern Med., 4(2),* 627-635.

Tom, S. (2008). Managing energy and comfort. *ASHRAE Journal*, *50*(6), 18-27.

Tord, K., David, B., Chris,F., Bruno,L., Matthias, O., and Olivia, H. (2016). Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. *Annu. Rev. Public Health*, 37, 97–11.

Tuomaala, P., Holopainen, R., Piira, K., and Airaksinen, M. (2013). *Impact of individual characteristics - such as age, gender, BMI and fitness - on human thermal sensation.* Paper presented at Proceedings of BS2013: 13th Conference of International Building Performance Simulation Association, Chambery, France http://ibpsa.org/proceedings/BS2013/p_2240.pdf

Uğursal, A., & Culp, C. (2013). The effect of temperature, metabolic rate and dynamic localized airflow on thermal comfort. *Applied Energy, 111, 64-73.* http://dx.doi.org/https://doi.org/10.1016/j.apenergy.2013.04.014

Vaisala, O. (2013). *Calculation Formulas for Humidity—Humidity Conversion Formulas*. Helsinki, Finland

Van,F J, Mazej M, Hensen, JLM. (2010). Thermal comfort: research and practice, *Front Biosci* , 15, 765-88.

Van Hoof, J., Mazej, M. and Hensen, J. (2010). Thermal comfort: Research and practice. *Frontiers in Bioscience*, *15*(2), 765-788.

Vernacchia, R.A., and Veit-Hartley, S. (1999). Psychological adaptation to heat stress. Retrieved from https://www.trackandfieldnews.com/technique/148_Vernacchia.pdf

Victor, L. (2003). Kajian Pendedahan Tegasan Haba dan Perubahan Fisiologi di Kalangan Pekerja Lelaki di Kilang Besi Daerah Selangor. Jabatan Kesihatan Komuniti, Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia.

Vink, P. (2012). *Advances in social and organizational factors*. Boca Raton, FL: CRC Press.

Wallace, R.F., Kriebel, D., Punnett, L., Wegman, D.H., Wenger, C.B., Gardner, J.W., and Gonzales, R.R. (2005). The effects of continuous hot weather training on risk of exertional heat illness. *Medicine Science Sport Exercise, 37*(1), 84-90.

Wang, Z.L., Yang, L., Ding, J.S. (2005). Application of heart rate variability in evaluation of mental workload. *Chin. J. Ind. Occup.*, *23*(3),182–184.

Wang, S.Y, Xiang, Y.Z., Zhu, X.Q., and Huang, Y.R. (2006). Development of calculation software on hydrologic frequency based on EXCEL. *Journal of Northwest Sci-Tech University of Agriculture and Forestry (Natural Science Edition).* pp.113-116.

Wang, L. and Wong, N.H. (2007). Applying natural ventilation for thermal comfort in residential buildings in Singapore. *Architect. Sci. Rev*., *50*(3), 224-233.

Wang, Y., and Hu, H. (2012). Hydropower computation using visual basic for application programming. *Physics Procedia, 24,* Part A, 37-43. DOI: 10.1016/j.phpro.2012.02.007

Warren, A. and Khogali, M. (1992). Assessment of desertification and drought in the SudanoSahelian region, 1985–1991. New York: United Nations Sudano-Sahelian Office (UNSO), UNDP.

Wexler, R. (2002). Evaluation and treatment of heat- related illnesses. *American Family Physician*, 65(11), 2307-2314.

Why it is important to keep your employees hydrated. (Retrieved April 20, 2017, from https://www.thehrbooth.co.uk/blog/the-hr-booth-updates/why-its important-to-keep-your-employees-hydrated

Williams, R.D. (1997). When summertime gets too hot to handle. *US Federal Drug Administration.* https://books.google.com.my/books?id=iv2pADDfACoC&pg=PA1&lpg=PA1&dq=When+Summertime+Gets+Too+Hot+to+Handle&source=bl&ots=9N8lIxChzW&sig=O9Qq0541hzvCh9iU8MWBVWi_LWM&hl=en&sa=X&ved=0ahUKEwiJr6fuubrXAhUZTI8KHYBNA74Q6AEIJzAA#v=onepage&q=When%20Summertime%20Gets%20Too%20Hot%20to%20Handle&f=false

Wilson, T., & Crandall, C. (2011). Effect of Thermal Stress on Cardiac Function. Exercise and Sport *Sciences Reviews, 39(1),* 12-17. http://dx.doi.org/10.1097/jes.0b013e318201eed6

Woodhouse, P.R., Khaw, K.T., and Plummer, M. (1993). Seasonal variation of blood pressure and its relationship to ambient temperature in an elderly population. *J. Hypertens, 11*(11), 1267–1274.

