ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCE SCHOOL OF PUBLIC HEALTH

Assessment of heat sress exposure level and heat- related illnessamong HabeshaSteel Millworkers in Bishoftu, Dukem Sub- City, Ethiopia.

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List of Acronyms and Abbreviation

ACGIH	American Conference of Governmental Industrial Hygienists
BMI	Body Mass Index
CAV	Clothing Adjustment Value
DNA	Deoxyribonucleic Acid
EL	Exposure Limit
ILO	International Labour Organization
ISO	International Organization for standardization
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
SMS	Steel Making Shop
SPSS	Statistical Package for Social Science
TLV	Threshold Limit Value
WBGT	Wet Bulb Glob Temperature
WHO	World Health Organization

Abstract

Background: Heat-related illness is a significant concern for workers in industrial settings, particularly in steel factories where high temperatures are common**.**

Objectives: This study aimed to assess the prevalence of heat-related illness, heat exposure level, and associated factors among workers in steel and water factories.

Methods: A comparative cross-sectional study was conducted to assess the prevalence of heat-related illness. Data were collected using questionnaires from 396 study participants, heat exposure levels were measured through WBGT, and observationchecklists were used to observe workplace environments.Descriptive and logistic regression were used for analysis using SPSS to describe the data and identify associated factors.

Results: Heat-related illness prevalence among workers in the steel factory was 150(75%) and that inthe water factory was 38(19.3%) respectively. The most heat-related symptom experienced by both factories' workers was sweating. In the steel factory, 167 (83.5%) participants,and in the water factory 125 (63.8%) of the participants reported sweating. Workers in the steel factory had higher odds of developing heat-related illnesses compared to thoseinthe water factory (AOR, CI = 95%, 11.2 (5.8-21.55)). Proximity to heat radiant, daily water intake, group of factory, and clothing were the main significantvariables (p-value<0.05). Heat exposure measurements using WBGT in thethree different workplaces of the steel factory were 28.1°C, 29.1 °C, and 29.2 °C which exceeded the threshold values. WBGT in the water factory was 22.6 °C, which was in the normal range.

Conclusions:. The heat-related illness in the steel factory was higher than that of workers in the water factory. There is an increased heat stress in the steel factory compared to that of the water factory as measured by WBGT: 28.1°C, 29.1°C, and 29.2°C in the steel factory highlight levels of heat exposure that exceeded recommended safety and health thresholds**.**

Keywords: Heat stress, heat-related illness,comparative study**,** WBGT

1. Introduction

1.1 Background of the study

Heat stress is the net heat load to which a worker is exposed from the combined contributions of metabolic heat, environmental factors, and clothing worn, which results in an increase in heat storage in the body. The heat load experienced by the worker provokes a physiological response, which functions to increase heat loss from the body to maintain a stable body temperature. This is not always successful and, when unsuccessful, may result in heat injury and death. The environmental factors of heat stress are temperature and movement of air, water vapor pressure, and radiant heat. The amount, thermal characteristics, and type of clothing worn also contribute by altering the rate of heat exchange between the skin and the air(1). Workers in various industrial settings such as manufacturing,construction and agriculture,frequently face high temparetures,leadind to heat stress and heat-related illness.There were about 33,890 work-related heat illness occur per years,requiring days a way from work in US,with an average of 3,389 incidents per year (2).Heat stress can cause a range of health issues,from mild heat cramps to severe heat stroke,which can be fatal if it is not treated promptly and also heat exposure exacerbates chronic health conditions such as cardiovascular,respiratory, and kidney disease.Heat stress lead to reduce productivity as workers suffer from fatigue,and lower all out put and increase health care cost due to medical treatment (3). Heat stress is the thermal environment, including individual activity, and other factors imposed on a person that can increase body heat storage(4).

The iron and steel industries permanently have potential heat hazards that need to be mitigated. It mainly emanates from an extremely high-temperature process involving liquid metal generation by-product gases and explosive constituents, a large amount of material handling, and manpower-intensive multi-unit operations(5). Heat gain from the surrounding environment is increased when working during the hottest parts of the day, which are typically the afternoons, when air conditioning is less accessible, and when process heat is generated by radiant workplace heat sources like furnaces, molten metal, and different machines(6).

1.2 Statements of the problem

Occupational heat stress risk is projected to become particularly high in the middle- and low-income tropical and subtropical regions, where optimal controls may not be readily available. With a warming environment and more frequent extreme heat events predicted, heat exposure and heat stress are becoming prominent employee safety issues(7).

Heat stress is frequently an overlooked occupational health risk in poor nations. The iron and steel industries are frequently associated with excessively hot conditions. Extended exposure to heat can lead to a decline in worker performance, especially when operating in a high-temperature interior environment. This can have an adverse effect on a worker's health and their ability to be productive(8). Most workers in developing nations are strained by the intense heat in industries like iron and steel(9).

Heat stress is one of the major hazards that workers in the steel industry are exposed to itwhen steel is manufactured; it involves several operations that expose workers to high temperatures, including extraction, tapping, burning scrap, casting, and molten steel. Numerous negative health effects, including exhaustion, tiredness, dizziness, heat rashes, irregular movement, and heat cramps, were brought on by high temperatures(10) . In Ethiopia some studies conducted in the agricultural industry on heat-related illness among workers indicate that there isa high relationship between heat stress and heat-related illness (11).Despite, a study conducted on heat-related illness among steel factory workers, additional research evidence on the health effect of heat stress is needed in this specific occupational setting to protect workers from extreme heat and to promote and maintain their health, safety, and well-being.

Therefore, there is a need for more research evidence on occupational heat stress and heat-related illness among steel industry workers to develop sustainable heat stress controlling policy and intervention planning at different levels. In the steel manufacturing process, in addition to hot air temperature, the heat radiated from molten materials and hot surfaces of the cast, are the causes of heat stress faced by the works. Hence, a better understanding of this phenomenon by continuous monitoring of the working environment and successfully managing it to prevent heat-related illness and promote the health of the workforce is an important issue for employers and the government. Therefore, the aim of this will be to collect and analyzeheat-related illness datato identify the proper way of reducing its health impact.

1.3. Rationale

This study is essential because steel industry workers are regularly subjected to extreme heat stress while at work, which can impair productivity and have an adverse effect on their survival and well-being.The physical nature of the work,including lifting,carrying,and operating heavy machinery,increases metabolic heat production in the body and industrial settings may have poor ventilation,which can prevent heat from dissipating effectively,leading to higher temparetures and humidity. In the context of Ethiopia, studies on occupational exposures using conventional measurements are uncommon(11). Heat stress exposure assessment in the workplace is rare in Ethiopia, particularly in the steel industry. Available studies often focused on outdoor heat stress like the agricultural industry.Therefore the purpose of this study is to measure the level of heat exposure in the steel Mill's work environment compare the risk of heat stress with the heat stress limit standards and determine the heat-related illness among workers of Steel Mills in Bishoftu City.

1.4 Significance

This study will help identify the factors that contribute to heat stress among steel industry workers and the impacts of heat stress. Also, the information gathered from this research would serve as a baseline for the industry's application of preventive control strategies. By mitigating the risk of heat-related illnesses ,workers can maintain higher productivity levels.The study can help identify risk factors and inform the development of safety provisions,thereby reducing the incidence of workplace accidents and ill.Occupational health practitioners and policymakers will benefit from the study's analysis of the heat stress conditions in high-heat workplaces and its mitigation strategies for bringing occupational heat stress exposures down to acceptable levels.

2. Literature Review

2.1 Heat Stress in Workplaces.

Heat stress is a physical risk that can have an impact on an employee's health, either directly or indirectly. It happens when the body can't let go of the heat after prolonged labor and is unable to control its internal temperature. It may lead to more tiredness and tension, which raises the risk of workplace accidents. Workers are subjected to getting distracted at work and developing symptoms of heat-related illnesses, including headaches, nausea, exhaustion, muscle cramps, heat rash strokes, and even death(12).Increased temperature exposure can also cause a decrease in alertness, which raises the possibility of accidents or safety failures(13).

2.2 Magnitude of the heat stress

The International Labor Organization (ILO) projects that by 2030, occupational heat stress will cause 880,000 work-life years and approximately 2.2% of all working hours to be lost globally, assuming a 1.5 °C rise in global temperatures by the end of the twenty-first century. Heat stress is a major issue in low- and middle-income tropical and sub-tropical nations, where workers may be more susceptible to occupational heat-related sickness and fatalities. In these nations, workers perform labor-intensive tasks for extended periods of time in hot, muggy (humid) weather without the benefit of regulations or other measures to safeguard their health and safety(14).Heat stress poses a health risk to employees, resulting in a host of negative health effects such as degradation of physical, mental, and psychological functions, skin issues, heat exhaustion, and heat stroke. It also has a severe effect on employee productivity 423 heat-related death was reported among agricultural workers in the USA from 1992-2006 and 22 heat-related death in Taiwan were reported from 2006-2007 (15).

Study burden of heat stress among sugar cane in Ethiopia indicatesthat the magnitude of occupational heat exposure was 72.4% (95% CI: 70.2%e74.8%), while 71.6% (95% CI: 69.3%e74.9%) of participants experienced symptom-related to heat stress. (16)Heat-related health concerns were prevalent among workers in the steel industry in India, including excessive sweating, fatigue, and tiredness reported by 50% of workers.(17)WBGT index in 64.7% of workstations exceeded 30°C and in 41.2% was over 32°C. The value of the WBGT index in 69% of workstations exceeded the threshold limit of the ACGIH standard in the melting and casting industry in Iran(18).

An increasing body of evidence suggests that many men with what is currently known as idiopathic male infertility may appear at work. Such effects can be brought on by occupational exposure to radiant heat (such as that experienced by bakers, kitchen workers, welders, furnace workers, and ceramics workers) as well as other hazardous factors. Males are more susceptible to heat stress at work when they are exposed to high ambient temperatures, particularly when working long hours near a radiant heat source(19).

2.3 Factors that Affect the Heat Stress

There are factors that influence the level of heat stress. Six parameters consist of two individual characteristics (clothing worn and physical work activity) and four environmental factors (air temperature, radiant temperature, air speed, and relative humidity).

Air temperature, the temperature of the air surrounding the individual will determine the rate and direction of heat transfer. If the air temperature is raised above the skin temperature, conduction and convection will act to transfer heat from the air to the body and this causes the body to gain heat(20).

Radiant heat, when the temperature of the radiant rises (temperature of the surrounding surfaces in the work environment) above the skin temperature, heat gain from the hot body (radiant) will increase. This can lead workers to heat disorders(1).

Relative Humidity: The amount of water in the air relative to the total amount that could be present for a given temperature. For the evaporation of sweat to occur, the moisture of the skin surfaces must be greater than that of the surrounding air. In humid work environments, a higher moisture content of the air slows the rate of evaporation and decreasesheat loss.

Airspeedand high air movement improve heat losses by convection and evaporation. If the air temperature is greater than the skin temperature, the increased air temperature can promote heat gain through convection as the gradient between skin air and air temperature is reversed(21).

Workload: During work activity internal body temperature increases in proportion to workload/ metabolic rate.When the heat generated from muscular work cannot be adequately dissipated by heat loss mechanisms, body temperature can increase and lead to heat stress(22).

Clothing, excessive clothing creates a barrier between the skin surface and the environment and impairs the effectiveness of heat lossmechanisms. On the other hand,non-use of personal protective equipment increases the heat stress(14).

Overweight and obese are characterized by a high body mass index (BMI).Obese and overweight people have higher metabolic rates than normal weight and lower recovery dissipation of heat load resulting from their lower ratio of surface area to body weight(23).

There are other personal characteristics, including gender, age, psychosocial factors, health difficulties, and unhealthy habits (drinking alcohol or tobacco), which also contribute to this occupational health danger. In the steel industry, furnaces are regarded as the primary sources of radiant heat. Climate factors mixed with the radiant and convective heat gains by the workers near the furnace cause a number of heat-related illnesses, including heat cramps, heat rashes, dehydration, fatigue, and even heat stroke(8).Organizational factors that may increase the risk of occupational heat stress include inadequate health care, inadequate supervision, a lack of safety training regarding the use of semi-permeable or impermeable protective clothing, inadequate on-site restroom, and resting facilities, a lack of rest periods, and productivity incentives(24).

