ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCE SCHOOL OF PUBLIC HEALTH DEPARTMENT OF PREVENTIVE MEDICINE UNIT OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH

# ASSESSMENT OF HEAT EXPOSURE, HEAT-RELATED ILLNESS, AND ASSOCIATED FACTORS AMONG WORKERS AT THE LEMI INJERA BAKING CENTER, ADDIS ABABA: A COMPARATIVE CROSS-SECTIONAL STUDY

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**COLLEGE OF HEALTH SCIENCE**

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## ACRONYMS:

AAU SPH:------------Addis Ababa University School Of Public Health
AAU SPH REC:-----Addis Ababa University School Of Public Health Ethics Review Committee
ACGIH: --------------American Conference Of Governmental And Industrial Hygienists
AOR:------------------Adjusted Odds Ratio
BMI: ------------------Body Mass Index
BOLSA: --------------Bureau Of Labour And Social Affairs
BP: --------------------Blood Pressure
CCOSH: --------------Canadian Centre For Occupational Health And Safety
CI:----------------------Confidence Interval
COR:-------------------Crude Odds Ratio
DMS:-------------------Detection Management Software
GDP:-------------------Gross Domestic Product
GIS: -------------------Geographic Information System
Hris: ------------------Heat-Related Illnesses
ILC:---------------------International Labour Conference
ILO: ------------------- International Labour Organization
Mm Hg: --------------- Millimetere Of Mercury
Molsa: -------------- Ministry Of Labor And Social Affairs
MPH: ------------------ Master Of Public Health
NIOSH: ---------------- National Institute For Occupational Safety And Health
ODK: ------------------ Open Data Kit
PLC: --------------------Private Limited Company
PPE: --------------------Personal Protective Equipment
SD:----------------------Standard Deviation
SOP: --------------------Standard Operating Procedure
TLV:--------------------Threshold Limit Value
USA: --------------------United States Of America
VIF:----------------------Variance Inflation Factor
WBGT: -----------------Wet Bulb Globe Temperature
WHO: -------------------World Health Organization

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## Abstract

**Background:** Heat stress is one of the major occupational health concerns in industries that are characterized by hot working environments, such as injera baking, which exposes employees to a high level of heat. In Ethiopia, Injera baking is a labor-intensive work that presents workers with increased exposure to heat. However, no literature examines the exposure to heat stress and associated health consequences among injera baking workers.

**Objectives**: This is to assess the heat exposure level, prevalence of heat-related illness, and associated factors among workers in the Baking and Market centers.

**Methods**: A comparative cross-sectional study was conducted at the Lemi Injera Baking and Local Market Centers. Data on heat stress exposure were collected using the Wet Bulb Globe Temperature tool for both groups, and the average values were compared with international standards. Individuals were selected through simple random sampling by matching sociodemographic variables. Survey data were collected from 154 subjects of Injera baking and 155 subjects from the Local Market using standardized, Kobo Toolbox-based questionnaires. Furthermore, an observation was made using an observational checklist to explore the working conditions. The survey data was exported from the Kobo Toolbox server in Excel format. The data was cleaned and analyzed using the Statistical Package for the Social Sciences version 26 with descriptive statistics and regression models.

**Results:** The average working-hour WBGT at the Baking Center was $26.4 \pm 3.7$°C, significantly higher than the Reference group's $18.6 \pm 2.6$°C ($p < 0.05$). At the Baking Center, it exceeded the ACGIH threshold limit (28.5°C ) for moderate work between 10:00 AM and 4:00 PM. Heat-related illness (HRI) was more common among Injera Baking workers (46.1%) (95% CI: 38.2%–54.0%) compared to Local Market workers (9.7%) (95% CI: 5.0%–14.4%). Among Injera baking workers, the common self-reported symptoms include excessive sweating (85.7%) and fatigue (80.5%). Work group (AOR=13.2, 95%CI:3.4- 50.7), drinking water access (AOR=4.3,95%CI:1.69-10.9), rest breaks (AOR=3.5, 95%CI:1.5-8.13), and water intake(AOR=3.9, 95%CI:1.55-9.73) were among statistically significant variables (p-value<0.05).

**Conclusion:** Injera Baking workers face higher HRI risks due to elevated temperatures. Improving hydration, breaks, and cold-water access is essential for the prevention of those risks.



**Key words:** HRI, Injera Baking workers, occupational heat exposure, WBGT, Comparative cross-sectional**.**

# Introduction

## Background

Heat stress is the cumulative heat load that a worker may be subjected to due to metabolic heat production and external heat sources, which affect workers' performance, safety, and health (1). Heat stress is an increasingly common, prolonged, and severe phenomenon all over the world (2,3). The evidence shows that heat stress can lead to certain health consequences like heat rash, heat cramps, heat exhaustion, and even heat stroke, all of which severely affect health and productivity (4). However, it is still the most neglected occupational hazard in many countries (5).

After a body is exposed to hot environments, it has to maintain thermoregulatory balance through sweating and vasoconstriction in the skin (6). Nevertheless, this may exhaust these mechanisms and lead to heat stress by chronic exposure. Heat stress occurs when the body receives more heat than it can handle, resulting in a range from mild manifestations, like heat rash or cramping, up to severe conditions, including heat exhaustion, heat stroke, or death (7). Extreme temperature events are both getting more frequent, longer-lasting, and more severe worldwide as climate change forces more and more making numerous sectors particularly vulnerable (8), such as food production industries.

In the baking industry, which is a vital industry in both developed and developing countries, workers are highly exposed to high temperatures coming in contact with baking ovens as an occupational activity (9). This exposure frequently results in health problems (10). Injera, the staple food in Ethiopia, is baked on clay griddles, locally known as *mitads,* which are operated at high temperatures (11). In Ethiopia, injera baking is a common site of work activity in which direct exposure to heat is significant. Injera production facilities, including the Lemi Injera Baking Center in Addis Ababa, employ a large staff, and they have to work in very high temperatures.

Despite obvious risks like heat-related illness, dehydration, and kidney damage (10), there is no evidence of any study on heat stress in the injera baking industry in Ethiopia. Most studies have focused on agricultural workers and other industrial processes, such as sugar and metal factories (12–15). The lack of evidence regarding heat exposure of injera bakers limits focused interventions, which draws attention to the need for investigations that can provide both health benefits and enhanced working conditions.

**Statement of the Problem**

Globally, the incidence of heat exposure and its related effects has increased. Between 2000–2004 and 2017–2022, heat-related deaths among people aged 65 and above rose by approximately 85% (16). Additionally, from 2000 to 2016, an extra ~125 million people were exposed to heatwaves, illustrating the increasing significance of heat stress as a public health problem (17).

The risk of occupational heat stress is expected to rise significantly in middle- and low-income regions within tropical and subtropical areas, where effective control measures may be limited. Heat stress is a serious yet underappreciated occupational health risk in countries like Ethiopia (18). Furthermore, current technology to assess occupational heat stress is not standardized throughout various sectors, hindering the ability to measure exposure accurately.

Despite its critical economic and cultural importance, Injera production remains under-researched, particularly concerning occupational heat stress risks. Injera making, which is a long-duration labor-intensive process, subjects people to sustained high temperatures from repeated oven operation (11). In Ethiopia, industrial injera baking facilities were currently expanding, like Lemi Injera Baking Centre, where the labor force is almost entirely female and exposed to high temperatures for an extended and strenuous time as an activity. Inadequate primary prevention, lack of awareness of heat stress, and inadequate occupational health resources amplify these risks. Even though similar problems have been recognized in other heat-exposed industries in low- and middle-income countries, the scope of this problem in injera injera-making field in Ethiopia is not well known. The level of exposure for specific heat, heat-related illness burden, and corresponding risk factors has not been sufficiently characterized in detail, thus representing an important knowledge gap.

The purpose of this study is to fill this gap and to explore the heat stress exposure level, prevalence of heat-related illnesses, and related factors among the workers of Lemi Injera Baking Center. By understanding these issues, the study can provide more evidence to inform targeted interventions, raise awareness, and enhance workplace safety and health for this potentially exposed worker.

## Rationale and Significance

### Rationale

In Ethiopia, injera production is more than just culturally important, it is also economically relevant, employing thousands, most of whom are women. But the occupational risks of this field, especially heat stress, are underrepresented.

Existing research on heat stress has predominantly focused on other industrial sectors (10,12,13,19,20), with limited attention given to food processing industries where workers are exposed to prolonged high heat. The Lemi Injera Baking Center, a major sector in Addis Ababa's food industry, serves a community and different institutions such as Addis Ababa University, Bole International Airport, a skylight hotel, a community, and others. By conducting a comprehensive assessment of heat stress exposure levels, heat-related illness and associated factors among workers, this study will provide critical data that can inform public health policies and workplace safety regulations.

### Significance

This research is significant for several reasons. To begin with, it will help to fill an important gap in the existing body of knowledge on occupational health and safety in Ethiopia, more specifically in food processing sector. The results will empirically determine the prevalence of heat-related illness and heat stress level in injera bakers and this will also contribute information currently unavailable in the literature.

Second, the findings of the study will have direct relevance to enhancing workplace safety. Identifying the direct factors contributing to heat stress in Injera baking units, the study will permit the formulation of specific interventions, such as worker education programs, and policy recommendations for safer working conditions.

Last, the study will help the primary goal of the health and well-being of the staff and will serve as a reference for future research and health care in both Ethiopia and other countries facing similar occupational health concerns.

# LITERATURE REVIEW

## 1. Occupational Heat Stress

The World Health Organization considers heat as an important environmental as well as workplace health hazard. It is the primary cause of weather-related death and can worsen pre-existing illnesses like heart disease, diabetes, psychological disorders, and asthma (21).

Heat stress-caused disorders are on the list of 35 occupational diseases that are mandatory to report in the context of the Workplace Safety and Health (WSH) Act (22). It can produce complex health consequences from mild illnesses like heat exhaustion, heat edema, heat rash, cramps, and syncope to extreme situations of heat stroke, a critical life-threatening state (23,24). Sometimes, heat stress may even kill life (21). Certain physiological changes like dehydration, thermoregulatory dysfunction, and cardiovascular stress have been confirmed in association with heat stress in the workplace (21,25). The results revealed that heat stress exposure had a notable effect on blood parameters, heart rate, and body temperature among other physiological parameters (20).

Apart from the health consequences, heat stress also negatively harms productivity. Evidence is showing that heat stress is not only a health concern but an economic issue too (26). It has also been found that workers frequently subjected to higher heat tend to feel fatigued, have diminished cognitive output, as well as low productivity (27). A meta-analysis estimated a workers will decline by 30% of productivity during heat stress conditions. Productivity decreases by approximately 2.6% for every degree rise above 24 °C WBGT (28). Additional factors contributing to productivity loss include a lack of workplace policies to ensure safety, such as increased break times (29), and sick leave due to occupational injuries (30). Projections by the WHO forecast that due to the effects of overheating, about a million working life years will be lost by 2030, coupled with a further 70 million working life years lost as a consequence of lowered productivity, which illustrates the grave impacts of heat on the global workforce and economies (31). Studies found a strong correlation between heat stress and decreased productivity, as well as higher injury rates due to worker fatigue (32,33).