World Health Organization (1985). Health Factors Involved in Working under Conditions of Heat Stress. Technical Report Series No. 412. Geneva: World Health Organization.

Xiang, J., Bi, P., Pisaniello, D., & Hansen, A. (2014). Health impacts of workplace heat exposure: an epidemiological review. *Industrial Health*, *52*(2), 91-101. DOI:10.2486/indhealth.2012-0145

Xu, X., Gonzalez, J.A., Santee, W.R.,Blanchard, L.A., and Hoyt, R.W. (2016). Heat strain imposed by personal protective ensembles: quantitative analysis using thermoregulation model. *International Journal Biometeorol., 60*, 1065-1074.

YaglouC.P., and , Minard, D. (1957). Control of heat causalities at military training centers. *Am. Med. Ass. Arch. Ind. Hlth., 16,* 302-316.

Yahia MW, Johansson E (2013) Evaluating the behaviour of different thermal Indices by investigating various outdoor urban environments in the hot dry city of Damascus, Syria. *Int J Biometeorol* 57(4):615–630

Yamazaki, F., and Hamasaki, K. (2003). Heat acclimatisation increase skin vasodilation and sweating but not cardiac baroreflex responses in heat-stressed humans. *Journal of Applied Physiology, 95*(4), 1567-1574.

Yang, C., Yin, T., & Fu, M. (2016). Study on the allowable fluctuation ranges of human metabolic rate and thermal environment parameters under the condition of thermal comfort. *Building and Environment, 103*, 155-164. http://dx.doi.org/10.1016/j.buildenv.2016.04.008

Yao, Y., Lian, Z., Liu, W., & Shen, Q. (2008). Experimental study on physiological responses and thermal comfort under various ambient temperatures. *Physiology & Behavior, 93(1-2),* 310-321. http://dx.doi.org/10.1016/j.physbeh.2007.09.012

Yao, Y., Lian, Z., Liu, W., Jiang, C., Liu, Y., and Lu, H. (2009). Heart rate variation and electroencephalograph–the potential physiological factors for thermal comfort study. *Indoor Air*, *19*(2), 93-101.

Yusof, N.D.M., Diyana, N.A., Karuppiah, K. and Mohd Tamrin, S.B.M. (2014). Heat related illness in palm oil mill workers under heat stress. *Advances in Environmental Biology*, *8*(15), 171-176.

Zhang, Y.F. (2011). Evaluation of research ideas to thermal adaptation of in built environment, HVAC. 41(2), 9-17.

Zulovich, J.M. (n.d.). Implementing Heat Stress Relief Systems. Retrieved from http://webcache.googleusercontent.com/search?q=cache%3AWrhaLK3vTwgJ%3Adairy.missouri.edu%2Fstress%2FHeatStressHandout.pdf%2B&cd=1&hl=en&ct=clnk

LIST OF PUBLICATIONS

Dayana Hazwani Mohd Suadi Nata and Shamsul Bahri Md Tamrin. (2014). Assessment on Physiological Effects of Heat Stress among Palm Oil Mill Workers in Tropical Climate Condition. *AENSI Journal*,67-71.

Shamsul Bahri Mohd Tamrin, Nor Maizura Yusoff, Anita Abd Rahman, Dayana Hazwani MSN, Mansour A. Balkhyour. (2016). The Prevalence of Hand Arm Vibration Syndrome Among Automobile Assembly Workers. *Malaysian Journal of Public Health Medicine*, 16 (2).

Shamsul Bahri Md Tamrin, Mohd Nazip Suratman, Ahmad Naqiyuddin Bakar, Karmegam Karuppiah, Shafie Sidek and Dayana Hazwani Mohd Suadi Nata. (2017). *Malaysian Palm Oil Milling Industry: Analyses on Economics, Social, Safety and Health.* Penerbit Universiti Pendidikan Sultan Idris.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : ____________________

TITLE OF THESIS / PROJECT REPORT :

ESTABLISHMENT OF HEAT STRESS INDEX TO IMPROVE THERMAL COMFORT INDUSTRIAL OPERATORS IN MALAYSIA

NAME OF STUDENT: DAYANA HAZWANI BINTI MOHD SUADI NATA

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐	**PATENT**	Embargo from ____________ until ____________ (date) (date)

Approved by:

____________________	____________________
(Signature of Student) New IC No/ Passport No.:	(Signature of Chairman of Supervisory Committee) Name:
Date :	Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]