2.4 Occupational Heat Stress Standards and Measurements Methods

NIOSH established 38°C as the accepted average limit for prolonged heat stress exposure and found that it is protective for 95% of workers, an average of 38°C for a particular protocol was used as the threshold temperature for evaluating heat stress.(1)The International Organization for Standardization (ISO) reference values and other international standards are used to establish OELs that comply with the WBGT and metabolic rate recommendations made by ACGIH and NIOSH. (25).The WBGT heat stress index has two main goals: 1) to ascertain whether a specific degree of overall heat stress will raise the risk of heat-related illness; and 2) to act as a basis for the recommendation of further management actions(26). The WBGT is a useful index for assessing environmental circumstances related to heat stress since it takes into account the four main thermal factors that influence heat stress: air temperature, humidity, air velocity, and radiant heat. Furthermore, WBGT measuring tools are simple to use, accurate, and fast in assessing the current conditions that may pose a risk of thermal exposure(18).

The WBGT allows for the inclusion of a clothing adjustment value (CAV) since clothes can affect the rate of heat exchange between a worker's skin and the surrounding ambient work situations.(27).For clothing materials and configurations that are different from traditional work wear, clothing adjustment values (CAVs) in WBGT temperature units are specified, and CAV is added to the measured WBGT in order to obtain an effective.(28)

The metabolic rate must be used to assess task demands in order to estimate heat stress. The quantity of heat produced by labor or activity is known as the metabolic rate, and it is measured in Watts (W). This is one of the essential components of thermoregulation(26).

Determination of WBGT: An overall estimation of heat stress levels on the body can be measured by utilizing the Wet Bulb Globe Temperature Index (WBGT).This combines the measurement of three parameters; natural wet bulb temperature (Tnw), globe temperature (Tg), and air temperature (ta), applied to the following formulae for both indoor and outdoor environments:

WBGT = 0.7tnw + 0.3tg ……………………………. (1)

Solar load (accounts for an overestimation of direct radiant heat from the sun (solar load)

WBGT = 0.7tnw + 0.2tg + 0.1ta ……………………… (2)

Wherenowstands for natura1 wet-bulb temperature, Tgstands for globe temperature, and t_a stands for $_{air}$ temperature

The Micro herm Heat Stress WBGT is a sensitive scientific instrument that should not be exposed to excessive moisture, vibration, or physical shocks. The sensors are manufactured to high standards of accuracy, stability, and sensitivity so that separate calibration is not normally required.

WBGT Measurement: Wet Bulb Globe Temperatureis a compact, site monitoring instrument intended primarily for tripod mounting but may also be handheld; it has the following main features:LCD graphics display, real-time display, full data logging facilities as standard,low water level warning,built-in alarm for WBGT levels, RH% and dew point calculation, automatic calculation of work/rest regimes via PC Software, Optional tripod mounting and extension cable,Meets the requirements of ISO.Forthe most consistent measurement, stay at least 20 minutes tt each station(33).

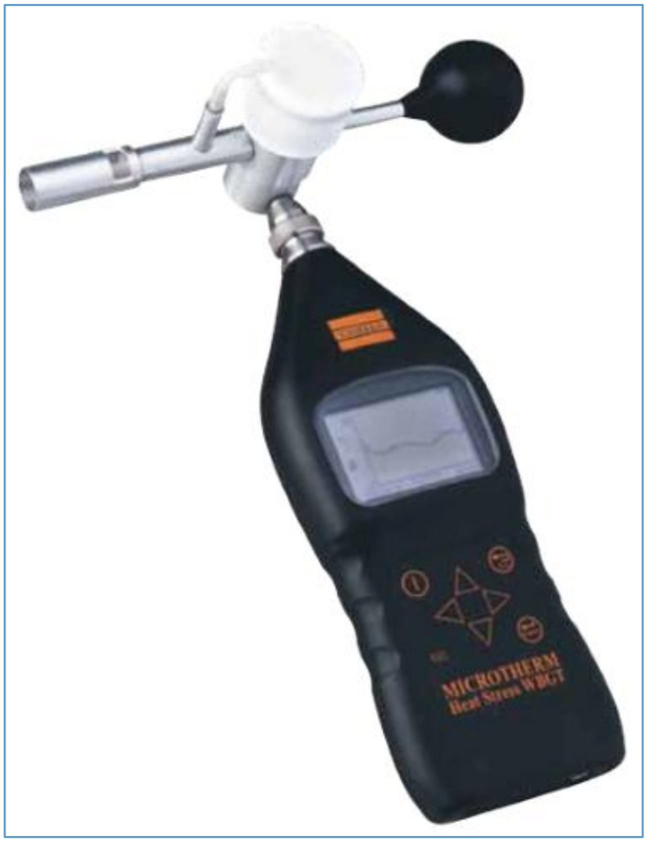


Figure 1Microtherm Heat stress WBGT

Table 1: ACGIH screening criteria for heat stress Exposure.WBGT values

Work and recovery (TLV)	(light work)	(medium work)	(heavy work)	(very heavy work)
75% to 100%	31	28	27	25.5
50% to 75%	31.5	29	27.5	26.5
25% to 50%	32	30.0	29.0	28
0% t0 25%	32.5	31.5	30.5	30.0

Sources (29)

2.5 Heat-Related Illness and Symptoms

Minor heat-related ailments and symptoms include cramping, fainting, heat rash, heat exhaustion, and heat edema. Heat stroke, exertion heat damage, and exceptional rhabdomyolysis are more severe heat-related illnesses and symptoms that can be fatal(30)..Heat exhaustion, heat syncope, cramps, and heat rash are examples of less serious illnesses that fall under the umbrella term "heat illness," but it also includes very devastating ailments like heat stroke that are directly linked to a rise in body temperature Severe heat(31).The symptoms of headache, nausea, dizziness, weakness, thirst, heavy sweating, irritability, and decreased urine output are common to both heat exhaustion and the early stage of heat stroke. Heatcramp Signs and symptoms are Muscle cramps, pain, or spasms in the abdomen, arms and legs Heat rash looks like a red cluster of pimples or small blisters that usually appears on the neck, upper chest, groin, under the breasts, and in elbow creases(1).

2.6 Individual risk factors that influence a worker to develop heat illness.

An individual risk variable a person's heat tolerance may be decreased by a single predisposing risk factor, but the risk of heat illness is increased when multiple factors work together. These individual risk variables include age, dehydration, previous heat illness, low physical fitness, lack of acclimatization, and body mass index. In addition, certain medical conditions (such as diabetes mellitus, cardiovascular illness, or infectious diseases) or drug interactions might make it difficult to tolerate heat, as can alcoholism or drug misuse(22).The physiological index assesses the degree of heat stress brought on by external variables, clothing, activity level, and individual characteristics like age, sex, and body mass index (18).

2.7 Behavioral Factors of heat stress

Behavioral factors such as the consumption of alcohol, and tobacco amount of Water drink daily contribute to increased occupational heat stressin the workplace(32).

2.8.Studies conducted related to heat stress in the Steel industry

A study conducted in Iran on steel mill workers findings indicated that the main operator room (18.52 °C) had the lowest heat stress exposure and the rolling operator unit (31.5 °C) had the highest heat stress exposure. Over the threshold limit value for heat exposure recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), workers in the rolling work operator, scissors operator, lift operator, ruffing operator, wrench operator, poker furnace operator, and lathe operator units experienced higher levels of heat stress, showing the highest heat stress on rolled operators, furnace operators, and lift operators(12).

Evidence in southern India, on Occupational Heat Stress Impacts on Health and Productivity in a Steel Industry,indicates that 90% of WBGT readings exceeded the suggested threshold limit values (27.2–41.7C) for heavy and moderate workloads, and the blooming-mill/coke-oven radiation heat from operations was extremely high (globe temperature of 67.6C). Concerns about heat-related illnesses were common among workers; 50% of them reported feeling excessively weary and sweaty. Workers who were exposed to direct heat had a considerably higher productivity loss than those who were exposed to indirect heat(17).

Research made in Malaysia on heat stress and physiological changes among workers in the steel manufacturing industry indicates the average WBGT temperature at the steel manufacturing factory was found to be 29.6°C, which may be classified as a mild heat stress situation(33).A comprehensive review of developing countries on occupational heat stress in high-heat furnace work environments indicates that widespread chronic heat stress hurts workers' health and results in a decline in performance(8).

In Ethiopia, even though the study was limited to steel industry occupational heat stress, studies were done on occupational heat stress in the floriculture industry,indicating that workers in cut-flower greenhouses are subjected to heat stress that is higher than the acceptable WBGT Index (26 °C). Employees noted a higher incidence of heat-related illnesses and lower output, particularly in the mid-altitude greenhouses. Health problems that people self-reported having included headaches, nausea, heat rashes, dehydration, sweating, and tiredness(34). Also, a study on heat-related illnesses of sugar industry workers shows heat-related symptoms such as sweating, heat exhaustion, and nausea were experienced by workers in the workplace(7).

Based on literature and the current availability of heat hazards in indoor occupational settingsespecially in the steel industry there is a need to assess heat stresslevels and determine heat-relatedillnesses experienced by steel mills workers and risk factors that influence the workers to heat stress and heat illness.

3. Conceptualframework of the study

The conceptual framework of the study on heat related illness explained graphically in relation with the main variables to be studied. It identifies the key factors and variables ,and show the expected relationship between these variables.The conceptual framework for this study explores how environmental factors, individual characteristics, and physiological and behavioral responses interact to influence the outcomes of heat-related illnesses. The following diagram shows the relationship between heat stress and environmental factors, personal, individual, behavioral, and organizational factors can increase heat stress and health outcomes or heat-related illness in the steel factory workplace. The diagram shows the health outcome of heat stress.

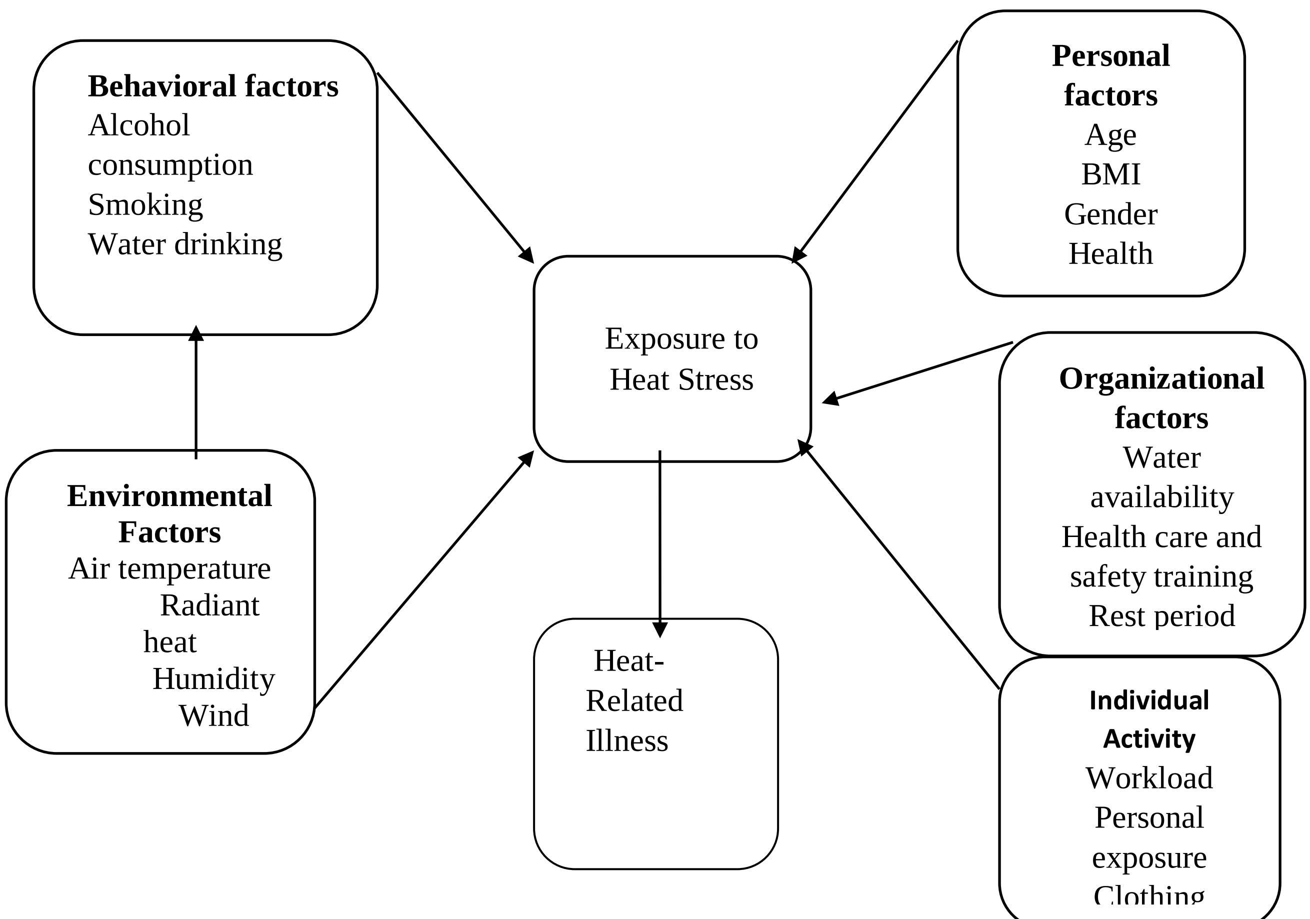


Figure 2: Heat stress conceptual frame work**,** it developed after extensive literature review (20,(35),(36)

4. Objectives

4.1 General Objective

The main objective of this study was to assess the level of heat stress and determine heat-relatedillness and associated factors among steel industry workers in Bishoftu City, Ethiopia.