## 2. Prevalence of Heat-Related Illness (HRI) and Its Measurement

The global prevalence of HRIs is on the rise, driven by increasing temperatures and the frequency of heat waves. A significant increase in HRIs has been documented over 33,000 cases reported among U.S veterans from 2002 to 2019, indicating a growing trend (34). Every year, approximately 489,000 people die from heat-related illnesses, and 45% of these morbidities are found in Asia and 36% in Europe (35).

A study conducted in Iran showed that the prevalence of heat-related illness among workers in the oven workstation was 80.2% (36). A study in India found high prevalence rates of heavy sweating, which is among the primary symptoms of heat-related illness common to worker populations in both iron foundries and ceramic industries (87.2%). Highlighting the significant impact of heat exposure in industrial settings (37).

A study in the Lebanese baking industry showed bakery workers were at high risk of HRIs. This is due to their prolonged exposure to high-heat levels. And also, emphasized the need for enhanced occupational health measures to protect workers in such high-heat environments (38). A study in Assiut City, Egypt, demonstrated that 23% of cases of heat exhaustion, 17% of cases of heat cramps, and 5% of cases of heat stroke were recorded in bakery workers out of 100 subjects, who were chosen randomly from 20 bakery stations (39). In Nigeria, the study found that bakery workers in Makurdi metropolis are highly exposed to heat stress and are likely to experience one disorder or the other, with possible consequences (40).

According to Ethiopian studies, HRIs are very commonly found in workers in different types of work. The study in the Metahara and Wonji Shoa sugar factories found 74.6% of workers reporting HRIs, including symptoms of generalized sweating (98.3%), and dehydration (98%) (13). Similarly, in Gonder city, 67.1% of kitchen hospitality workers reported heat-stress symptoms over six months, with sweating as a prominent symptom reported (10). In addition, a study of steel and aluminum factories near Addis Ababa found that 83.9% and 85.3% of workers reported HRIs, respectively (19,20). These findings illustrate the pervasive effect of occupational heat exposure in different sectors in Ethiopia. The consistently high prevalence proportion of heat-related morbidities in this body of work is likely due to the potential hazards in the industrial environment, specifically in countries such as Ethiopia, where safety-related measures on occupational safety may not be adequately enforced.

The ways of assessing HRI vary across studies, reflecting differences in research settings, populations, and clinical focus. In Ethiopia, a commonly used approach by the researcher involves self-reported symptoms. I this method, individuals are considered to have experienced HRI if they report at least four of the following symptoms: sweating, thirst, muscle cramps, exhaustion, fainting, excessive tiredness, weakness or dizziness, headache, nausea or vomiting, and prickly heat or rashes, particularly during hot seasons (13,19). Other studies have used simplified tools that include a yes/no checklist of symptoms such as dizziness, sudden muscle cramps, hot and dry skin, nausea or vomiting, confusion, and fainting during work in extreme heat; the presence of at least one symptom qualifies as a positive case (41).

The other aspect is a clinical one, which categorizes HRIs by severity. “Mild HRIs” include heat edema, heat cramps, and heat rash. “Moderate HRIs” include heat syncope and heat exhaustion are characterized by symptoms like nausea, dizziness, headache, and rapid heartbeat, often caused by fluid and electrolyte imbalance. The most “severe HRIs” (heat stroke) is a medical emergency manifested by high body temperature, confusion, delirium, seizures, or coma, and potentially leads to multi-organ failure (42,43).

## Factors Contributing to Heat Stress in the Workplace

### 2.1. Environmental factors

Environmental factors are the direct contributors to exposure to workplace heat (44). Low wind speed impairs the resilience to low temperatures, especially in confined work places where air exchange is scarce, leading to increased convective heat buildup. Also, humidity hinders the evaporation of sweat, the main body cooling process, and thus hot, humid conditions pose a greater risk than hot, dry ones. Elevated air temperature further worsens the body, especially in association with radiative exposure (45,46). In workplaces like baking centers, radiant thermal exposure from ovens is a substantial part of the total heat load, particularly when there is no effective heat shielding (47). HRI incident reports between 1984 and 2020 showed that HRIs were highly influenced by season and time of day, with 77% of incidents in the summer months and 64.1% between 11 am and 5 pm (48). These factors magnify the risks of heat strain and must be carefully monitored to protect worker health.

### 2.2. Organizational factors

Organizational factors are of major importance for the control or exacerbation of heat stress hazards. Strong organizational policies are essential in preventing heat stress (21). Managers who monitor environmental conditions, provide training on heat management, and offer access to cooling areas and regular breaks can significantly reduce the rates of heat-related illnesses (49). Findings have shown that workplaces with proactive heat stress management programs experience far fewer HRIs than those without such protocols (50). Workplace design, especially in poorly ventilated, small facilities or facilities without heat barriers, can make heat stress more severe. Poor access to preventive interventions such as clean drinking water, breaks, and shade exacerbates the ability of workers to cope with heat stress. Work schedules are another vital aspect; workplaces operating during peak heat hours subject workers to extreme thermal stress, which could be mitigated by shifting tasks to early morning or evening hours (49,51–53).

### 2.3. Personal factors

Individual factors are also a factor for worker thermoregulatory vulnerability to heat stress. In particular, hydration status is important as it enhances the thermoregulatory capability and the risk of heat-related illnesses (24,53,54). Other physiological factors, such as age and sex, also play a role, with older workers and women often experiencing reduced heat tolerance (53,55). Moreover, body weight can increase heat strain as overweight individuals tend to produce more metabolic heat while having reduced heat dissipation capacity (56,57). Conversely, heat vulnerability is increased by the health status, because people with underlying diseases such as cardiovascular diseases, diabetes, or respiratory diseases are not as well equipped to maintain temperature control of the body core (21). Pregnant women are particularly at risk, as heat stress can have adverse effects on maternal and fetal health by increasing the risk of miscarriage and the development of complicated health problems (58). Additionally, the level of acclimatization to heat exposure is crucial; workers not adequately exposed to high-heat environments are more prone to developing heat stress symptoms (59).

### 2.4.Behavioral factors

Behavioral factors influence heat stress risk. Wearing non-permeable clothing and PPE can cause a thermal buildup, thus hindering the dissipation of body heat (20,60). Lightweight, air-permeable clothing is critical to reducing heat stress in hot environments. Individual behaviors, such as alcohol use and smoking, are also involved in the generation of heat vulnerability; alcohol, by a consequence of dehydration, compromises thermoregulation, and smoking reduces cardiovascular efficiency, making it more difficult to manage thermal burden (13). Among iron foundry and bottling plant workers in Malaysia, 35% of those consuming less than 3 L of water reported experiencing muscle cramps, compared with 5% of the bottling plant workers and consuming greater than 3 L of water 20% and 7%, respectively, for cramp sufferers among those in the two occupational groups this difference was statistically significant (61).

## 3. Standards and Tools used to Measure Heat Stress.

The WBGT meter is generally accepted as an optimum and realistic tool for assessing heat stress in workplaces. It combines various parameters such as air, wind speed, humidity, and radiant heat from machines or the sun (62). In bakery settings, heat stress levels often exceed the ACGIH recommended WBGT threshold limit of 28.5°C and 27.5°C for moderate and heavy work, respectively, indicating a substantial risk to workers' health (63). The work-rest regimen recommends that workers should work 75% and rest 25% per hour to protect them from acute heat stress, as does the wet bulb globe temperature, for which continuous labor for one hour is safe (64). (Table 1)

**Table 1: Threshold limit values of WBGT based on ACGIH standard (WBGT in °C).**

| **Work and rest cycle** | **Acclimatized** | | | | **Unacclimatized** | | | |
|---|---|---|---|---|---|---|---|---|
| | Light | Moderate | Heavy | Very heavy | Light | Moderate | Heavy | Very heavy |
| 100% work | 29.5 | 27.5 | 26 | - | 27.5 | 25 | 22.5 | - |
| 75% work-25% rest | 30.5 | 28.5 | 27.5 | - | 29 | 26.5 | 24.5 | - |
| 50% work-50% rest | 31.5 | 29.5 | 28.5 | 27.5 | 30 | 28 | 26.5 | 25 |
| 25% work-75% rest | 32.5 | 31 | 30 | 29.5 | 31 | 29 | 28 | 26.5 |

For indoor and outdoor settings, the WBGT index is calculated using the formula:
For shaded or indoor $WBGT=0.7T_{nw}+0.3T_g$ (65)

For conditions in direct sun exposure (outdoor) $WBGT=0.7T_{nw}+0.2T_g+0.1T_a$ (66)

Where: $T_{nw}$ is natural wet bulb temperature, $T_g$ is globe temperature, and $T_a$ is air temperature, which is measured using the WBGT tool.

The WBGT was developed and initially implemented in the 1950s as part of an effective effort to combat severe heat illness outbreaks in U.S. Army and Marine Corps training camps (62). Heat measuring instruments are important in the evaluation of the thermal environment in work environments because they provide information on the degree of heat stress to which people are subjected, thereby informing health and safety interventions.
One widely used metric for measuring heat stress is the Wet Bulb Globe Temperature (WBGT) (67), which combines four different factors, like temperature, humidity, radiation, and wind (68). There are many models of WBGT devices, including heat stress monitors like the Ques Temp 34WI, USA, Casella MicroTherm Heat Stress WBGT, Extech HT30 Heat Stress WBGT Meter, and Kestrel 5400 Heat Stress Tracker.

**Ques Temp 34WI, USA** is a portable heat stress monitor that measures dry bulb, wet bulb, and globe temperatures to provide WBGT readings for both indoor and outdoor environments, along with humidity and heat index. It is compatible with standards from ACGIH and the U.S. Navy, making it suitable for industrial and military settings. The device can log data at intervals from 1 to 60 minutes, and supports real-time display. Data can be exported via 3M's Detection Management Software (DMS), and an optional air probe is available to assess airflow for a complete thermal comfort analysis (69) (Fig. 1).


**Figure 1: Wet bulb globe temperature measuring device (Ques Temp 34WI (USA) WBGT)**

The **Casella MicroTherm Heat Stress WBGT** is another widely used instrument for measuring heat stress. It is a scientifically sensitive device designed to avoid exposure to excessive moisture, vibration, or physical impact, due to its precisely manufactured sensors that offer high accuracy, stability, and sensitivity, eliminating the need for frequent calibration. This compact instrument is typically mounted on a tripod but can also be used handheld. It has an LCD graphical interface, real-time monitoring, built-in data logging, low water level alerts, integrated alarms for WBGT thresholds, and others. Also, it supports automated work/rest cycle calculations through laptop software and complies with ISO standards. For optimal accuracy, it is recommended to maintain the device at each measurement site for at least 20 minutes (70) (Fig. 2).