4.2 Specific Objectives

1. To determine the prevalence of heat stress-related illnessamongworkers at Habeshasteel Mills in Bishoftu, Dukem sub-city, and Sheger Water factory

2. To assess factors associated with heat-related illness among workers in the Habesha Mills steel factory in Bishoftu Dukem sub-city and Sheger Water factory

3. To assess the level of heat stress in the Habesha SteelMillsindoor workplace in Bishoftu, Dukem Sub cityand Sheger Water factory

5. Methods

5.1 Study Area

The study was conducted among workers in Habesha Steel Millsfound in Oromia Regional State, Bishoftu Dukem Sub-city, which is located about 47 km from Addis Ababa, the capital city of Ethiopia, and Sheger water factory**.**The altitude of the Dukem town is ranging from 1800 – 2100 m above sea level.

There are five steel factories found in Bishoftu City, Habesha Steel Mills PLC Abyssinia Integrated Steel PLC, Metal and Engineering Corporation Steel Processing, C&E Brothers Steel Factory PLC, and Steely RMI PLC. Habesha Steel Mills PLC is one of the largest Steel industries and produces rebar from scrap and billets, from semi-finished steel products in Ethiopia.

The Sheger water factory is found in Sebetacity (Sheger city Gelan Guda, sub-city) around Kentery.Sebeta is one sheer sub-city and is situated at about 24km on the southwest of Addis Ababa. The elevation of Sebeta city ranges from 2050-2500m above sea level.

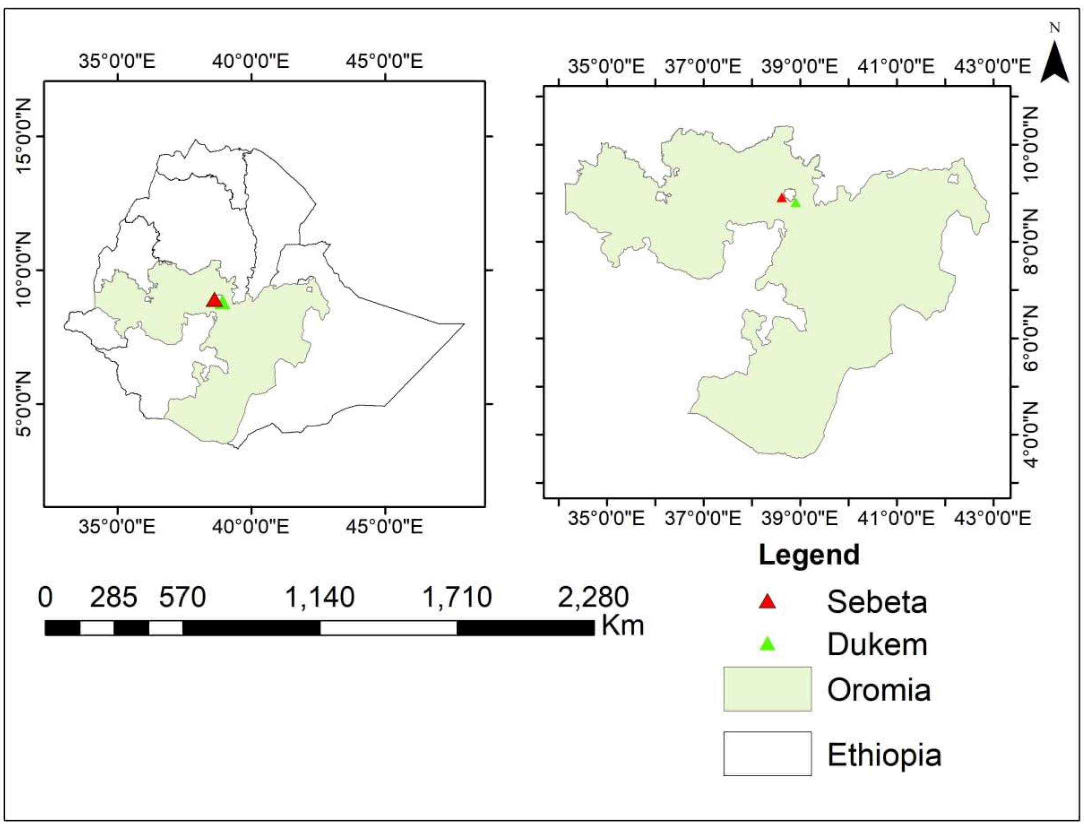


Figure:3 Geographical location of study area

5.2 Study Design

The study wasemployedan institutional comparative cross-sectional study design to compare the heat exposure level and heat related illnessprevalence amongthe two factory workers.

5.3 Study Population

5.3.1 Source Population;the Source population was all workers working in Habesha Steel MillsPLC in Bishoftu Dukem Sub-City and Sheger water factory

5.3.2 Study Population; the study population was all employees who participated in thestudy at Habesha Mills Steel and Sheger water factory

5.4 Inclusion and exclusion criteria

5.4.1 Inclusion criteria: Allworkersengaged in the production of Habesha steel mills and Sheger water bottling factoryandabove 18 years old in both factories.

5.4.2 Exclusion Criteria: Workers who currently taking medication that could influence their heat tolerance were excluded from the study.

5.5 Sample size Determination

5.5.1 Sample determination for objective one: The Sample size was determined by employing the double population proportion formula. A Comparative study was done in India between Iron foundry and ceramic workers found the prevalence of heat stress at 94.1% and 87.2% respectively(37). The sample size wasdetermined bya double population formula,

$$n= \frac{(Z\ \alpha/2+Z\beta)\ 2*(P1\ (1-P1)\ +P2\ (1-P2)}{(P1-P2)2}$$

Where, P1= 94.1% (prevalence of sweating in iron industry workers) P2= 87.2% (prevalence of sweating in ceramic factory workers) ,

$Z\alpha/2$ = Level of statistical significance 1.96 at a confidence level of 95% $Z\beta$ = Desired power for 90% power (1.28)

P1-P2 = Difference between proportions by inserting each valuen= 368 for each groups(steel factory) and water factory .

The total sample size was736. By adding a 10% non-response rate the total sample size was810participants. The total population in both factories is 791. As the total number of population is less than 10,000 populations we were used the finite population correction formula. Therefore, by using standard Z score of 1.96 n= n /1+ n/N, where n =810 and N =791 and 810/1+810/791 = 400

Therefore, the final sample was 200 for each study population group.

5.5.2 Sample determination for objective two: Tocalculatethe Sample size for the association risk factors of heat stressthe double population formula was used.A comparative study conducted in Ethiopia among steel factory and Pepsi colaworkers found that the prevalence of Fluid intake less than 3L was 94% and fluid intake greater than 3L was 69.2% respectively(36).

By using a 95% CI and 90% power the sample size was determined as:

Where p1 = proportion HRI among workers take water less than 3L

P2 = proportion HRI among workers take water greater than 3L

Zα/2=level of statistical significance 1.96 at a confidence level of 95%

Zβ =Desired power for 90 %(1.28) power and P1-P2= Difference between proportions

$$n= \frac{(Z\ \alpha/2+Z\beta)\ 2*(P1\ (1-P1)\ +P2\ (1-P2)}{(P1-P2)2} = 51$$

By adding 10% a non-respondent rate the sample size was 56 for each factory.The total sample size for the two factories works was 102 .

This sample size was less than the sample size of the first objective and since it is very small, we took the larger sample size, 200 for each group.

5.5.3 Sample determination for objective three: The study measured the workplace heat exposure from selected different work sections in Habesha steel mills and Sheger water factory. Workplace heat stress measurement was done by taking each work section from which the participants were selected.

5.6 Sampling Procedures

The steel mill industry was purposely selected from five steel industries because of resources and time constraints.In order to ensure a representative sample for the study on heat related illness, a stratified sampling procedure was employed.This method was chosen to capture the different work force and to ensure that all department wee adequately represented.Workers were divided into distinct strata based on the department they worked.Each department represente a separated stratum. The identified departments includes,Steel melting shop (SMS),rolimg mill,continous casting machine(CCM),quality control,and mentainance.The allocation was based on the proportion of total workers and finaly random sampling was conducted to select the study participants.

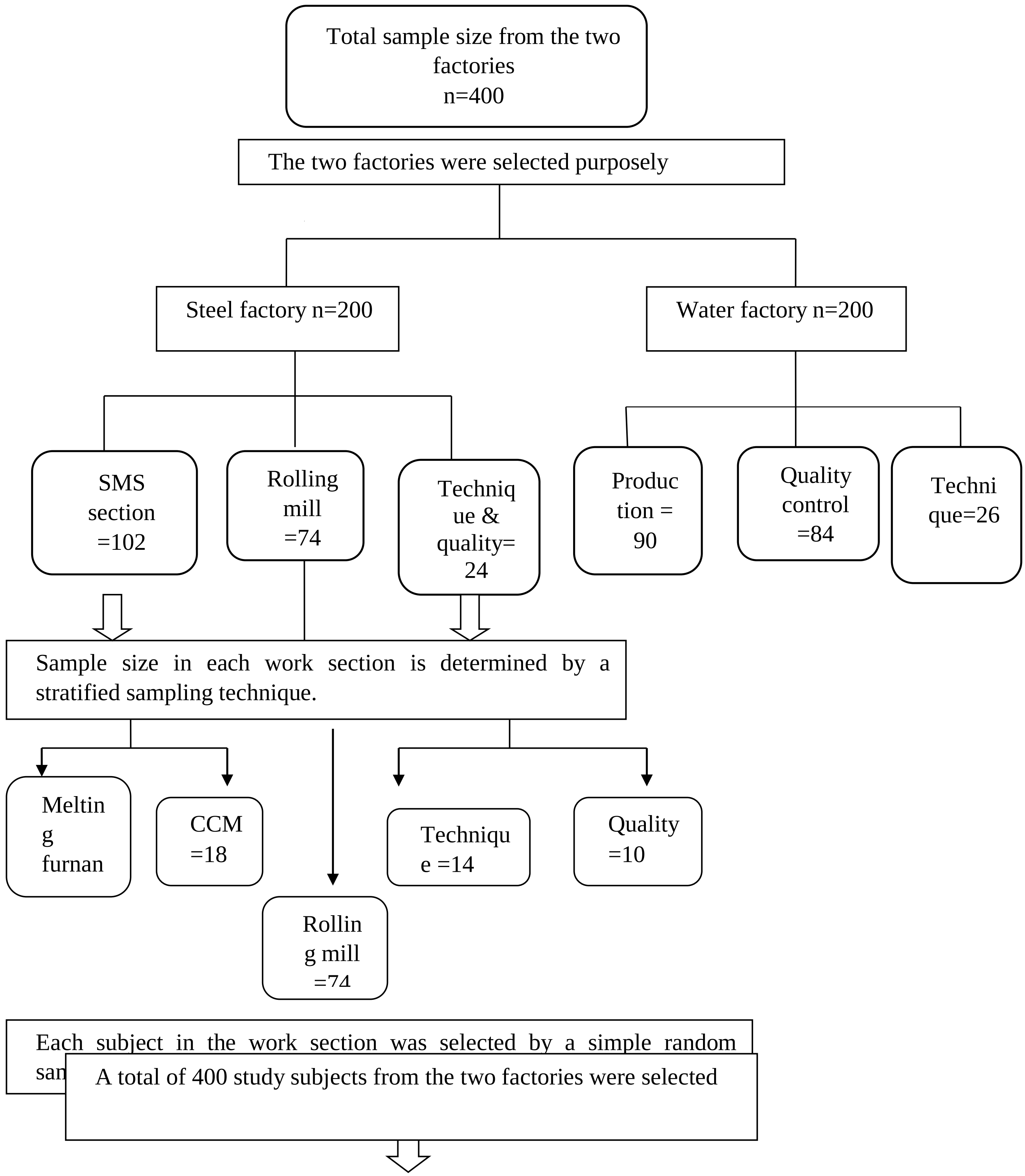


Figure 4: Sampling procedure

5.7 Data Collection Methods

5.7.1 Quantitative data

The primary data collection method in this study was a structured standardized High Occupational Temperature Health and Productivity Suppression (HOTHAPS) questionnaire(36). The questionnaire was designed to capture various demographic information, type of work, workers' exposure to heat, health impact, productivity impacts, impacts of clothing, coping mechanisms, productivity loss due to heat stress, loss of work day/hours, or wage loss due to heat-related illness, and heat-related symptoms such as heavy sweating, thirst, fatigue, headache, irritability, clammy skin, rash, muscle cramps, vomiting, dizziness, and fainting were assessed.

Data was collected by proposed data collectors through structured face to face intervie questions, and it was supervised by the principal investigator. Also, training was given to data collectors on data collection processes.

5.7.2 Instrument measurement (WBGT)

Workplace environment data were collected using Wet Bulb Globe Temperature WBGT) measurements. The measurement location was selected based on the initial walkthrough of the survey before starting the actual measurmen. WBGT measurements were taken at different locations, three locations from the steel factory(furnances work section,countinious casting machine,and rolling mill work section) which were selected due to their high tempareture environment and one location from the water bottling factory to ensure a representative sample of environmental conditions. WBGT is the most commonly used metric for evaluating the environmental contributions to heat stress.(38)

Wet Bulb Globe Temperature (WBGT) was used to evaluate environmental factors of heat stress like air temperature, humidity , and radiant heat. The monitoring device was placed at a height of 3.5 feet (1.1 m) for standing individuals or 2 feet (.6 m) for seated individuals, and it took 10 minutes for the sensor readings to stabilize(29). The WBGT was measured in the workplace for full working hours in a selected location of each work section.

Figure 5: Heat stress Measurements using WBGT

WBGT was calculated for the work sections as follows (as it is measured in indoor environments). WBGT = 0.7 T w + 0.3 T g. Where: T w = Natural wet-bulb temperature (combined with drybulb temperature indicates humidity T g = Globe temperature

The data collected for these values was compared to reference values (as defined by the standard and appropriate “work rest” regimes) that can then be adopted in the workplace or more detailed medical(39).

5.7.3 Observational checklist

The observation was performedby using an observational checklist and workplace ventilation, air temperature, availability of water for drinking and showers,usage of personal protective equipmentPPE, work-rest implemented, work activities, and cool place were observed, and important data was obtained by the investigator.In some work sections there were not artificial ventilation which can inctease air flow for cooling .

5.8 Study variables:

5.8.1 **The dependent variable**:Heat-related Illness

5.8.2. Independent variables:

1. **Environmental factors are**: air temperature, humidity, radiant heat, and wind speed
2. **Individual factors are**: Workload, Clothing, personal exposure, educationalstatus, Work experience
3. **Behavioral factors:** Amount of Water drinks daily, Alcoholconsumption,andSmoking habit.
4. **Organizational factors:** Health care, safety training, rest period and rest room, and working hours.

5.9 Operational definition

Wet bulb globe temperature (WBGT): A device used to measure the combine heat stress effectesis a heat stress.Itsscreening method to establish the presence or absence of heat stress(28).

Heat-relatedillness: A worker who self-reported at least four and more of the following symptoms: headache, heat/rashes, nausea/vomiting, weakness/dizziness, and fainting; self-reported sweating; fatigue; cramping in the muscles; and thirst(16).

Heat Exhaustion: An elevated core body temperature (38°C–39°C) with the symptoms of headache, nausea, dizziness, weakness, thirst, and heavy sweating(40).

Heat Cramps: heat illness associated with a continued loss of salt in the sweat, accompanied by a copious intake of water without appropriate replacement of salt.

Light workload:workers who are sitting or standing to control workers or workers performing light hand or arm work (e.g. using a table saw); occasional walking; driving.

Workers managing other workers or those doing simple hand or arm tasks (such as using a table saw); infrequent strolling; drivers(16) .

Moderate workload – workers who are walking about with moderate lifting and pushing or pulling; walking at a moderate pace; e.g. scrubbing in a standing position are classified as having Moderate workload .

Workers with a moderate workload are those who move around doing light lifting, pushing, or pulling; they also move at a moderate pace, such as when they scrub while standing.

Heavy workload – workers who are on picking and shoveling activities, digging, carrying, pushing/pulling heavy loads; walking at a fast pace; e.g. carpenter sawing by hand.

Employees engaged in tasks such as excavating, lugging, pushing, or dragging big objects, walking quickly, or performing manual tasks like sawing wood (40).

5.10 Data Management

The principal investigator supervised the data collection process routinely.The completed questionnaire was reviewed for accuracy, consistency, and completeness. Each morning, the primary investigator and data collectors discussed the previous day's data collection process. Any questions were addressed before moving on to the next work.

Data collectedwas checked before being entered or exported to SPSS software to ensure missing data and enhance the quality of the data. The data entry was employed in the epi-info software and then exported to SPSS software for further analysis.Data accessibility was restricted to the investigator.

5.10 Data Analysis

The Data was analyzed using SPSSversion 25.0. Heat-related Illness is considered as categorical variable. To analyzeheat-related illness data descriptive statistics was used by calculating frequency and logistic regression was used to assess the relationship between one or more independent variables and dependent variables.

Data analysis for heat-related illness (for objective one) wasanalyzed by using descriptive statistics with frequencies, and percentages to indicate the prevalence of heat-related illness.

Data analysis for associated factors (objective two) Bivariate logistic analysis of heat-related illness among variables was computed, for independent variables having- value < 0.2.,and a multivariable logistic regression model was used to indicate the association between different independent variables and heat-related illnessto show factors associated with heat-relatedillness. A standard cutoff $P < 0.05$ and 95% confidence level was considered statistically significant for all analyses.

Analysis of data measured by using WBGT (objective three)the data measured by using WBGT was analyzed using descriptive statistics with maximum, minimum and average values**.**

5.11 Ethical Consideration

Ethical approval was obtained from the research Committee of the School of Public Health. Both oral and written informed consent will be obtained from each study participant after thoroughly explaining the objectives and benefits of the study. To ensure confidentiality, any personal identifying information about participants will not be collected. The data collected for this study did not be used for any other purpose than academics. All international and institutional research ethics conventions were strictly obeyed during our study process.

5.12. Dissemination of the Results

The findings of the study will be disseminated to Addis Ababa University College of Health Sciences School of Public Health, and the thesis will be available in the library for reference. The findings will be presented to the relevant stakeholders, which include the Ministry of Labor and Skills, the Ministry of Health, the Bureau of Labor and Social Affairs, the Climate Change Environmental Authority, and the Ministry of Industry. Finally, the paper will be published in peer-reviewed journals

6. Results

6.1 Socio-demographic and individual characteristics of respondents

There were 396 study participants out of a total sample size of 400. The response rate for the study is 99%.This indicates that nearly 99% of the eligible participants responded to the study, providing data for analysis. The study comprised a total of 396 participants, with 337(85.1%) male and 59(14.9) female among the participants, the majority fell within the age group of 20 – 29, consisting of 276(69.7%) individuals. A smaller proportion belonged to the age group of 30 – 39, with 115 participants (29%). A minimal number, only 5 individuals (1.3 %), fell within the age range of 40 – 49.

The educational profile of the study participants was reported 59 individuals (14.9%), have completed primary school, 145 individuals (36.6%), have attained secondary school, 172 individuals (43.4%) have attained college education, and 20 individuals (5.1%) attained highest level of education (University) among the study participants. overall socio-demographic data was relatively similar among both factories. Majority of the respondent's occupation were workers, 383(96.7%) (Table: 1)

Table 1: socio-demographic and individual characteristics of steel and water factories respondents HRI, 2024

		Steel Factory(n=200)		**Water Factory(n=196)**			
Variables	Category	Frequency	%	Frequency	%	N = 396	P value
Sex	Male	182	91	155	79.1	337(85.1%)	0.089
	Female	18	9	41	20.9	59 (14.9%)	
Age groups	20-29 years	135	67.5	141	71.9	276(69.7%)	0.19
	30-39 years	61	30.5	54	27.6	115(29%)	
	40-49	4	2	1	0.5	5(1.3%)	
Educational status	Primary	38	19	21	10.7	59(14.9%)	0.125
	Secondary	66	33	79	40.3	145(36.6%)	
	college	84	42	88	44.9	172(43.4%)	
	University	12	6	8	2	20(5.1%)	
Chronic Disease	Yes	4	2	2	1	6(1.5%)	0.006
	No	196	98	194	99	390 (98.5%)	
Occupation	Worker	193	96.5	190	96.9	383(96.7%)	0.073
	Supervisor	7	3.5	6	3.1	13(3.3%)	

Pearson Chi-square: $\chi 2$ test, significant p-value ≤ 0.05

6.2 Behavioral and institutional characteristics of respondents

Smoking Habits, in the steel factory, 4 (2%) out of 200 participants reported smoking, while 196 (98%) did not smoke. In the water factory; only 2(1%) out of 196 participants reported smoking, with 194(99%) being nonsmokers. In the steel factory, 65(32.5%) out of 200 workers reported alcohol consumption, while 135(67.5%) did not. In the water, 22(11.22%) out of 196 workers reported alcohol consumption, with 174 (88.78%) abstaining. Alcohol consumption in steel factory respondents was higher than that of water factory.

Daily water intake, a considerable number of workers reported inadequate daily water intake, with the majority consuming less than the recommended 3 liters. However, the daily water intakes in of respondents from the steel factory were reported higher when compared with the water factory.

Regarding the availability of water in the steel factory out of 200 participants, 86 (43%) reported access to drink and shower water all the time and 114(57%) reported did not. While in the water factory, 149 (76%) workers out of 196 reported access to sufficient drink and shower water, and 47 (24%) workers reported did not have access to water. The lower proportion of workers in steel factories reporting access to water suggests a potential susceptibility to heat-related illness due to inadequate hydration. In contrast, the higher percentage of participants with access to water in the water factory indicates a more proactive approach to mitigating heat stress. The training was not given to both factory workers on the health impacts of heat stress, heat-related illness symptoms, and coping mechanisms.

***Table 2: Behavioral and institutional characteristics of respondents from steel and water factory**:*

		Steel Factory n=200		**Water Factory=196**			
variables	Category	Frequency	%	Frequency	%	N = 396	P value
Smoking	Yes	4	2	2	1	6(1.5%)	0.075
	No	196	98	194	99	389 (98.5%)	
Alcohol	Yes	65	32.5	22	11.2	87(22%)	<0.001
	No	135	67.5	174	88.8	309(78%)	
Daily water intake	< 3L	97	48.5	153	78.1	250(63.1%)	<0.001
	≥3L	103	51.5	43	21.9	146(36.9%)	
Water Availability	Yes	86	43	149	76	235(59.3%)	<0.001
	No	114	57	47	24	161(40.7%)	
Training on Heat stress	Yes						
	No	200	100	196	100	396(100%)	

Pearson Chi-square: $\chi 2$ test, significant p-value ≤ 0.05

6.3 Work-related characteristics of respondents

In the steel factory, 130 (65% participants reported heavy work, followed by moderate work, 61(30.5%), and a small proportion engaged in light work, 9 (4.5%). This indicates a significant proportion of workers in the steel factory are exposed to heavy physical activities that potentially increase their susceptibility toheat-related illness. In contrast, in the water factory, 114 participants (58.2%) were engaged in moderate work activities 42 participants (21.4%) reported heavy work and 40 workers reported light work (20.4%).

Regarding proximity to heat sourcesin a steel factory, 124 participants (62%) reported working near heat radiant, and 76(38%) of them had not worked near heat sources. In the water factory, 114 participants (58.2%) reported working near the heat source and 82 respondents (41.8%) were not. The majority of workers in both factories reported working near heat sources, with 62% in the steel factory and 58.2% in the water factory.

Regarding to workplace ventilation, in a steel factory, 92 study participants (46%) reported not having adequate workplace ventilation, while in the water factory, 106 workers (54.1%) reported not a well-ventilatedworkplace. The water factory workplace is slightly ventilated than the steel factory workplace.