**Figure 2: Casella MicroTherm Heat Stress WBGT.**

The **Extech HT30 Heat Stress WBGT Meter** stands out for its small, all-in-one design that measures air temperature, globe temperature, and humidity without external sensors. It has a built-in black globe sensor, user-settable audible alarms, and displays all key readings simultaneously. This device is an affordable, user-friendly, and good option for quick heat stress monitoring (71) (Fig. 3).


**Figure 3: Heat Stress WBGT Meter Model HT30.**

**Kestrel 5400 Heat Stress Tracker** is an advanced WBGT and environmental monitoring device designed for high-accuracy, real-time heat stress assessment without water-based sensors or bulky equipment. Unlike other WBGT meters, the Kestrel 5400 uses natural wet bulb temperature derived from onboard sensors, offering over 15 environmental measurements, including WBGT, thermal work limit (TWL), wind speed, pressure, and humidity. Built to withstand tough field conditions. It has LiNK Bluetooth connectivity; users can wirelessly track live conditions and export data to mobile devices. The data logging capacity is 10,000+ records (72) (Fig. 4).


**Figure 4: Kestrel 5400 Heat Stress Tracker.**

**4. Heat Stress in the Baking Industry**

There is little research examining the bakery worker population across most studies of the bakery worker population, with a particular emphasis on the respiratory implications of dust exposure from flour under industrial baking conditions (73,74). Other studies have evaluated ergonomic risks, as well as mental and self-reported health among bakery workers (75).

A small number of studies have examined the heat exposure for bakery workers and have reported high heat stress in this population (76). Some research has also compared the working conditions and associated risks between traditional and industrial bakeries, revealing that workers in traditional bakeries experience higher heat stress (77).

## Conceptual Framework

The conceptual framework of this study was developed by synthesizing major variables that affect heat stress and heat-related illness based on the previous studies. It offers an organized way to learn how these variables are related to each other and their role in heat-related illness, to help design specific interventions for the baking sector.

The dependent variable in this framework is heat-related illness, which is the main outcome among four domains of independent variables. Organizational factors (workplace safety rules, ergonomic design of the workplace, drinking water access, rest periods, training) play an important role in workers' exposure and reduction of heat stress. Environmental factors like air temperature, humidity, radiation, and wind speed directly influence the magnitude of the heat stress experienced by the workers. Personal characteristics, such as age, sex, hydration status, acclimatization, body mass, overall health, and pregnancy, influence acute heat stress susceptibility in an individual. Last, behavioral factors (wearing of PPE, smoking, alcohol consumption, and drugs' exposure) can influence the risk of the occurrence of heat-related illness by either increasing or decreasing exposure to the etiologic factors.

This framework highlights the relationship of these factors and their cumulative effect on heat-related illnesses. By offering a clear understanding of these dynamics, the framework provides a foundation for analyzing these relationships and developing interventions to improve working conditions and reduce health risks for workers at the Lemi Injera Baking Center. (Fig. 5)

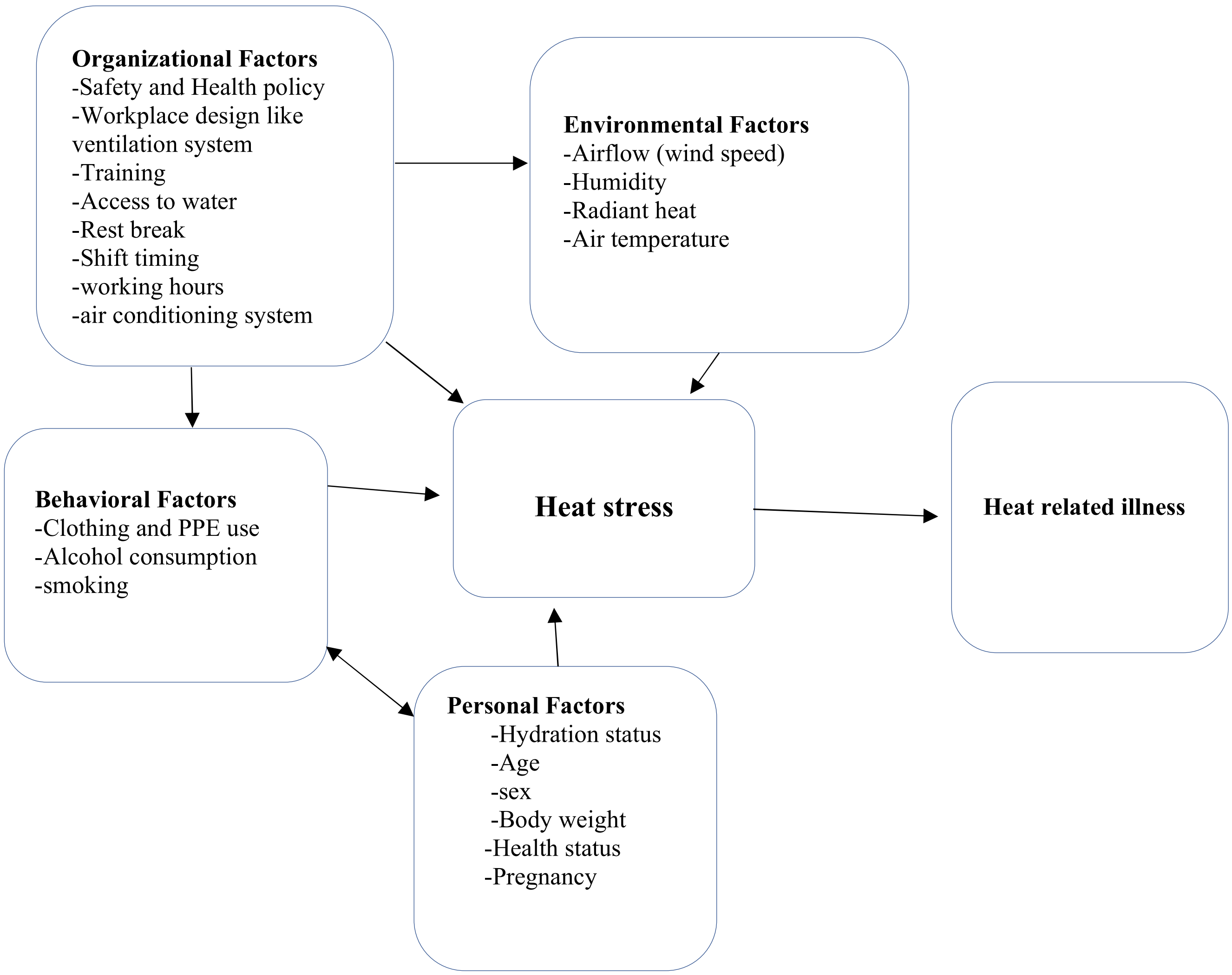


**Figure 5: Conceptual framework on heat-related illness risk factors**(13,78)**.**

## Objectives:

### General Objective

- To assess heat exposure level and heat-related illness among workers in Lemi Injera Baking and Local market centers, Addis Ababa.

### Specific Objectives

- To measure heat exposure level using Wet Bulb Globe Temperature (WBGT) between the work centers.
- To assess the prevalence of heat-related illnesses among workers in Lemi Injera Baking and Local Market centers, Addis Ababa.
- To identify the factors associated with heat-related illness among workers in Lemi Injera Baking and Local Market centers, Addis Ababa.

# Methods

## Study Setting

Addis Ababa, Ethiopia's capital city, located at an altitude of 2,200 to 2,500 m above sea level, is characterized by a temperate climate with annual average temperatures ranging from 9.89°C to 24.64 °C (79). The city is the country's center for socio-economic development, which contributed 38.3% ( $61.2 billion) to the national GDP (80).

The Lemi Injera Baking Centre, which is found in Lemi Kura sub-city, was established in 2023 by the Addis Ababa City Administration. This center specializes in the production of large-scale injera, a kind of Ethiopian food. The shades were made of thick iron sheets. Workstations equipped in shifts with more than 490 employees in a high-temperature work area with multiple high-temperature ovens, with an overall thermal background of a persistently high-heat environment.

The comparative study site is a Local Market Centre in the same sub-city as the main study site. This center houses over 500 workers who prepare and sell a range of products in a shared marketplace. Workers work in an area not exposed to direct sun or other extreme sources of heat, and it is a suitable comparison environment for the study. The shades were made of iron sheets A good part of these workers are mainly women, similar to the socio-demographics of the injera baking workers (age and economic status). The overlaps facilitate a scientifically sound benchmarking of the primary study sample, thereby allowing for valid comparison. A map based on a GIS and an Image of the study area is below. (Fig. 6&7)

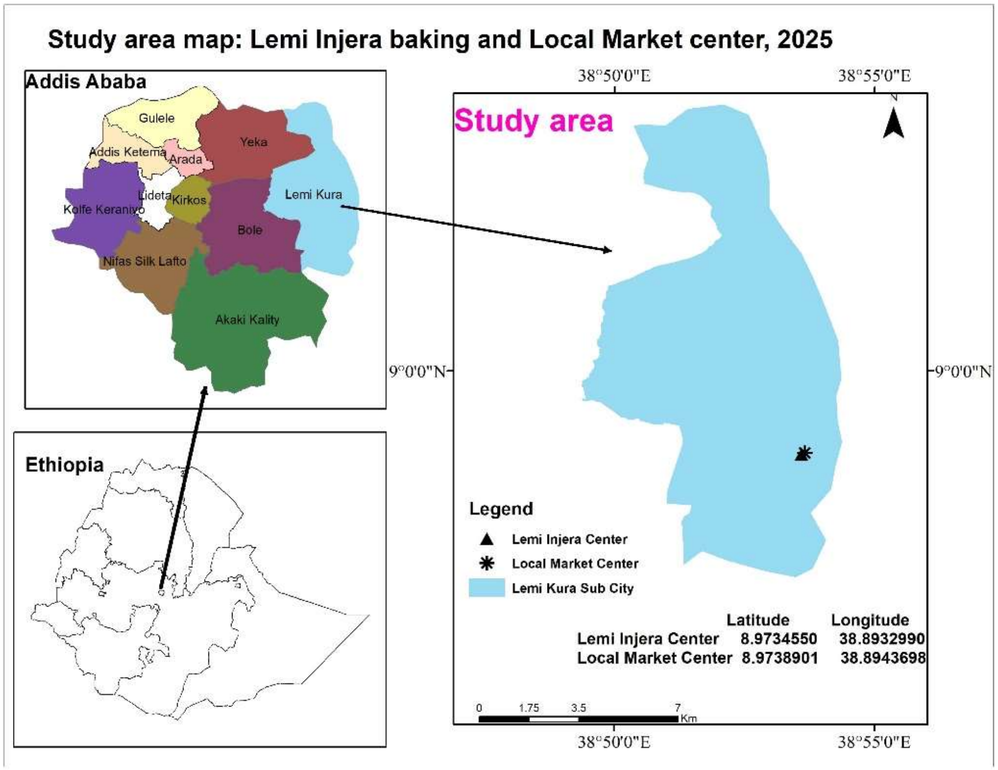


**Figure 6: Study area: Map of Baking and Local Market, Lemi Kura, Addis Ababa**


**Figure 7: Study area: Image of Baking and Local Market, Lemi Kura, Addis Ababa.**

**The workflow of the injera baking**

Production starts with the collection of teff, which is cleaned, sifted, and milled into fine flour. The flour is processed with water to a batter (locally called *Lit*), which ferments for 3 to 4 days to give injera the characteristic sour taste.