The type of working clothing worn by respondents was examined to identify potential correlations with heat stress-related illnesses. In the steel factory, the majority of respondents were found to be wearing thick cotton overalls(tuta made from cotton). Specifically, 165 out of 200 participants (82.5%) reported wearing this type of clothing. Thick cotton overalls can be attributed to their durability and protective qualities, which are essential in the harsh, high-temperature environment of the steel factory. However, this type of clothing might not be the most effective in terms of breathability, potentially contributing to the prevalence of heat-related illnesses. A smaller proportion, 35 (17.5%) respondents were wearing breathable cotton attire. In contrast, only 52 (26.5%) wore thick cotton overalls. The majority of water factory respondents, 128 individuals (65.3%), wore breathable cotton. (Table: 3)

Table 3: Work-related and working environment characteristics of steel and water factory respondents of the study

		Steel Factory (n=200)		**Water Factory (n= 196)**			
Variables	Category	Frequency	%	Frequency	%	N = 396	P value
Types of work	Light	9	4.5	40	20.4	49(12.4%)	<0.001
	Moderate	61	30.5	114	58.2	175(44.2%)	
	Heavy	130	65	42	21.4	172(43.4%)	
Working hours	=8hour	43	21.5	61	31.1	104(26.3%)	0.092
	>8hours	157	78.5	135	68.9	292(73.7%)	
Work near heat-radiant	Yes	124	62	114	58.2	238(60.1%)	<0.001
	No	76	38	82	41.8	133(33.67%)	
Workplace ventilation	Yes	108	54	90	45.9	198(50%)	0.84
	No	92	46	106	54.1	198(50%)	
Work experience	<5 years	98	49	99	50.5	197(49.7%)	0.76
	≥5years	102	51	97	49.5	206(50.3%)	
Sick leave heat stress	Yes	6	3	3	1.3	9(2.3%)	0.012
	No	194	97	193	98.5	387(97.7%)	
Working clothing	Thick cotton overalls	165	82.5	52	26.5	217(54.8%)	<0.001
	Breathable cotton	35	17.5	128	65.3	163(41.2%)	
	Nylon	0	0	16	8.2	16(4%)	

Pearson Chi-square: $\chi 2$ test, significant p-value ≤ 0.05

6.4 Prevalence of Heat-Related illness among participants

The prevalence of heat-related illness, in the steel factory, 150 out of 200 participants reported experiencing heat-related illnesses, representing a prevalence rate of 75% with a CI (0.69 – 0.81) of 95% ,and only 38 out of 196 participants from the water factory reported heat-related illnesses, resulting in a prevalence rate of 19.3%,with CI (0.14 – 0.25) of 95%. The results reveal a significantly higher prevalence of heat-related illness among workers in the steel factory compared to those in the water factory. This disparity can be attributed to several factors, including differences in working conditions, such as temperature, humidity, physical exertion level, and workplace ventilation. The steel factory likely exposes workers to higher temperatures and greater physical demands, increasing the risk of heat-related illnesses. The water factory has better ventilation and lower physical activity, contributing to a lower prevalence of heat-related illnesses.

The study participants from both factories self-reported various heat-related symptoms, including sweating, exhaustion, thirst, muscle cramps, tiredness (weakness), headache, dizziness, nausea/vomiting, increasedheartbeat, and fainting. In the steel factory, out of 200, 167 participants 83.5% reported sweating, 148 respondents 74% reported thirst, 97 respondents 48.5% reported muscle cramps, 117 respondents 58.5% reported tiredness and 120 respondents 60% reported headaches respectively. In the water factory, out of 196 participants, 125 respondents 63.8% reported sweating, 77 respondents 39.3% reported thirst, 71 respondents 36.2% reported tiredness, and 57 respondents 29.1% reported headaches. Sweating is the most commonly reported symptom in both factories, with a higher percentage observed among steel factory (83.5%) compared to water factory workers (63.8%). Exhaustion and muscle cramps were more prevalent among steel factory workers, indicating the physically demanding nature of their work environment. Thirst, tiredness, headache, and dizziness were also reported in higher proportion among steel factory respondents (Table: 4).

Table 4: Prevalence of HRI among participants of Steel and water factory,Heat-related Illness symptoms ≥ 4

		Steel Factory (n=200)		**Water Factory (n= 196)**			
Variables	Category	Frequency	%	Frequency	%	N = 396	P value
Sweating	Yes	167	83.5	125	63.8	292(73.7%)	<0.001
	No	33	16.5	71	36.2	104(26.3%)	
Exhaustion	Yes	78	39.	24	12.2	102(25.8%)	<0.001
	No	122	61	171	87.7	293(74.2%)	
Thirst	Yes	148	74	77	39.3	225(56.8%)	<0.001
	No	52	26	119	60.7	171(43.2%)	
Muscle cramps	Yes	97	48.5	16	8.2	113(28.6%)	<0.001
	No	103	51.5	180	91.8	283 (71.5%)	
Tiredness(weakness)	Yes	117	58.5	71	36.2	188(47.5%)	<0.001
	No	83	41.5	125	63.8	208(52.5%)	
Dizziness	Yes	51	25.5	23	11.7	74(18.7%)	<0.001
	No	149	74.5	173	88.3	322(81.3%)	
Headache	Yes	120	60	57	29.1	177(44.7%)	<0.001
	No	80	40	139	71.3	219(55.4%)	
Nausea/vomiting	Yes	52	26	26	13.3	78(19.7%)	<0.001
	No	148	74	170	86.7	318(80.3%)	
Increase heart beat	Yes	39	19.5	25	12.8	64(16.2%)	<0.001
	No	161	80.5	171	87.2	332(83.8%)	
Fainting	Yes	4	2.	1	0.5	5(1.3%)	<0.001
	No	196	98	195	99.5	391(98.7%)	
Skin redness	Yes	34	17	2	1	36(9.1%)	<0.001
	No	166	83	194	99	360(90.9%)	

Significant p-value ≤ 0.05

6.5 Results of Logistic Regression Analysis

The binary logistic regression analysis was conducted to identify independent variables that exhibited a p value of less than 0.2 and variables that hada p-value less than 0.05 were selected and exported into multivariate logistic regression. Independent variables such as Sex of respondents, age group of the respondents, Educational status of the respondents, Occupation, work activities,overtime work, and smoking have p-values> 0.05 and were not significantly associated with the risk of developing heat-related illness. Group of industry, Heat radiant sources, water availability, appropriate amount of water intake, and Alcohol consumption were significantly associated with the risk of developing heat-related illness (P< 0.05).

Table 5: Bivariate logistic regression of Heat-related illness among study respondents in Habesha steel and sheger water factory

Variables	Category	Heat-related Illness (HRI symptoms ≥ 4) yes	No	COR (CI=95%)
Sex of respondents	Male	166(49.3%)	171(50.7%)	1.633 (0.92-2.9)
	Female	22(37.3%)	37(62.7%)	1.00
Age-group	20-29	125(45.3%)	151(54.7%)	1.00
	30-39	63(52.5%)	57(47.5%)	0.75(0.48- 1.15)
Educational Status	Primary	35(59.3%)	24(40.7%)	0.36(0.13-1.1)
	secondary	73(50.3%)	72(49.7%)	0.53(0.2-1.4)
	College	73(42.4%)	99(57.6%)	0.7(0.27-1.9)
	University	7(35%)	13(65%)	1.00
Group of industry	Steel	150 (75%)	50(25%)	12.474(7.74-20.11)*
	Water	38 (19.4%)	158(80.6%)	1.00
Occupation	Worker	185(48.3%)	198(51.7%)	3.114 (0.844-11.49)
	Supervisor	3(23.1%)	10(76.9%)	1.00
Alcohol consumption	Yes	64(73.6%)	23(26.4%)	4.15(2.45-7.04)*
	No	124(40.1%)	185(59.1%)	1.00
Water Intake	<3L	95(38%)	155(62%)	0.35(0.23-0.53)
	≥ 3L	93(63.7%)	53(36.3%)	1.00
Type of work	Light	8(16.3%)	41(83.7%)	1.00
	Moderate	64(36.6%)	111(63.4%)	2.95(2.31-5.6)*
	Heavy	116(67.4%)	56(32.4%)	10.616(4.67-24.15*)
Heat radiant	Yes	135(56.7%)	103(43.3%)	2.597(1.71-3.95)*
	No	53(33.5%)	105(66.5%)	1.00
Water Availability	Yes	85(36.2%)	150(63.8%)	0.319(0.21-0.48)
	No	103(64%)	58(36%)	1.00
Work Clothing	Breathable cotton	41(22.9%)	138 (77.1%)	0.14(0.1-0.22)
	Thick cotton overall	147(67.7%)	70 (32.3&)	1.00

6.6 Multivariate Logistic Regression Analysis Results

Variables such as working near heat radiant or heat sources, water availability, daily amount of water intake, alcohol consumption,and the group of factories werestatistically significant (p-value<0.05).

Participants who work near radiant heat were 3.75 times more likely to develop heat-related illnesses (AOR, 95% CI, 3.75 (2.03-6.94) as compared to participants who work far from heat radiant sources.

Participants who consumed alcohol were 2.13 times more likely to develop heat-related illnesses (AOR, 95% CI, 2.13(1.027 - 4.421) as compared to participants who were not drinking alcohol. Workers who worked in Habesha Steel factories had 11.22 times (AOR, CI = 95%, 11.22(5.846-21.55)) higher odds of developing heat-related illness than the water bottling factory workers.

Table 6: Multivariate logistic regression analysis of HRI among study respondents in steel and water factory

		Heat-related Illness (HRI symptoms ≥ 4)		COR (CI=95%)	AOR (CI=95%)
Variables	Category	yes	No		
Group of industry	Steel	150 (75%)	50(25%)	12.47(7.7-20.1)	11.(5.8-21.5)**
	Water	38 (19.4%)	158(80.6%)	1.00	1.00
Occupation	Worker	185(48.3%)	198(51.7%)	3.114(084-11.49)	3.5(0.68-18.21)
	Supervisor	3(23.1%)	10(76.9%)	1.00	1.00
Alcohol consumption	Yes	64(73.6%)	23(26.4%)	4.15(2.44-7.039)	2.1(1.0- 4.4)*
	No	124(40.1%)	185(59.1%)	1.00	1.00
Water Intake	<3L	95(38%)	155(62%)	0.35(0.23-0.53)	0.46(0.3-0.85)*
	≥ 3L	93(63.7%)	53(36.3%)	1.00	1.00
Type of work	Light	8(16.3%)	41(83.7%)	1.00	0.35(0.116-1.1)
	Moderate	64(36.6%)	111(63.4%)	3.6(2.31-5.6)	0.8(0.413 -1.6)
	Heavy	116(67.4%)	56(32.4%)	10.6(4.67-24.151)	1.00
Heat radiant sources	Yes	135(56.7%)	103(43.3%)	2.59(1.709-3.945)	3.7(2.03-6.94)**
	No	53(33.5%)	105(66.5%)	1.00	1.00
Water Availability	Yes	85(36.2%)	150(63.8%)	0.319(0.21-0.484)	0.486(0.26-.8)*
	No	103(64%)	58(36%)	1.00	1.00
Work Clothing	Breathable cotton	41(22.9%)	138 (77.1%)	0.14(0.1-0.22)	0.47(0.2 -0.9)*
	Thick cotton overalls	147(67.7%)	70 (32.3&)	1.00	1.00

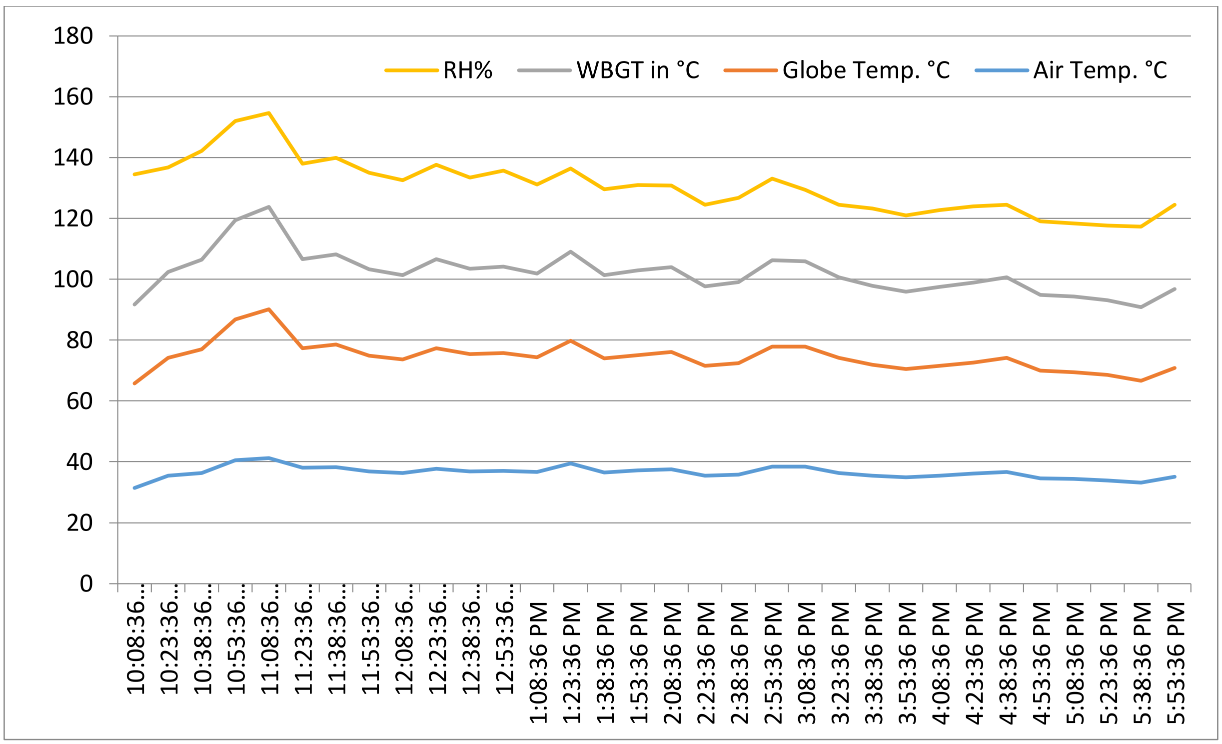
Significant p-value ≤ 0.05, **p-value ≤0.01, *p-value ≤0.05, Reference value = 1.00

6.7 Heat stress Exposure level measurement Results

In the study on heat-related illnesses among workers in Habesha steel mills and water bottling factories, heat exposure levels were assessed using the Wet Bulb Globe Temperature (WBGT). The WBGT combines measurements of temperature, humidity, and radiant heat to provide an indication of the workplace heat stress experienced by individuals in hot environments.

From the steel mills, measurements of WBGT Time-Weighted Average (TWA) were obtained from three different work departments (sections), Furnaces platform, continuous casting machine (CCM), and rolling mill within the factory. The WBGT TWA readings were recorded at 28.1 °C in Furnace'splatform, 29.1 °C in the continuous casting machine (CCM) work section, and 29.0 °c in the rolling mill work section respectively. These measurements reflect the average heat exposure level experienced by workers at each of the designated locations or work sections over a specified time period(over 8-hourperiods). In contrast, in the water bottling factory, the maximum and minimum TWA WBGT measurementswere21.6 °C,25.3 °C, and 22.6°C, respectively.

Furnaces platform work section: A pattern of high WBGT levels was occurring during both the late morning and in the afternoon. The highest WBGT measurement at 11:08 AM, was 33.6 °C and at 1:23 PM.These peaks implied that both the morning sun and the heat generated from the factory operations contribute to the elevated WBGT levels during these times.The graph shows fluctuations in the WBGT values over 8-hours periods.RH values typically inversely correlated with air tempareture;as air tempareture rises,RH tends to decrease,assuming no additional moisture is added to the environment (Figure:6).

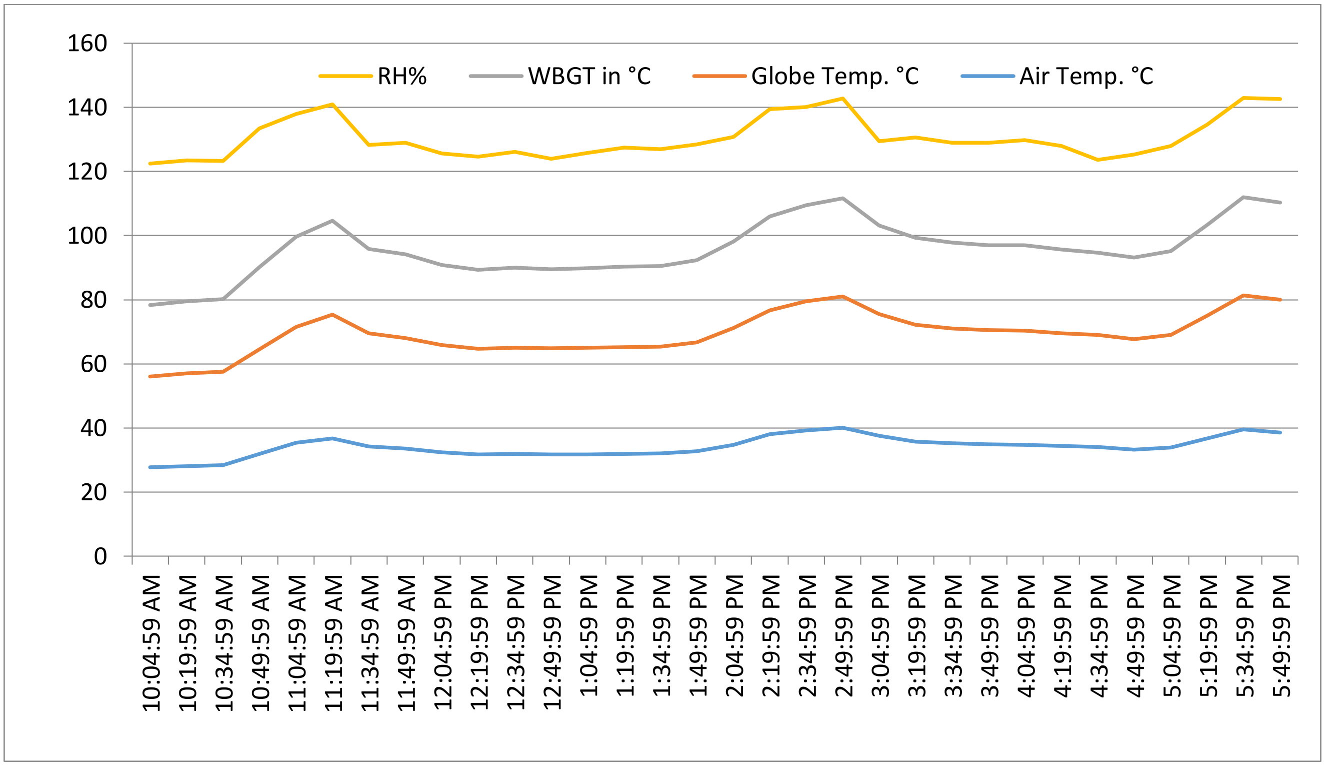


Time

NB; Y-axis: the left T℃ and X-axis time

Figure 6: WBGT measurement of Furnaces platform work section in a steel factory

Continuous casting machine (CCM) work section: The peaks were at 11: 19 AM and 2:34 PM. The peaks were at the WBGT values of 29.2 ° C, 30.6° C, and 30.6 ° C.This section's slightly later afternoon peak is attributed to its specific operational changes The graph shows fluctuations in the WBGT values over 8-hours periods (Figure : 7).



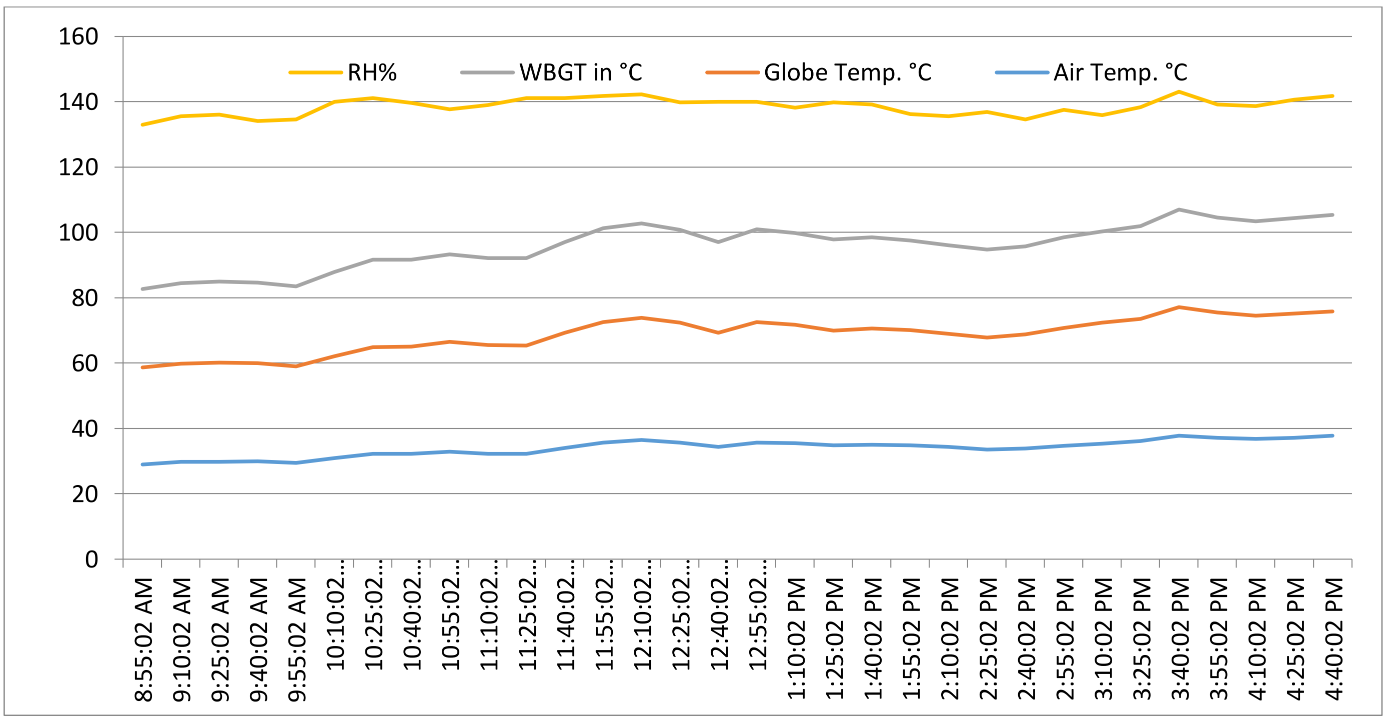
Time

NB; Y-axis: the left T°C and X-axis time

Figure 7: WBGT measurement of continuous casting machine (CCM) work section

Rolling millworksection: The WBGT measurements of this section started to peak at 11 am and went steadily up to the end of the work shift. The increased WBGT in this section is due to a combination of operational and sunlight radiation which is high in the afternoon The graph shows fluctuations in the WBGT values over 8-hours periods (Figure : 8).

°C



Time

NB; Y-axis: the left T°C and X-axis time

Figure 8: WBGT measurement of Rolling Mill Department

Table 7: WBGT heat stress level measurements among steel and water factory

Factory groups	WBGT TWA In (°C)			Tg°C			Ta°C			Tnw (°C)			RH (%)		
	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
Steel factory															
Furnace platform	24.7	28.1	31.4	30.1	38.0	53.8	29.0	36.5	46.2	19.1	23.0	31.7	23.4	28.6	42.8
CCM	23.3	29.1	29.5	27.8	35.4	43.4	27.6	34.2	40.6	18.8	22.7	27.6	26.4	34.5	44.0
Rolling mill	24.5	29.0	29.2	26.9	34.8	40.2	26.9	34.0	39.2	21.1	24.2	27.7	34.6	42.4	52.1
Water factory	21.6	22.6	25.3	22.7	30.0	33.0	22.7	29.0	31.1	18.1	21.4	23.5	40.9	49.0	68.6

6.8 Observations Results (observation Findings)

The working environment of both factories was done by using observation checklist. The steel factory working environment was characterized by intense heat and challenging working conditions. Workers are exposed to significant radiant heat sources such as furnances, casting machines, rolling mills, and welding machines.

There was dusts formed from raw material (scraps) and smokes when raw material burned .This is limited the movement (flow) of fresh air and disturb the breathing systems of workers and increase the likely hood of heat related illnesses. Access to water in the steel factory partial, even it is available for drinking and showering, it is not consistently accessible throughout the workday.

Most of the workers in steel factory were engaged in heavy physical activity, and performed their activity near radiant heat. In steel factory, workers moving raw materials, operating machines, loading and unloading raw materials and products, lifting, pushing, and pulling heavy materials which require physical exertion and coordination to control the machines.Most workers were not use personal protective equipment like helpmate, gauntlet Gloves, Face shield, goggle, aluminum overall.

In the water bottling work place, there were adequate access to water for drink and showers that are available for almost all workers at all time. Heat radiant sources machines were less intense than that of steel factory.

Raw materials (scraps) Platform FurnancesLadle furnancescasting machine

Rolling millsBilletsproduct Billet formation

Figure 9: Work processes of Habesha Steel mill

7. Discussion

The study found the prevalence of heat related illnesses among workers in steel factory was 75% with 95% of CI (0.69- 0.81),and was 19.3% with 95% of CI (0.13 – 0.24) among workers in water factory. The WBGT measured from three location in steel factory were 28.1 °C in the Furnace platform (melting furnace) section,29.1 °C in the continuous casting machine (CCM) work section, and 29.2 °C in the rolling mill department respectively. Factors such as worked near radiant heat, access to water,heavy physical activities and hydration were significantly associeated with heat-related illnesses.