The process of baking injera on a griddle begins with cleaning and smoothing the griddle surface using mashed spinach seeds. After that batter(*Lit*) is poured onto the griddle circularly, which is subsequently covered with a griddle lid to ensure even baking. After the injera is baked, the griddle lid is removed, and the injera is carefully lifted from the griddle. It is then stored appropriately and prepared for distribution to customers. By this systematic procedure, it guarantees standardization of quality and freshness, and the facility provides an ideal setting for studying heat stress due to the continuous exposure of workers to elevated temperatures (Fig. 8).


**Figure 8: Image showing steps of injera baking: Lemi Injera baking room.**

### Study Design

A comparative cross-sectional study was applied to determine the level of heat exposure and HRI among workers at Lemi Injera Baking and Local Market Centers in Addis Ababa. With this design, it was possible to compare heat stress levels and HRIs between Injera baking and Market workers.

### Study Period

Data collection was conducted from February 17 to March 2, 2025.

### Source population

The source population includes all bakers from the Lemi Injera Baking Center. A similar source population from the Local Market includes all women workers working in a nearby market locality with similar sociodemographic variables, but not subjected to the effect of heat stress.

### Study Population

The study population for this research consists of all baking workforces selected at the Lemi Injera Baking Center who experience heat stress challenges. A matched group was also selected from the Local Market workers in the nearby location.

### Inclusion and Exclusion Criteria

#### Inclusion Criteria

**For both groups**

- Only women aged above 18 years, because men are not engaged in a baking activity.

#### Exclusion Criteria

**For Both Groups**

- Pregnant women.
- Aged 60 years and above, because they are more susceptible to heat stress.

**For Minimarket workers**: Those who have a history of engagement in heat-intensive job.

**Sample Size Determination**

**For the 1st objective:** To measure the heat stress level using the Wet Bulb Globe Temperature (WBGT) in the working environments.

The study measured heat stress levels for a total of five days (4 days at the baking center (2-day time shift and 2-night time shift and 1 day at the market center). It was assessed at a representative point at both sites (*Figs 9 and 10*). Measurement was conducted using WBGT, Ques Temp 34WI, USA monitor by a trained professional for a minimum of 8 hours per day from 8 AM to 5 PM daytime and 8 PM to 5 AM nighttime. Heat levels were measured in the Injera baking area where employees are stationed during their shifts (both day and night) over two days for each shift, to capture variations between different days. Measurements were taken at a height of 1.1m, and positioned approximately 20 centimeters away from the *'mitad',* ensuring proximity without interfering with work activities.


**Figure 9: WBGT placement in the Injera Baking area.**


**Figure 10: WBGT placement in the Local Market area**

**For the 2nd objective:** To compare the prevalence of heat-related illnesses among worker sites. The sample size for this work was determined by the double population proportion formula under the assumption of a 10% difference between bakers and the control group's prevalence of heat-related illness. Because there is no similar comparative cross-sectional study among Bakers and other similar work settings. An Egyptian study of baker workers in Assiut City reported that 45% presented with heat-related illnesses (39). The study design involves a 95% confidence interval and 90% power to guarantee reproducible and strong outcomes.

We use the following sample size formula for two independent proportions:

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

**Where:**

**n:** The sample size required for each group to detect a statistically significant difference.

**Zα/2:** The Z-score corresponding to the desired confidence level (95% in this case) ($Z\alpha/2=1.96$)

**Zβ**: The Z-score corresponding to the desired statistical power (90% in this case, $Z\beta=1.28$)

**P1**: The proportion of HRIs for bakery workers (45% or 0.45.

**P2:** The estimated proportion of HRIs for the control group (35% or 0.35.

**P1−P2:** The difference between the two proportions.

$$n = \frac{(1.96 + 1.28)^2 * (0.45(1 - 0.45) + 0.35\ (1 - 0.35))}{(0.45 - 0.35)^2}$$

$$n = \frac{10.5*0.056}{0.01} = \frac{0.6}{0.01} = 60$$

For each group, we would need 60 participants with 95% confidence and 90% power **.**

Adjustment for non-response**:** we expect a 10% non-response rate adjusted sample size is 66. Therefore, the total sample size for both groups is 172, which is very small.

**For the 3rd objective:** To identify the factors associated with heat-related illness among workers. The sample size was estimated based on a two-population proportion formula. This calculation was based on the results of a study done in Gonder city on heat stress among kitchen workers, which investigated the association between the prevalence of the ventilation system and frequency of heat stress symptoms. In this study, heat stress symptoms were found to be prevalent in 61.2% of workers who were working in the area with a ventilation system, compared to 78.2% among those working in the area with no ventilation system (10). The calculation assumes a 95% confidence interval and 90% power to guarantee statistically significant and reliable study results.

$$n = \frac{\left((Z\frac{\alpha}{2}+Z\beta\right)^2 \cdot (p1(1-p1)+p2(1-p2))}{(p1-p\ \ )^2} = \frac{((10.4976)*(0.17+0.24))}{0.03} = \frac{4.3}{0.03} = \mathbf{143.3 \sim 144}$$

**Where**:

**n** = required sample size per group

**P1** = proportion of heat stress symptoms among workers working in an area without a ventilation system (P1 = 0.782 or 78.2%

**P2** = proportion of heat stress symptoms among workers working in the area with a ventilation system (P2 = 0.612 or 61.2%)

**Zα/2** =Z-score for the desired confidence level (typically 1.96 for 95% confidence)

**Zβ**: The Z-score corresponding to the desired statistical power (90% in this case, Zβ=1.28)

**P1−P2**: The difference between the two proportions.

For each group, we would need 144 participants or 288 participants for both groups.

Adjustment for non-response: We expect a 10% non-response rate.

Adjusted sample size =159 participants per group, or 318 participants in total

Since the sample size required for Objective 1 (n=172) is smaller than that of Objective 2 (n=318), we used the largest sample size from Objective 2 to cover both objectives. ***Therefore, the final sample size ($n_{final}$) was 318 participants in total, with 159 participants in each group.***

**Sampling procedure**

In this study, the total workforce of the Lemi Injera Baking and Market Centers was 490 and 500 workers, respectively. Up to 159 employees were randomly drawn from Injera Baking Center. Additionally, 159 individuals were randomly selected from a reference population not engaged in heat-intensive occupations. With this, the total number of study subjects becomes 318 people (Fig 11).

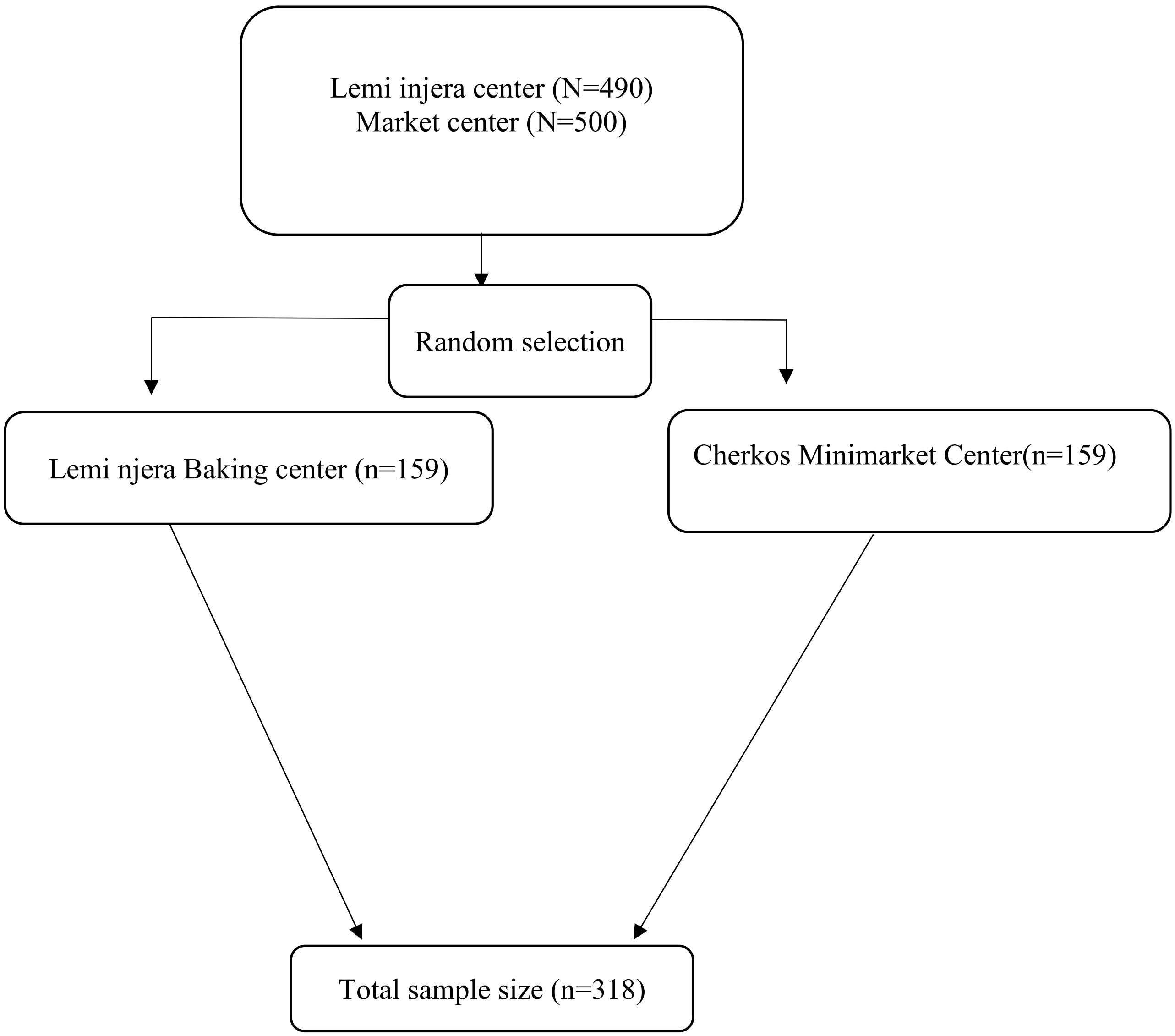


**Figure 11: Sampling procedure of samples from the study population.**

**Data Collection**

The data collection process involved a combination of environmental monitoring, self-reported surveys, and observation of work sites to comprehensively assess heat exposure and its effects on workers in both the injera baking center and the comparison group. A detailed Standard Operating Procedure (SOP) guided the use of the Wet Bulb Globe Thermometer, ensuring consistency and accuracy in measuring heat stress.

**Environmental Monitoring using WBGT:** Heat exposure levels in both working environments were measured using the WBGT instrument: Ques Temp 34WI, USA, is a widely recognized instrument for assessing heat stress in occupational settings. This approach ensures more robust data collection and enhances confidence in the findings for better decision-making. The WBGT provides reliable data on ambient temperatures, humidity, air movement, and radiant heat in work environments (62). Heat exposure measurements were taken at the working centers to capture variations across locations by a trained professional. In each WBGT measurement of the work area, the following SOPs were followed.

**Procedures for WBGT Measurement:** To operate the WBGT instrument, start by pressing the ON/OFF button to turn it on and allow it to warm up for 5 to 10 minutes. Calibrate the instrument before use. Prepare the wet bulb by wetting its wick and filling the reservoir with distilled or de-ionized water, ensuring the wick is clean and only distilled water is used. Place the instrument approximately 1.1 meters (for standing individuals) above the ground in the work area. Check the battery and replace or recharge it if the voltage is 6.4 volts or lower. Allow the sensors to stabilize for 10 minutes before pressing the Run/Stop key to begin data logging. Use the Up/Down Arrow keys to view the desired measurements. Finally, download the data using Detection Management Software (DMS) (69,82).

**Questionnaire**: Survey data was collected using interviewer-administered structured questionnaires (a modified version of the HOTHAPS questionnaire (83)) through the Kobo Toolbox, ensuring efficient and accurate data collection. Three trained health professionals, each holding a Bachelor of Science degree, conducted the interviews. The surveys gathered self-reported information on sociodemographic, heat-related health issues, working conditions, and coping strategies. These interviews provided valuable insights into the workers' experiences and perceptions of heat-related risks.

**Observational Checklist:** An observational checklist was utilized to assess the use of personal protective equipment (PPE), the availability and accessibility of water, showers, and the working environment, particularly focusing on ventilation.

**Operational Definitions**

**Self-reported heat-related illness:** Workers who reported at least four of the following symptoms: excessive sweating, fatigue, cramping in the muscles, headache, skin color change/rashes, nausea/vomiting, weakness/dizziness, and fainting, especially during hot times of work (13,19,20).

**Acclimatization:** The body's adaptation to repeated heat exposure reduces strain and improves effectiveness, with a lower risk of heat injury (33,78).

**Heat Stress**: Heat stress refers to the total heat load experienced by an individual, resulting from environmental and metabolic heat generated by physical activity(78,84). In this study, heat stress was categorized and evaluated using the Wet Bulb Globe Temperature (WBGT), according to the guidelines of the American Conference of Governmental Industrial Hygienists (ACGIH). The WBGT threshold limit values are set at 27.5°C for heavy workloads and 28.5°C for moderate workloads (64).

**Water access**: workers who have adequate water access near to work area <3 minutes walking distance (85).

**Clothing**: workers who dressed in thick clothes (by summation: underwear with short sleeves and legs, shirt, trousers, and a heavy quilted outer jacket) (86).

**Chronic illness:** Conditions lasting ≥1 year, requiring ongoing care, limiting daily activities, or both, e.g., heart, lung, musculoskeletal diseases, type 2 diabetes, dementia, and cancer (87).

**Heat Exhaustion:** Manifested by Headache, nausea, vomiting, weakness and fatigue, Dizziness or light-headedness, Moist and pale skin, Rapid heart rate and breathing, irritability (51).

**Heat Cramp:** Muscle spasms due to excessive sweating and low salt intake, mainly affecting the arms, hands, legs, and feet(78).

**Heat Stroke:** A severe medical emergency caused by extreme heat, leading to a body temperature above 41.1°C (106°F), fainting, and failure of the body's temperature regulation(78,88).

**Heat Syncope**: Fainting or collapse during heat exposure without a rise in body temperature or stopping of sweating, similar to vasovagal fainting but triggered by heat (78).

**Heat Rash:** Workers report symptoms of red clusters of pimples appearing on the neck, chest, and elbows, commonly referred to as heat rash or prickly heat (78,89).

**Light Workload**: This includes workers who are mostly sitting or standing to monitor equipment or perform simple hand or arm tasks (19).

**Moderate Workload**: This applies to workers who are walking while doing moderate lifting, pushing, or pulling. It could also involve walking at a steady pace or tasks like scrubbing while standing (19).

**Heavy Workload:** This category includes workers who perform physically demanding tasks like carrying or moving heavy loads (19).

**Sufficient rest break:** is total rest time (excluding bathroom use) during a shift: ≥60 minutes for up to 8 hours, ≥75 minutes for 8–10 hours, and ≥90 minutes for 10–12 hours. Workers below these thresholds are considered to have insufficient rest.

**Data Management**

The primary data is collected through measurement, observation, and face-to-face interviews. Supervision and necessary interventions were made by the Advisor and investigator. The data entry was managed through a secure database with regular error and completeness checks and daily discussions with data collectors. Kobo Toolbox (ODK) is used for real-time data entry and monitoring. Data was stored securely with regular backups and access restricted to authorized personnel.

Data cleaning, coding, and analysis were conducted using SPSS version 26. From logistic regression, first, bivariate analysis was done, which means every independent variable was computed with the dependent variable by identifying the reference category for each categorical variable. Secondly, a collinearity test was done for the variables with a p-value $< 0.2$, and then variables with a Variance Inflation Factor (VIF) above 5 were excluded from multivariable analysis to address multicollinearity. The final model (multivariable analysis) assessed independent associations, with significance set at $p < 0.05$. Then the data was interpreted and analyzed to produce research findings.

WBGT data were transferred to a desktop via a portable cable and managed using detection software to export measurements. Recorded parameters included dry bulb, wet bulb, globe temperature, relative humidity, and WBGT.

**Data Analysis**

**First Specific Objective** (To measure the heat stress level using the WBGT meter in the working environments): The aggregated WBGT values at each site were calculated averages and were used in comparison to occupational health standards to determine if the heat levels at the bakery center of rising above the permitted safety levels. Also, the mean WBGT among the baking center and the market was compared to quantify the intensity of heat stress in the heat-exposed environment. This analysis provided a clear assessment of the thermal risk posed to workers.

**Second Specific Objective** (To compare the prevalence of heat-related illnesses among workers in Lemi Injera Baking and Local Market Centers): The descriptive statistic was done separately for each sample. For every workplace, frequency tables were applied to estimate the number of workers who reported symptoms related to heat stress. Second, the prevalence of these diseases was calculated as a proportion of the total population in each group.

**Third Specific Objective** (To identify the factors associated with heat-related illness among workers in Lemi Injera Baking and Local Market centers): Using bivariate and multivariable analysis, the contributors to heat-related illness in workers of both the heat-exposed and non-heat-exposed groups were investigated. Initially, bivariate analysis was examined for each independent variable with the presence of the dependent variable (heat-related illnesses) within each group. Factors with a p-value of $< 0.2$ in this bivariate analysis were considered for inclusion in the multivariable model, ensuring that potentially important variables are not excluded prematurely after doing a collinearity test (factors with VIF>5 were excluded). In the multivariable logistic regression, it assesses the independent effect of each factor on heat-related illness while controlling for confounders, using a cutoff of $p< 0.05$.

### Data Quality Assurance

To ensure the reliability, validity, and consistency of the data collected through multiple sources such as WBGT environmental monitoring, questionnaire surveys, and direct observations, a comprehensive data quality assurance protocol was implemented before the start of data collection. The WBGT instrument (Ques Temp 34WI, USA) was calibrated according to the manufacturer's instructions using a standard calibrator. The individual was trained on SOPs covering device handling, calibration, settings, and accurate data recording.

Training was provided for three health professionals, who collected the survey data. A pretest was performed for a questionnaire to assess the clarity and relevance, which was adapted from the HOTHAPS questionnaire. Changes were made based on pretest findings. It was translated into local languages for the interview and exported into English for analysis.

Regarding observational data, a standardized checklist was used to evaluate workplace conditions such as PPE use, ventilation, and water availability.

Daily data reviews, field supervision, and the use of digital tools supported real-time quality control, helping to ensure accurate and complete data across all components of the study.

## Ethical Considerations

This study was conducted following the ethical guidelines of the Addis Ababa University School of Public Health Ethics Review Committee (AAU SPH REC). Ethical clearance was also obtained from the Addis Ababa Health Bureau. Informed consent was secured from all study participants verbally, which covered the details of the aims, methodology, potential risks, and benefits of the study. Participant privacy was strictly preserved. Those with health problems were linked to nearby health centers for better checkups. The data were securely stored. The study was reviewed by an ethics committee to maintain adherence to all ethical protocols and standards.

### Dissemination of Findings

The findings of this study will be made available through several dissemination channels to achieve maximum reach and impact. Results will be further shared at AAU SPH, Addis Ababa Health Bureau, and published in peer-reviewed journals related to occupational health and safety. A thesis summary report will be shared with the stakeholders (Lemi Injera Baking Centre, MoLSA, and the Federal Minister of Health). Finally, the findings will be communicated to policymakers to inform future interventions and policies regarding heat stress management.

## Results

### 1. Socio-demographic characteristics data of workers.

Of the total (318) study participants, 309 (97.2%) respondents participated in the study. Among these participants, 154(49.8%) were from the injera baking and 155 (50.2%) were from the Local market center. All participants were female for both groups. The mean age was 37.28±7.44 for the participants from Injera Baking and 38.26±8.40 for the participants from Local Market. Among the study participants, 155 (50.2%) had at least a primary education. 226 (73.1%) of participants were married. The overall socio-demographic variables were relatively similar between both work centers with no significant difference (all variable have p-value of 0.5 and above) (Table 2).

**Table 2:** Socio-demographic and individual characteristics of Injera baking and Market center respondents.

| Variable | Categories | Work center | | Total | P- |
|---|---|---|---|---|---|
| | | Injera Baking (n=154) | Local market (n=155) | **(N=309)** | **value** |
| Age category | 20-34 | 55 (35.7%) | 55 (35.5%) | 110 (35.6%) | |
| | 35-44 | 69 (44.8%) | 59 (38%) | 128 (41.4%) | 0.3 |
| | >=45 | 30 (19.5%) | 41 (26.5%) | 71 (23%) | |
| Educational Level | No formal education | 42 (27.3%) | 40 (25.8%) | 82 (26.5%) | |
| | Primary education | 110 (55.2%) | 70 (45.2%) | 155 (50.2%) | |
| | Secondary and above | 27 (17.5%) | 45 (29.0%) | 72 (23.3%) | 0.05 |
| Marital Status | Single | 9 (5.8%) | 17 (11%) | 26 (8.4%) | |
| | Married | 120 (77.9%) | 106 (68.4%) | 226 (73.1%) | |
| | Divorced | 17 (11%) | 16 (10.3%) | 33 (10.7%) | 0.11 |
| | Widowed | 8 (5.2%) | 16 (10.3%) | 24 (7.8%) | |

### 2. WBGT-based heat exposure measurement

Wet Bulb Globe Temperature levels were assessed at both work sites (an Injera Baking Center and a Local Market) to evaluate occupational heat exposure during working hours. The mean±SD WBGT during working hours at the Baking Center was significantly higher at 26.4 ± 3.7°C compared to 18.6 ± 2.6°C in the control group ($P < 0.05$) (Table 3).