The study findings indicated significant differences in the prevalence of heat-related illnesses and WBGT levels between workers in the steel factory and those in the water factory. In the steel factory, 75% of the 200 workers reported experiencing heat-related illness, compared to only 19.3% of the 196 workers in the water factory. The WBGT measurementswere notably higher in the steel factory, with readings of 28.1 °C in the Furnace platform (melting furnace) section,29.1 °C in the continuous casting machine (CCM) work section, and 29.2 °C in the rolling mill department. These findings highlight a strong relationship between elevated WBGT levels and the prevalence of heat-related illnesses. In contrast, WBGT measurements in the water factory were 22.6 °C which indicated a slightly low reading.

The results of this study show notable differences in the prevalence of heat-related illness among workers in steel and water bottling factories, 75% in steel factories and 19.3% in the water factory. The higher prevalence of heat-related illnesses among participants in the steel factory suggests that they are more susceptible to heat stress due to the specific work conditions, high heat radiant sources, and job tasks associated with the steel factory. The findings of the study align with a study conducted in Ethiopia on steel mill industry workers with heat-related illness a prevalence of 83.90 %(36).Most workers engaged in heavy physical work near sources of radiant heat,exacerbating their heat exposure. Workers performing heavy tasks near furnances and molten steel experienced higher levels of heat stress due to the combine effects of metabolic heat and radiant heat(41). This study underscore the critical role of task demands and proximity to heat sources in elevating the risk of heat-related illness.

Our study identified that a 75% prevalence of heat-related illness among workers in steel factory,with sweating being the most commonly reported heat-related symptom affecting 83.5% of the workers.This prevalence was consistent with findings from other study among steel workers,wich reported that workers experienced heat related symptoms including sweating about 86% of workers , 77.2% of them reported tiredness/weakness, muscle cramps, and 33% reported headaches commonly in the steel factory (17).

Workers who worked in Steel factories had 11.22 times (AOR, CI = 95%, 11.22(5.846-21.55)) higher odds of developing heat-related illness than the water bottling factory workers.This result was comparable with a study in Ethiopiafound that working in a steel factory (exposed) increases the odds of developing HRI by six times (AOR, CI = 95%, 6.026 (0.784–59.113)) as compared to the non-exposed groups (36). This significant difference can be attributed to several key factors inherent to working conditions and the workplace of the steel factory. The nature of steel production involves extremely high temperatures due to the processes of melting and molding of metals.

The WBGT Time-Weighted Average (TWA) record was obtained from three different work departments (sections), Furnaces platform, continuous casting machine (CCM), and rolling mill in steel factory,28.1°C,29.1°C and 29.2°C,and 22.6°C from water factory. The WBGT values recorded from the steel factory are significantly higher than the values recorded at the water factory. These differences indicate the varying thermal environments inherent to the two types of industrial settings. These results align with a study conducted in Malaysia, on the steel industry, which was measured using WBGT ranging from 27.7 °C to 29.6 °C from different work sections(33) .In Iran heat exposure of workers measured in steel mill, WBGT of 18.5 °C to 31.5 °C (12).

Participants who work near radiant heat were 3.75 times more likely to develop heat-related illnesses, (AOR, 95% CI, 3.75 (2.03-6.94) as compared to participants who work far from heat radiant sources. Radiant heat sources, such as furnaces, molten metals, and high-temperature machinery, emit intense heat that elevates the body temperature of the workers. Workers working near these sources are subjected to direct heat exposure which can increase the likelihood of developing a heat-related illness. Workers who work very cloth to extreme heat sources have greater odds of developing spectrum of heat related illness (16).The reason behind tha was due to radiant heat directly can increases the body tempareture workers,making it harder for their bodies to dissipate heat,the body's natural cooling mechanisms become less effective,leading to heat stress.

As stated by OSHA (Occupational Safety and Health Administration), workers' physical activity was classified as light, moderate, and heavy.The result of this finding showed 67.4% and 36.6% of steel factory workers were engaged in heavy and moderate work types, respectively (36)

Most workers were consuming less than 3 liters water per day.The radiant heat from the furnances,combine with the air tempareture of the factory,created an environment where maintaining hydration was crucial. Sufficent water intake to meet the fluctuations of daily tempareture, humidity and work tasks, may not consumed by workers.Lower level of water consumption at work place were significantly associated with repoted heat –related illness (42).

In our study during workplace observation we found that most of the steel factory workers did not used appropriate personal protective equipment and clothing. Other study found that wearing improper protective equipment and clothing can further exacerbated heat stress comparing to workers who use proper personal protective equipments,workers who did not use PPE and clothing experienced a higher odds of developing heat related illness (16).

The lack of appropriate cooling areas for workers was observed in our study. The absences of designated cooling areas significantlyincrease the risk of heat related illness.The importance of providing cooling areas where workers can rest and recovery from heat exposure. Spending even a few hours in a cool environment, or with a working air conditioner or cooling unit, reduces vulnerable populations' risk to heat exposure(43).

The WBGT Time-Weighted Average (TWA) measurements recorded at different locations within a steel factory and one location in a water factorywere obtained as Furnace'splatform (28.1 °c), continuous casting machine (CCM),(29.1° c),and rolling mill (29.2°c) within the factory, and 22.6°C from water factory. All measured locations in the steel factory (28.1 °c, 29.1° c, and 29.2°c) exceed the ACGIH threshold for moderate and heavy work(34) . This indicates a significant risk of heat stress that needs heat stress management practices. In contrast, in the water factory, the acceptable range (22.6°C) for moderate work was recorded. This suggests a relatively low risk of heat stress, although preventive measures are recommended.

Our study findings were in line with the established occupational health and safety guidelines. The American Conference of Governmental Industrial Hygienists (ACGIH) sets threshold limit values (TLV) for WBGT to manage heat stress in occupational environments. According to ACGIH, WBGT values above 25 °C for heavy work activities require immediate action such as work-rest cycles, hydration, and the provision of cool areas for recovery (30,ACGIH,2019). The WBGT values in the steel factory, which ranged from 28.1 °C to 29.2 °C, clearly exceed the threshold value of these guidelines and it highlights the need for enhanced protection measures(44).

The National Institution of Occupational Safety and Health (NIOSH) also recommends comprehensive heat stress management plans for environments with high WBGT values .

8 .Strengths and Limitations of the Study

Strengths

The study compares two different work environments and provides insights into how different types of industrial settings affect heat-related illnesses**.**

Limitations

Since the questionnaire relies on self-reported data regarding heat-related illness symptoms, there is the chance of recall bias, where participants may not accurately remember their experiences.

Heat exposure can vary based on the time of day; theremay be repeatedmeasurements of one location to see the variation of measurements at the same location. The outside temperature was not controlled by using other WBGT, since we used only one device.

Clinical data, such as medical records, and physiological measurements (core body temperature, heart rate, and skin temperature) of the individuals were not used to support the evidence of heat-related illnesses.

9. Conclusion

The results of the study highlighted the differences in the prevalence of heat-related illness among the two factories, 75% of steel and 19.3% of water bottling factories. There were significant differences in both the prevalence of heat-related illnesses and measurements of WBGT for heat exposure assessment. Heat-related illness symptoms such as sweating, thirst, headache, and muscle cramps were common symptoms reported by the steel factory workers.

Workers in the steel factory were at higher risk of developing heat-related illnesses orhad higher odds of developing heat-related illnesses as compared to water bottling factory participants.

The group of factory, daily water intake of water, sources of heat radiant, access to drinking water and shower,clothing, and heavy work activities were the significant associated factors of heat stress.

The WBGT measurements, 28.1°C, 29.1°C, and 29.2°C in the steel factory consistently indicated levels of heat exposure that exceeded recommended safety and health thresholds, highlighting the need for improved cooling measures, hydration provision, and frequent breaks to mitigate these problems.

10. Recommendation

Based on the study findings important recommendations are given to the concerned body.

To ensure the safety and health of the workers, it is important to implement comprehensive heat stress management strategies.

Habesha Steel Mill

- ✓ Regularly monitor the temperature and humidity level of the workplace to ensure they are safe with the threshold limit value of guidelines.
- ✓ Designate cool-down areas where workers can rest and recover from heat exposure during breaks.
- ✓ Train workers to recognize the symptoms of heat stress and how to take preventive measures.
- ✓ Conduct regular health checks and monitor workers for signs of heat-related illness..
- ✓ Prove lightweight, breathable, and heat-resistant clothing for workers.
- ✓ Schedule work shifts from the current two shifts to three shifts per day (24 hours) to reduce the pressure of heat stress.
- ✓ To reduce heavy work of workers it is important to replace it by modern machines.

Ministry of Labor and Skill

- ✓ Follows up on the implementation of existing occupational safety, health, and environmental guidelines, regulations, and directives.
- ✓ Monitor and conduct regular inspections to ensure compliance of workplace safety and health regulations.
- ✓ Provide trainingprograms on recognition and preventing heat-related illnesses and ensure workers are trained in first aid specific to heat related conditions.

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12.Annexes

Appendix A. Heat stress Questionnaire

ID ------------------

Date ---------------------------- Code of Industry ---------------------

Part 1 General information about participants			
S.N	Question(Variables)	Response	Skip…
1	Age group	1.20-29 2. 30-40 3. 40-50 4. 50 and above	
2	Sex	1.Male 2.Female	
3	Height (cm) and Weight (Kg)	Write in m ----- and in kg -----	
4	Marital status	1. Single 3.Divorced 2. Married 4.Widowed	
5	Education	1. Do not attend formal education 2. Primary 3. Secondary 4. Higher /college/ 5.University	
6	Designation	1.Worker 2. Supervisory 3. Manager	
7	Smoking	1. Smoker 2. Non-Smoker 3. Ex-smoker	
8	Consuming alcohol	1. Yes 2. No 3. Ex	
9	Do you suffer from chronic illnesses (a multiple answer is possible)?	1. No 2.Diabetes 3. Hypertension 4.Respiratory illness, specify 5. Kidney diseases 6.Others ----------	
Part 2 Questions concerning the type of work			
10	Type of work:	1. Light 2. Moderate 3. Heavy 4. Very heavy	
11	How long you are employed here?	Write year of employment ------	

12	What were your previous job and where (relating to temp)?	Write previous job ----------	
13	How many hours a day do you work	1.8 hour 2.more than 8hour 3.less than 8 hour	
14	When and how long are the regular breaks?	Write -------------------	
15	Do you work near a direct heat source(naked flame/hot surface air//radiant heat) ?	1. Yes 2. No	
16	Is the place you work well ventilated?	1.Yes 2. No	
17	Do you have additional breaks during hot time?	1. Yes 2. No	
18	If yes for question,	mention no. of hours/minutes__________________	
Part 3 Questions in relation to heat exposure at work			
19	Are you comfortable with the workplace temperature	1. Yes 2. No	
20	What do you feel about the temperature now?	1. Hot 2. Warm 3. slightly warm 4. neutral 5. slightly cool 6. cool	
	What would you like to do now?	1. Cooler 2. Warmer 3. No change	
21	How many months do you feel hot /uncomfortably hot in this Workplace?	1. 1-3 months 2. 4-6 months 3. 7-9 months 4. 9-12 months 5. Never	
22	Is sufficient drinking water and showers available at all times when you need it?	1. Yes 2. No	
23	During the hot season, how much water do you drink daily?	____________L	
24	Describe how bad the heat stress can be in the hot season	1. Extremely bad 2. Very bad 3. Bad 4. Manageable 5. No stress at all	
25	What impact does a hot workplace have on your work (a multiple answer possible)?	1. No impact 2. Impact on well-being	

		3. Impact on concentration 4. Impact on productivity 5. Health impact 6.Other --------------------------------	
Part 4 Questions concerning symptoms of heat stress or the impact of heat on health			
26	What symptoms do you face when you work in the factory?	1. Sweating 2. Exhaustion 3. Thirst 4. muscle cramps 5.Tiredness/weakness 6. Dizziness 7. Headache 8. Nausea or vomiting 9. Fainting 10. increase heartbeat 11. skin, chest, and neck redness 12. Others ----------------------	
27	To achieve the production target or complete do you have to work extra hours?	1.Yes 2.No	
28	Have you ever been hospitalized for one of the problems listed above?	1. Yes 2. No	
29	If you answered YES to the previous question, specify which one.	Write for which symptom ------------	
Part 5 Questions concerning the impacts of clothing on heat stress			
30	Dress material of the workers	1. Breathable cotton 2. Thick cotton overalls 3. Rayon/Nylon 4. Plastic PPE 5. Others_____	
31	Do you feel hotter with a uniform/ Does the Dress Material increase heat stress?	1. Sure 2. Maybe 3. Not sure 4. No, not at all	
32	Have you taken any training concerning Heat stress?	1. Yes 2. No	
33	If yes	When ---------------------	
Part 6 heat stress coping mechanisms			
34	How do you try to reduce exposure to heat (a multiple answer is possible)?	1. The exposure cannot be reduced 2. Increasing the number of breaks 3. Using a cooler place for breaks	