**Table 3: Summary of environmental WBGT measurements in the work area.**

| Work center | WBGT (°C) | | | | |
|---|---|---|---|---|---|
| | Minimum | Maximum | Mean | Std. Deviation | Median |
| Injera Baking Center | 20.8 | 32.4 | 26.4 | 3.7 | 25 |
| Local Market Center | 13 | 22 | 18.6 | 2.6 | 19.5 |

At the Baking Center, during the day shift, WBGT levels rose steadily from 20.8°C at 8 AM to a peak of 32.4°C at 11 AM. After a slight decrease to 32.3°C at noon, levels dropped more notably at 1 PM, when injera baking activity was inactive. Then after WBGT increased again to 31.1°C at 3 PM, before gradually declined to 25.2°C by 5 PM. Generally, these values are beyond the international standard TLV for moderate work (ACGIH) from 10:00 AM to 4:00 PM. The reference area WBGT showed consistently lower values, ranging from 13°C at 8 AM to a peak of 22°C at 1 PM, with more gradual changes than the Baking Center. The figure indicates generally lower heat stress at the Local Market Center during the day (Fig. 12).

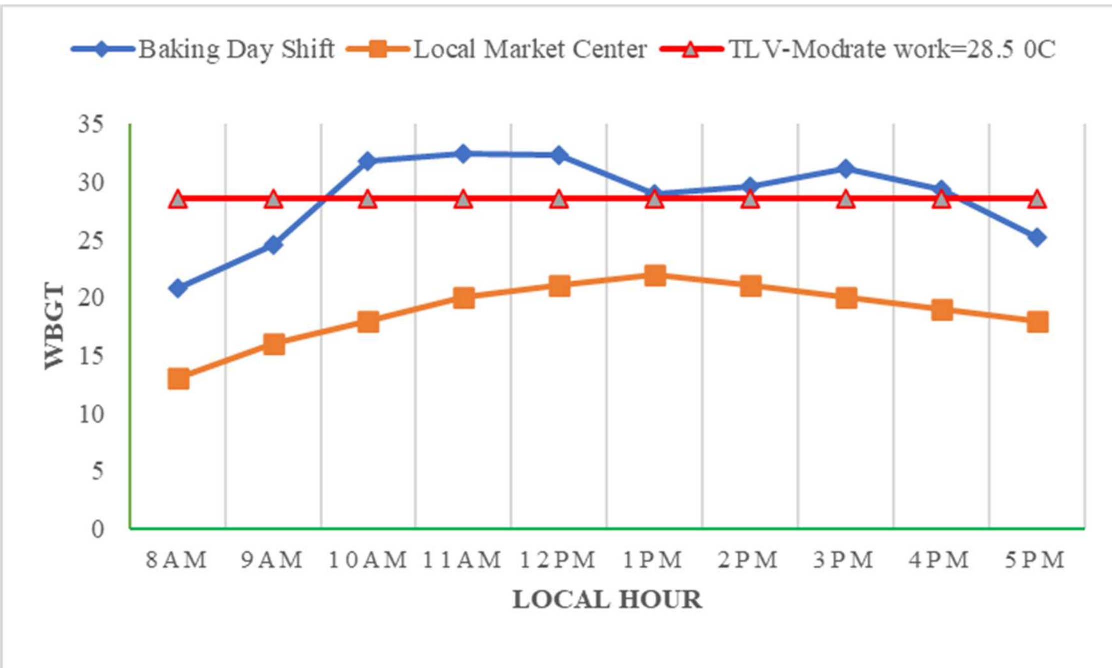


**Figure 12: Hourly average WBGT in both work centers (**TLV: Threshold limit value**).**

During the night shift, WBGT levels increased from 8 PM and 10 PM, reaching a peak of 27.4°C at 10 PM, when the baking activity was at fast with full staff. The lowest WBGT, 21.3°C, was recorded at midnight when injera baking activity was stopped. After midnight, WBGT increased again until 3 AM as baking resumed, followed by a gradual decrease (Fig. 13).

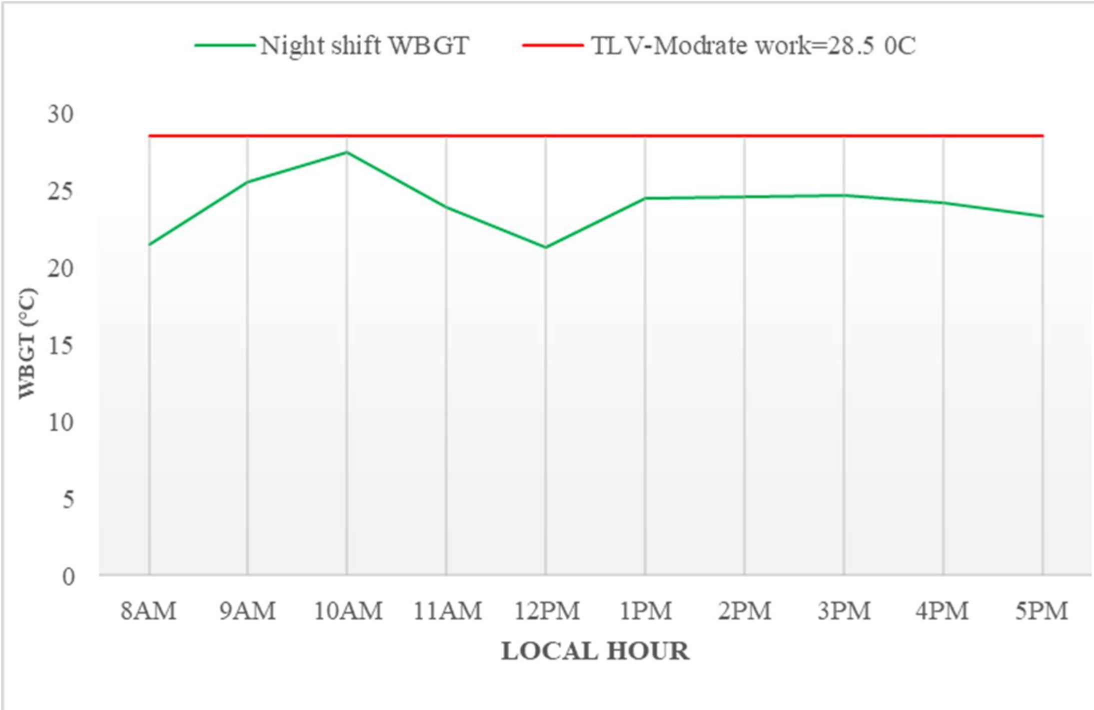


**Figure 13: Hourly trend of WBGT in Baking Center (**TLV: Threshold limit value**).**

### 3. Prevalence of heat-related illnesses and self-reported symptoms

Heat-related illnesses were significantly higher among Injera Baking workers (46.1%; 95% CI: 38.2%-54.0 %) than Local Market workers (9.7%; 95% CI: 5.0%-14.4%) (Table 4).

**Table 4: Prevalence of heat-related illnesses by work group.**

| | **HRIs (at least 4 symptoms)** | |
|---|---|---|
| **Work group** | Yes (%) | No (%) |
| Injera Baking center(n=154) | 71 (46.1) | 83 (53.9) |
| Market center (n=154) | 15 (9.7) | 140 (90.3) |
| Total | 86 (27.8) | 223 (72.2) |

Self-reported heat-related symptoms were significantly more prevalent among Injera bakers (n=154) than local market workers (n=155). 85.7% and 80.5% of workers in the baking center self-reported excessive sweating and fatigue, respectively. While from a local market, 28.4% and 49.7% of workers self-reported excessive sweating and fatigue, respectively. In baking, the above symptoms were followed by higher rates of muscle cramps, headaches, nausea, dizziness, rapid heartbeat, and confusion. Fainting occurred only among Injera bakers (6.5%). These findings indicate greater heat exposure and health risks in the Injera baking occupation (Table 5).

**Table 5: Prevalence of self-reported Heat-Related Symptoms among study participants.**

| ***Symptoms*** | ***Injera Baking (n=154)*** | ***Local market center (n=155)*** |
|---|---|---|
| Excessive Sweating | 132 (85.7%) | 44 (28.4%) |
| Fatigue/Exhaustion | 124 (80.5%) | 77 (49.7%) |
| Muscle Cramps | 66 (42.9%) | 11 (7.1%) |
| Headache | 71 (46.1%) | 19 (12.3%) |
| Nausea/Vomiting | 53 (34.4%) | 13 (8.4%) |
| Dizziness | 24 (15.6%) | 15 (9.7%) |
| Rapid Heartbeat | 41 (26.6%) | 10 (6.5%) |
| Confusion | 21 (13.6%) | 2 (1.3%) |
| Fainting | 10 (6.5%) | 0 |

## 4. Bivariate Logistic regression analysis

Based on the result of bivariate logistic regression analysis, variables with p-value less than 0.2 includes educational status, level of monthly income, work group, type of work, working hour, type of work, availability of cooling fans, availability of cold drinking water, availability of sufficient break time, availability of cool work station, work clothing, and water intake. These variables were prioritized for further analysis, so as not to lose important variables. On the other hand, variables with p-values 0.2 and above, indicating a weaker association with the outcome variable, were excluded, including age, marital status, body mass index, blood pressure, and having a previous job. These variables were not considered for further analysis at this stage. (Table 6&7)

**Table 6: Socio-Demographic Characteristics and Physical Factors.**

| Variables | Category | HRIs (%) | | COR (95% CI) | P-value |
|---|---|---|---|---|---|
| | | Yes | No | | |
| Age-group | 20-34 | 55 (35.7%) | 55 (35.5%) | 1.00 | |
| | 35-44 | 69 (44.8%) | 59 (38%) | 1.4 (0.76-2.44) | |
| | >=45 | 30 (19.5%) | 41 (26.5%) | 1.5 (0.74-2.83) | 0.466 |
| Educational status | No formal education | 24 (29.3%) | 58 (70.7%) | 2.30 (1.03-5.10) | |
| | Primary education | 51 (32.9%) | 104 (67.1%) | 2.719(1.318-5.610) | 0.025* |
| | Secondary education and above | 11 (15.3%) | 61 (84.7% | 1.00 | |
| Marital status | Single | 6 (23.1%) | 20 (76.9%) | 1.00 | |
| | Married | 62 (27.4%) | 164 (72.6%) | 1.26 (0.48-3.28) | |
| | Divorced | 12 (36.4%) | 21 (63.6%) | 1.91(0.60-6.05) | |
| | Widowed | 6 (25.0%) | 18 (75.0%) | 1.11 (0.303-4.07) | 0.663 |
| Level of monthly income (ETB) | <=2,000 | 5 (10.4%) | 43 (89.6%) | 1.07 (0.305-3.73) | |
| | 2,001-3000 | 75 (37.5%) | 125 (62.5%) | 5.50 (2.26-13.39) | <0.001* |
| | >=3000 | 6 (9.8%) | 55 (90.2%) | 1.00 | |
| BMI (Kg/m$^2$) | 18.5-24.99 | 52 (26.9%) | 141 (73.1%) | 1.00 | |
| | <18.5 | 6 (46.2%) | 7 (53.8%) | 2.324 (0.75-7.24) | |
| | >=25 | 28 (27.2%) | 75 (72.8%) | 1.01 (0.59-1.73) | 0.34 |
| Systolic BP | 90-119 | 61 (28.8%) | 151 (71.2%) | 1.00 | |
| | >=120 | 25 (25.8%) | 72 (74.2%) | 0.86 (0.50-1.48) | 0.59 |

Key: *p-value < 0.2 in bivariate logistic regression, 1.00 = reference value.

## Table 7: Work Environment and Behavioral Factors.

| Variables | Category | HRIs (%) | | COR (95% CI) | P-value |
|---|---|---|---|---|---|
| | | Yes | No | | |
| | Injera Baking Center | 71 (46.1%) | 83 (53.9%) | 7.98 (4.30-14.84) | |
| Work group | Local Market Center | 15 (9.7%) | 140 (90.3%) | 1.00 | <0.001* |
| Type of work | Moderate work | 27 (15.4%) | 148 (84.6%) | 1.00 | |
| | Heavy work | 59 (44.0%) | 75 (56.0%) | 5.91 (3.32-10.54) | <0.001* |
| Working hours per day | <=8hr | 17 (18.5%) | 75 (81.5%) | 1.00 | |
| | >8hr | 69 (31.8%) | 148 (68.2%) | 2.06 (1.13-3.74) | 0.018* |
| Availability of Cooling fans | Yes | 14 (19.7%) | 57 (80.3%) | 1.00 | |
| | No | 72 (30.3%) | 166 (69.7%) | 1.77 (0.93-3.37) | 0.085* |
| Availability of cold drinking water | Yes | 15 (12.4%) | 106 (87.6%) | 1.00 | |
| | No | 71(37.8%) | 117 (62.2%) | 4.29 (2.32-7.94) | <0.001* |
| Availability of sufficient break time | Yes | 16 (14.2%) | 97 (85.8%) | 1.00 | |
| | No | 70 (35.7%) | 126 (64.3%) | 3.37 (1.84-6.16) | <0.001* |
| Availability of a cooler work site | Yes | 8 (10.0%) | 72 (90.0%) | 1.00 | |
| | No | 78 (34.1%) | 151 (65.9%) | 4.65 (2.13-10.14) | <0.001* |
| Work Clothing | Thin breathable cloth | 57 (22.1%) | 201 (77.9%) | 1.00 | |
| | Thick cloth | 29 (56.9%) | 22 (43.1%) | 4.65 (2.48-8.71) | <0.001* |
| Water intake per day | <3 Liter | 8 (15.7%) | 43 (84.3%) | 2.33 (1.05-5.18) | |
| | >=3 Liter | 78 (30.2%) | 180 (69.8%) | 1.00 | 0.038* |
| Having a previous job | Yes | 35 (28.0%) | 90 (72.0%) | 1.014 (0.61-1.68) | |
| | No | 51 (27.7%) | 133 (72.3%) | 1.00 | 0.96 |
| | No | 22 (12.9%) | 148 (87.1%) | 1.00 | |

Key: *p-value < 0.2, in bivariate logistic regression. 1.00 = reference value.

## 5. Multivariable logistic regression

The results from multivariable logistic regression showed some variables that were statistically significantly associated with heat-related illness, which include the work group, availability of cold drinking water, availability of sufficient break time, and water intake.

This study found that the odds of developing HRIs among Injera baking workers are 13 times higher than those of local market workers, AOR=13.2 (95% CI: 3.4-50.7). Cold drinking water availability was also very important; workers without access to cold drinking water had over four times the risk of acquiring heat-related illness (AOR=4.3, 95% CI: 1.69-10.9). Sufficient break time also had an effect; workers without sufficient breaks had over three times the risk of acquiring heat-related illness (AOR = 3.5, 95% CI: 1.5-8.13). Drinking less than 3 liters of water per day during hot weather increases the odds of heat-related illness by over three times (AOR =3.9, 95% CI: 1.55-9.73, p = 0.004) compared to those drinking more (Table 8).

**Table 8: Summary of Multivariable Logistic Regression analysis of HRI among study participants.**

| Variables | Category | HRIs (%) | | COR (95% CI) | AOR (CI=95%) | P-value |
|---|---|---|---|---|---|---|
| | | Yes | No | | | |
| Work group | Injera Baking Center | 71 (46.1%) | 83 (53.9%) | 7.98 (4.30-14.84) | 13.2 (3.4-50.7) | <0.0001* |
| | Local Market Center | 15 (9.7%) | 140 (90.3%) | 1.00 | 1.00 | |
| Educational status | No formal education | 24 (29.3%) | 58 (70.7%) | 2.30 (1.03-5.10) | 1.4 (0.5-3.8) | 0.24 |
| | Primary education | 51 (32.9%) | 104 (67.1%) | 2.719(1.318-5.610) | 2.1 (0.85-5.00) | |
| | Secondary education and above | 11 (15.3%) | 61 (84.7% | 1.00 | 1.00 | |
| Level of monthly income (ETB) | <=2,000 | 5 (10.4%) | 43 (89.6%) | 1.07 (0.305-3.73) | 1.5 (0.4-5.5) | 0.83 |
| | 2,001-3000 | 75 (37.5%) | 125 (62.5%) | 5.50 (2.26-13.39) | 1.3 (0.33-5.38) | |
| | >=3000 | 6 (9.8%) | 55 (90.2%) | 1.00 | 1.00 | |
| Type of work | Moderate work | 27 (15.4%) | 148 (84.6%) | 1.00 | 1.00 | |
| | Heavy work | 59 (44.0%) | 75 (56.0%) | 5.91 (3.32-10.54) | 1.9 (0.867-4.2) | 0.11 |
| Working hours per day | <=8hr | 17 (18.5%) | 75 (81.5%) | 1.00 | 1.00 | |
| | >8hr | 69 (31.8%) | 148 (68.2%) | 2.06 (1.13-3.74) | 0.8 (0.35-1.7) | 0.53 |
| Availability of Cooling fans | Yes | 14 (19.7%) | 57 (80.3%) | 1.00 | 1.00 | |
| | No | 72 (30.3%) | 166 (69.7%) | 1.77 (0.93-3.37) | 1.5 (0.51-4.30) | 0.468 |
| Availability of cold drinking water | Yes | 15 (12.4%) | 106 (87.6%) | 1.00 | 1.00 | |
| | No | 71(37.8%) | 117 (62.2%) | 4.29 (2.32-7.94) | 4.3 (1.69-10.9) | 0.002* |
| Availability of sufficient break time | Yes | 16 (14.2%) | 97 (85.8%) | 1.00 | 1.00 | |
| | No | 70 (35.7%) | 126 (64.3%) | 3.37 (1.84-6.16) | 3.5 (1.5- 8.13) | 0.003* |
| Availability of a cooler work site | Yes | 8 (10.0%) | 72 (90.0%) | 1.00 | 1.00 | |
| | No | 78 (34.1%) | 151 (65.9%) | 4.65 (2.13-10.14) | 0.5 (0.17-1.33) | 0.156 |
| Work Clothing | Thin breathable cloth | 57 (22.1%) | 201 (77.9%) | 1.00 | 1.00 | |
| | Thick cloth | 29 (56.9%) | 22 (43.1%) | 4.65 (2.48-8.71) | 1.2 (0.51-2.98) | 0.65 |
| Water intake per day | <3 Liter | 8 (15.7%) | 43 (84.3%) | 2.33 (1.05-5.18) | 3.9 (1.55-9.73) | 0.004* |
| | >=3 Liter | 78 (30.2%) | 180 (69.8%) | 1.00 | 1.00 | |

Key: *statistically significant at $p < 0.05$; in multivariable analysis. 1.00 = reference value.

## 6. Observational findings

For this research, a standard checklist was used to assess the working conditions at an Injera production facility and a Local market center. We noticed that workers at the injera facility mostly worked close to a baking stove (nearly 20cm) and managed three stoves at a time, while those at the market center did tasks with less heat exposure.

At the injera production site, there was a local exhaust ventilation system, but it wasn't working (Fig. 14). Management explained that when they did use it, the quality of the injera got worse. The natural airflow was also poor because the air entering the openings was too small and not well-designed. They also weren't positioned to take in the usual eastern winds, so they weren't effective in cooling down the workspace. In contrast, the market center had good natural ventilation. This improved air quality and made the work environment more comfortable for workers.

The injera production site did not have enough access to clean drinking water and shower facilities for workers. The main water source is from a mobile water truck to fill the tanker that was installed at the work site. Water was not available continuously some workers had to bring their own drinking water from home due to concerns about cleanliness and availability.

Workers in the injera production facility commonly wore double workwear, including a standard uniform. Conversely, workers in the market center typically wore breathable cotton full-body suits, which are more conducive to maintaining thermal comfort.


**Figure 14: shows the ventilation system of Injera Baking Center.**

## Discussion

The study showed differences in heat exposure level and HRIs between Injera Baking and Local Market workers in Addis Ababa. WBGT measurements showed significantly higher heat exposure among Injera Baking workers, mean ± SD (WBGT: 26.4 ± 3.7°C) compared to Local Market workers (18.6 ± 2.6°C). The prevalence of heat-related illnesses was markedly greater among Injera Baking workers (46.1%) than Local Market workers (9.7%), with self-reported symptoms such as excessive sweating, fatigue, and muscle cramps being far more common among the baking group. Factors significantly associated with HRIs include work setting, access to cold drinking water, rest breaks, and water intake ($p<0.05$).

The working hours average WBGT levels (±SD) at the Baking and Market Centers were 26.4 ± 3.7°C and 18.6 ± 2.6°C, respectively. The Baking WBGT, which is significantly higher than Local Market Center ($P < 0.05$). This difference mainly due to the continuous operation of multiple baking stoves in a space with poor ventilation.

In the Baking Center WBGT peaked at 32.4°C by 11 AM because of the combined effects of rising outdoor temperatures, sunlight, and accumulated indoor heat. A temporary drop occurred at 1 PM during break time. Between 10:00 AM and 4:00 PM the WBGT values exceeded $28.5^{0}$C (threshold limit) recommended by the ACGIH standard for moderate work (64). During night shift at the Injera Baking Center, the maximum WBGT was 27.4°C, which was around 10 PM, when baking activity was highest with full staff.

The occupational heat exposure guideline (ACGIH) is based on the maximum WBGT value for various work levels. The ACGIH standard provides specific recommendations. Based on moderate workload and WBGT level recorded (above 28.5 °C) at the Injera Baking Center, workers should get 25% rest and 75% work per hour between 10:00 AM and 4:00 PM. As this is necessary to prevent HRI by controlling the core body temperatures below 38°C (64).