		4. Wearing more suitable clothes 5. Drinking more water 6. Moving work activities early in the morning or in the evening 7.Other -------------------------------	
35	How do you limit heat exposure, when needed?	1. get away for a while 2. remove the clothing 3. drink water 4. any other method, ___	
36	If you are feeling unwell from the heat exhaustion how do you cope with this?	1. take a rest 2. cool shower, or sponge bath 3. move to an air-conditioned/cooler environment 4. switch to Lightweight clothing 5. drink water 6.any other method,___	
37	What do you recommend to cope with heat stress levels?	1. Take a rest 2.cool shower, or sponge bath 3. Move to an air-conditioned 4.switch to Lightweight clothing 5. Drink water 6.any other method,___	
Part 7 Questions concerning the impacts of heat on worker's productivity			
38	Have you ever taken sick leave/permission due to heat?	1.Yes 2.No	
40	If yes, question 38	Approx. how many hours in a week or day ---	
41	Have you ever been admitted toa hospital/medical centre due to heat-related sickness? Yes/No	1.Yes 2.No	
42	If yes, question 41	approximately how many days__________	
43	Have you lost any wages due to	1.Yes	

	absenteeism because of heat related illness?	2.No	
44	If yes, question 43	how much _____(in birr)	

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መታወቂያ --------------------------

ቀን ---------------------------------- የኢንዱስትሪኮድ --- ----

ክፍል 1 ስለተሳታፊዎችአጠቃላይመረጃ			
S.N	ጥያቄ(ተለዋዋጮች)	ምላሽ	ወደ..ሐድ
1	እድሜክልል	1.18-29አመት 2.30-40 አመት 3.40-50 አመት 4. > 50 አመት	
2	ጾታ	1.ወንድ 2. ሴት	
3	ቁመትእናክብደት	ቁመት - -,ክብደት -------- ኪ.ግ	
4	የስራመደብ	1.ሰራተኛ 2.ተቆጣጣሪ 3.ሃላፊ	
5	የጋብቻሁኔታ	1.ያላገባ 2. ያገባ 3. የተፋታ 4. ባልየሞተባት	
6	የትምህርትደረጃ:heat-related	1ያሌተማረ 2. የመጀመሪያዯረጃት/ት 3. ሁሇተኛዯረጃ 4. ኮላጅ 5. ዩንቨርሲቲ	
7	የማጨስባህሪይ	1. አጫሽ 2. የማያጨስ 3. የቀድሞአጫሽ	
8	አሌኮሌየመጠሰደሁኔታ/የማጠጥ ባህሪዎ:	1. አዎ 2. አይ	

		3.ደሮእጠጣ በር	
9	ሥርበሰደደበሽታዎችይሰቃያሉ (ብዙሚልስማገኘትይቻላል)?	1. አይ 2.የስኳርበሽታ 3. የደምግፊት 4.የመተንፈሻአካላትበሽታ, ይግለጹ 5. የኩላሊትበሽታዎች 6. Others ----------	
ክፍል 2 ስለሥራወዓይነ ትጥያቄዎች			
10	የሥራወዓይነ ት	1.ቀላል 2.መካከለኛ 3. ከባድ 4. በጣምከባድ	
11	የቀድሞስራዎምንነ በር፤ ሰራቦታስየ መቃትሁኔታወስ ?	---	
12	እዚህድርጅትከተቀጠሩምንያክልጊ ዜሆነ ዎት?	--------ዓመት---------ወር	
13	በቀንስንትሰዓትይሰራሉ	1.ከ 8 ሰዓትበታች 2. 8 ሰአት 3. ከ 8 ሰአትበላይ	
14	መደበኛእረፍቶችመቼእናለምንያህልጊዜናቸው?	----------------	
15	በምትሰራበትቦታቀጥታየ መቀት ም ንጩአለእሳት/ወባቅአየ ር/ቀጥታፀሃይወዘተ) ?	1. አዎ 2. አይ	
16	የምትሰራበትቦታብደንብአየ ርይናፈሳል?	1. አዎ 2. አይ	
17	በሞቃትጊዜተጨሜሬእረፍቶችአሉዎት?	1. አዎ 2. አይ	
18	ለጥያቄአዎከሆነ ,	ቁጥርመጥቀስ።የ ሰዓት/ደቂቃ_----------------------	

19	የምትሰራዉንስራግልጽአድርግእስኪ	-------------------------	
ክፍል 3 በስራላይካለዉሙቀትመጋለጥጋርየተያያዙጥያቄዎች			
20	የሥራቦታሙቀትተመችቶሃል?	1. አዎ 2. አይ	
21	በአሁኑ (በዚህ) ሠዓትሙቀቱእንዴትነው?	1.በጣምሞቃት 2.ሞቃት 3.ቀለልያለሙቀት 4.ሙቀትምቅዝቃዜምየለም 5.ቀለልያለቅዝቃዜ 6.በጣምቀዝቃዜ	
22	በአሁኑ (በዚህ) ሠዓትየአካባቢዉሙቀትምንእንዲሆንይፈልጋሉ?	1) ቀዝቀዝያለ (እንዲቀዘቅዝ) 2) ሞቅያለ 3. ለውጥአስፈልግም	
23	በአመትዉስጥምንያህልወራትሞቃትይሰማዎታል?	1. 1-3 ወራት 2. 4-6 ወራት 3. 7-9 ወራት 4. 9-12 ወራት 5. በጭራሽ	
24	አንተበምትፈልግበትጊዜበቂዉሃእና ሻወርታገኛለክ?	1. አዎ 2. የለም	
25	በሙቀታማወቅትምንያክልዉሃበቀ ን ትጠጣለክ?	________________________-	
26	በሞቃታማወቅትየሙቀቱሜጠንምንያክል የከፋይሆናልብለህታስባለህ?	1.እጅግበጣምከባድ 2. በጣምከባድ 3. ከባድ 4. መቁቁምየሚቻል 5. ምንምሙቀትየለም	
ክፍል 4 የሙቃትተጽኖበጤናላይየሚያስከትለዉችግርየተመለከቱጥያቄዎች			
27	በስራቦታበሙቀትምክንያትምንአይነትስሜት/ህመም/ምሌክት/ ይሰማዎታል?	1. ማላብ 2. አቅምማጣ ስ 3. የዉሃጥም 4.የጡንቻመሸማቀቅ	

		5. ከፍተኛድካም 6. ራስማዞር 7. የራስምታት 8.ማቅለሽለሽ/ማስመለስ 9.ራስንመሳት 10.የልብምትመፍጠን 11.የቆዳ፤ አንገት፤ ደረትሽፍታ 12. ሌላካለይግለጹ_________	
28	የምርትማጠንእቅድለማካካትአሊያም ተጨማሪክፍያለማግኘትተጨማሪ ሰዓትይሰራሉ?	1.አዎ 2. አይ	
29	ከላይከተዘረዘሩትችግሮችበአንዱሆስፒታልገብ ተወያውቃሉ? **ጥያቄዎች27**	2. አዎ 2. አይ	
30	ለቀደመውጥያቄአዎብለውከመለሱየትኛውንይግለ ጹ**ጥያቄዎች 26** .	---	
ክፍል 5 ልብሶችበመቅትጫቀትላይስለሚኖራቸውተጽእኖየሚመለከቱጥያቄዎች			
31	የሰራተኞችየስራልብስምንአይነትነው?	1. ስስየጥጥልብስ 2. መሉወፍራምልብስ 3. የናይለንጨርቅ /ሀርመሳይሌብስ 4. ፒሊስቲክመከሊከያ 5.ሌላአይነትከሆነ ግለጽ_______	
32	የስራጋወንበመጠቀማችሁበስራቦታ መቅትይጨምርባቸዋል/ የስራጋወንመልበስእንዲሞቃችሁያደ ርጋል)	1.በትክክል 2. ሊሆንይችላል 3. እርግጠኛአይደለሁም 4. አያደርግም	
33	የመቃትተጽኖበጤናላይየሚያስከት ለውችግርአስተመልክቶስሌጠና/የግ ንዛቤማስጨበጫውስደውያውቃሉ	1.አዎ 2. አይ	
34	አወከሆነመችነውየወሰደ	-------------	
ክፍል 6መቅትንለመካላከልየምንጠቀምበትሂደቶችጋርበተያያዘያሉጥያቄዎች			
35	ለመቅትመጋለጥንለመቀነስእንዴትይሞክራሉ (ብዙመልስማግኘትይቻላል)?	1. ተጋላጭነቱንመቀነስአይቻልም 2. የእረፍትብዛትመጨመር 3. ለእረፍትቀዝቃዛቦታማጠቀም 4. ይበልጥተስማሚልብሶችንመልበስ 5. ተጨማሪውሃማጠጣት 6.በማለዳ ወይምበማታላይየስራእንቅስቃሴዎችንማን	

		ቀሳቀስ 7.ሌላ -------------	
36	የመቀትችግርንለመቋቋምምንቢደረግይመከራለ?	1. ለተወሰነ ስአትወደውጪበመውጣት 2. ልብስበማውለቅ 3. ውሃ ማጠጣት 4. ሌላካለይጥቀሱ________	
37	በመቀትምክንያትደህንነትየሚሰማዎት ከ ሆነ አሌያምየ መቀትጫዓቅስያጋጥምመቀ ትንለመቀነ ስምንይደረጋል ?	1.በር /መስኮትበመክፈት 2.አርቲፊሻ ልቬንትሌሽንማጠቀም 3.ውሃ ማጠጣት 4.ስስ ልብስበመልበስ 5.በቀዝቃዛ ውሃገላንመታጠብ 6.ሌላካለይጠቀስ -------	
38	በስራቦታዎያለውን መቀትለመቀነ ስ ምንቢደረግይሻላልይላሉ?	1.በር /መስኮትበመክፈት 2.አርቲፊሻል ቬንትሌሽንማጠቀም 3.ውሃ ማጠጣት 4.ስስ ልብስመልበስ 5.ሌላካለይጠቀስ________	
ክፍል7 የመቀትችግርበምርታማ ትላይየሚየመጣውንተጽእኖአስመልክቶየሚጠየ ቁጥያቄዎች			
39	በመቀትምክንያትፈቃድጠይቀው /የህመምመውጫፈወያወቃሉ	1.አዎ 2.የለም	
40	ለጥያቄቁ39 መሌሶአዎከሆነ	በአማካኝስንትስአትይሆናልበሳምንት-------በወር---------------	
41	በመቀትምክንያትታመውየህክምናማእከልተኝተው ታክመውያወቃ?	1. አዎ 2.የለም	
42	ለጥያቄቁ 41 መሌሶአዎከሆነ	በአማካኝለስንትያክልቀናትይሆናል_____ ____________________	
43	ከመቀትጋርበተያያዘታመውከስራቀርተወበዚህም ክንያትደመወዝዎተቆርጦያወቃል?	1. አዎ 2.የለም	
44	ለጥያቄቁ 43 መሌሶአዎከሆነ	ምንያክል ____________(በብር)	

<u>Observational checklist: Workplace heat assessment Steel factory workplace</u>

Factors to be considered in heat stress assessment in the factory workers

Date ---------------, Department__________________________

Investigator ____________________________________

S.N	Activities	Yes	No

1	Radiant heat sources		
	Furnaces		
	Molten metal		
	Machinery		
	Welding		
	Equipment that produces steam		
2	Working at ventilated		
	Is the place you work well ventilated?		
	Are open doors used to increased air flow		
	Are blowers or fans used to increase air flow in poorly ventilated areas?		
3	Performing heavy manual work		
	Are mechanical aids provided or powered lifting machinery used, as appropriate, to minimize physical exertion?		
	Is the work reorganized to minimize intensity and pace of bodily movement of workers so far as reasonably practicable?		
	Are suitable rest breaks?		
4	Provision of drinking water on site		
	Is the drinking water provided at locations within close proximity to all workers?		
	Is Sufficient rest/brake cool room?		
	Are sufficient showers available at all times when you need it?		
5	Clothing		
	Do the workers wear thin and air permeable cloth?		
	Does your job require the use of heat protective clothing?		
6	Does your job require the use of heat protective clothing		
	Gauntlet glove		
	Face shield		
	Google		
7	Are there necessary precautions		
	Eg.providing cooling vests) adopted at workplaces with a higher risk of heat stroke (e.g. in poorly ventilated places with hot machinery in use Posters		

Annex X; Assurance of principal investigator

Declaration

I, the undersigned declare that this my original work, has not been presented for a degree in this or another university and that all sources of materials used for this thesis have been fully acknowledged.

Name: Beyene Ketema

Signature ____________________

Place: Addis Ababa University

Date of submission

This thesis has been submitted for examination with my approval as university advisor,

Name: Abera Kumie (Ph.D.)

Signature: Signed as ABERAKUMIE