Generally, the average WBGT during working hours at the Injera Baking Center (26.4 ± 3.7°C) exceeds the ACGIH Action Limit of 25°C for moderate workloads (64), indicating a clear risk of heat-related illnesses if proper heat control measures are not implemented. This finding is much lower than previous studies in similar occupational environments. In an Egyptian study, among bakeries reported the average WBGT value was 31.6°C at the baking site (39). Similarly, in the same country, the study in hospital kitchens found mean WBGT level was 32.4 ± 1.4°C (90). This difference may be attributed to several factors, like seasonal variations, differences in building structure, weather, and the intensity or scale of heat-generating equipment used.

Socio-demographic characteristics of study participants were generally comparable between the two study groups, which minimizes the confounding variables when comparing HRIs. This includes the mean age, work experience, and monthly income.

The prevalence of HRIs was greatly different between the two study groups. It was 46.1% and 9.7% among Injera Baking and Market workers, respectively. The higher prevalence of HRIs among baking workers is linked with prolonged exposure to high-heat sources in often poorly ventilated spaces. In contrast, market workers typically operate in more ventilated settings, reducing their heat exposure risk.

This result was much lower than the result from previous Ethiopian studies among other occupational settings with high heat exposure, where HRI rates were 83.9% and 12.6%, respectively, among Steel and Pepsi-Cola factory workers (19). Similarly, higher rates were reported among aluminum and water bottling factory workers, at 85.3% and 27%, respectively (20). These discrepancies may be attributed to differences like heat exposure level, workload, and duration of exposure.

Among baking workers, the most commonly self-reported symptoms were excessive sweating, and tiredness/fatigue, while fainting was the least common reported. In contrast, Local market workers primarily reported tiredness/fatigue then excessive sweating. The differences are attributed to the prolonged and direct heat exposure among baking workers.

The previous study conducted in Gonder city among kitchen workers reported lower rates of sweating (43%), tiredness (41.5%), but almost similar fainting cases (6.6%) (10). The variation in prevalence of the first two symptoms between the studies could be attributed to differences in work exposure time, and the larger sample size in the previous study may have influenced the detection rates of symptoms.

There were significantly higher odds (AOR =13.2, 95% CI: 3.4-50.7) of developing HRIs among bakeries compared to those in the Local Market. This indicates a strong association between occupational setting and the risk of heat-related illness.

The finding was in line with the comparative study conducted in the Aluminum and Water Bottling factory near Addis Ababa, which concluded that workers in the Aluminum factory had almost ten times the odds of developing HRI compared with the control groups(AOR=9.98, 95%CI:4.16–23.95) (20).

The absence of water access increased the odds of heat-related illness more than fourfold (AOR=4.3, 95%CI: 1.69-10.9, p =0.002) than those who had access to water. Other studies showed that the availability of water in a working area decreases the risk of HRIs (13,19,51). This ensures access to drinking water is a vital preventive measure against HRIs for heat-exposed workers.

The lack of sufficient rest breaks was found to be a significant risk factor in this study, with workers who did not have sufficient breaks being over three times more likely to develop heat-related illnesses (AOR=3.5, 95%CI:1.5-8.13, p = 0.003). The finding was parallel with the study result from Tanzania and Japan, which highlights that the absence of sufficient breaks was associated with a higher risk of HRIs (51,52). This shows the importance of routine rest periods as an effective measure to reduce HRI risks in hot working environments.

Concerning water intake, workers who consumed less than 3 liters of water per day had over two times the odds of developing heat-related illnesses compared to those who drank 3 liters or more (AOR = 2.33, 95% CI: 1.05-5.18). The National Institute for Occupational Safety and Health (NIOSH) recommends a daily fluid intake of 5.7 to 9.5 liters for individuals working in hot environments. Inadequate water intake impairs the ability of body to regulate temperature, which increases the risk of HRIs. The finding is nearly supported by research conducted among industrial workers that found individuals consuming less than 3 liters of water per day were five times more likely to experience HRIs compared to those taking 3 liters or more (AOR=5.08, 95%CI: 2.79–9.27) (20). A study from Malaysia also reported consistent results, reinforcing the importance of adequate fluid intake in preventing HRIs for heat-exposed workers (91).

Among Injera baking workers, neither BMI nor age showed a statistically significant association with HRIs (p-value >0.05). This is supported by a study done in Tanzania (51). However, other studies have reported that obese individuals have a higher risk of developing HRI than those with normal BMI (92,93), which is contrary to the finding here. This is due to workers with higher BMI in this study may have been less physically active. Similarly, age above 60 years is recognized as a risk factor for HRIs due to diminished thermoregulatory capacity (53); this association was not observed in the current study. This is likely because individuals over the age of 60 were excluded from this study.

These findings highlight the need for interventions such as adding more work-rest scheduling, water access, and worker education on HRI risks to mitigate them in the workplace.

## Strengths and limitations of the study

### Strengths

- The Wet Bulb Globe Temperature tool was used to measure the heat exposure, which improves the accuracy and reliability of the finding.
- A comparative cross-sectional study design was applied, which increases the accuracy of findings.
- The study combined structured questionnaires, observational checklists, and WBGT measurement, providing a comprehensive assessment.

### Limitations

- Heat-related illnesses were assessed using self-reported symptoms (recall bias and reporting inaccuracies), which might have led to overestimation of results.
- Now the study was done at just a specific point in Addis Ababa, and this means that the results may not be fully true to other places where injera is baked or for people in other industries who have more or less heat exposure or different kinds of job characteristics.
- Heat stress levels were monitored over a limited number of days, which may not fully represent long-term variations in exposure due to seasonal changes or production fluctuations.

## Conclusion

Injera Baking workers were exposed to significantly higher heat levels (mean WBGT 26.4 ± 3.7°C) than Local Market workers (18.6 ± 2.6°C). The WBGT values at the baking center often exceed the ACGIH TLV of 28.5°C for moderate work, particularly between 10:00 AM and 4:00 PM. Of baking workers, 46.1% had reported HRI, and 9.7% among the Market Center workers. Some variables were significantly associated with HRI this including: work group, access to drinking water, sufficient rest breaks, and daily water intake (P-value $<0.05$). The findings highlight the immediate need for targeted interventions to minimize heat exposure and improve workplace safety in baking environments.

## Recommendations

The study identified a need for heat-related illness prevention in the workplace, particularly in the Injera Baking Center, by concerned bodies:

**Ministry of Labor and Skills (MOLS)**

- Provide policies on the work area to minimize the risks of workers' exposure.
- Regular inspection and monitoring of heat levels in the workplace, such as through regular WBGT measurements and access to medical services when needed.
- Ensure the availability of sufficient water and that workers are made aware of the need to drink.

**To Lemi Injera Baking Center**

- Do more work at night as the temperature is relatively good.
- Schedule working hours earlier or later in the day during hot seasons
- Use work/rest (75%/25%) schedules following ACGIH standard (10 am - 4 pm)
- Installing a pipe for clean water at the work site for drinking and showering.
- Training programs should be introduced to raise awareness about the benefits of drinking enough water and the signs and symptoms of heat-related illnesses.

**For Researchers**

- ➢ Longitudinal studies are needed to better understand the lasting health impacts of repeated heat exposure.
- ➢ Given that Injera baking is mostly done by women, future research should explore gender-specific risks, especially by including bread bakeries and hotel kitchen workers.
- ➢ Broader studies across different regions and seasons would help clarify how climate and work conditions influence heat-related illnesses.

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# ANNEXES:

### Annex I: Participant's Information Sheet

**Study Title:** Assessment of heat stress exposure level and heat related illness among workers in Lemi Injera Baking Center, Addis Ababa.

**Principal Investigator**: Belay Gezahegn Chamo, School of Public Health, Addis Ababa University. Contact: +251 903176862 / belaygezahegn123@gmail.com

**Purpose of the Study**: The purpose of this study is to screen the degree of heat burden of workers at the Lemi Injera Baking Centre and analyze its health effect. Results will facilitate recommendations of interventions to enhance worker health and safety in hot work.

**What Participation Involves**: If you take part, you will be interviewed (20-30 minutes) about your experiences of heat stress, any associated health problems, and how you cope with working in the heat.

**Risks**: There are no known risks. Interviews will be on a one-to-one basis and physical measurements will be non-intrusive and risk free.

**Benefits**: While there is no direct benefit to you, your participation will contribute to understanding heat-related health risks and improving workplace conditions for workers in similar environments.

**Confidentiality**: Your responses will be confidential. Privacy data will be stripped of any personal identifier and the results will be reported ins constructively, without naming any participant. You can, however, ask for an overview of the findings.

**Voluntary Participation**: Participation is voluntary. You may withdraw at any time without penalty, and any collected data will be destroyed if requested.

**Results of the Research**: Study outcomes will guide policymakers and workplace managers in terms of the heat risks and provide guidance on producing health and safety management strategies for the protection of workers' health and safety. Results may be published or presented at conferences.

**Consent to Participate**: If you agree to participate you will give consent before the interview. You can withdraw at any time

## Annex II: Participant's Information Sheet (Amharic version)

**የጥናት ርዕስ፡-** የሰራተኞች የሙቀት ጭንቀት ተጋላጭነት ደረጃ እና ከሙቀት ጋር የተያያዘ ህመም ግምገማ በለሚ እንጀራ መጋገሪያ ማዕከል፣ አዲስ አበባ፡፡

**ዋና ተመራማሪ፡** በላይ ገዛኸኝ ጫሞ፣ የሁለተኛ ዲግሪ እጩ፣ የህብረተሰብ ጤና ትምህርት ቤት፣ በአዲስ አበባ ዩኒቨርሲቲ። አድራሻ: +251 903176862 / belaygezahegn123@gmail.com

**የጥናቱ ዓላማ፡-** ይህ ጥናት በሌሚ እንጀራ መጋገሪያ ማዕከል ውስጥ ያሉ ሰራተኞች የሚያጋጥሟቸውን የሙቀት ጭንቀት ደረጃ ለመገምገም እና የጤና ጉዳቶቹን ለመገምገም ያለመ ነው። ግኝቶቹ ከፍተኛ ሙቀት ባለባቸው አካባቢዎች የሰራተኛ ጤናን እና ደህንነትን ለማሻሻል ጣልቃገብነቶችን ለመምከር ይረዳል።

**ተሳትፎው ምንን ያካትታል፡** ከተሳተፉ ከ20-30 ደቂቃዎች ስለ ሙቀት ጭንቀት፣ ስለማንኛውም ተዛማጅ የጤና ጉዳዮች እና በሞቃት አካባቢ ውስጥ መስራትን እንዴት እንደሚቆጣጠሩ ለ20-30 ደቂቃዎች ቃለ መጠይቅ ይደረግልዎታል።

**አደጋዎች**: ምንም የሚታወቁ አደጋዎች የሉም ቃለመጠይቆች ግላዊ ይሆናሉ፣ እና ማንኛውም የሚደረጉ አካላዊ መለኪያዎች ወራሪ እና ጉዳት የሌላቸው ይሆናሉ።

**ጥቅማ ጥቅሞች፡** ለእርስዎ ምንም አይነት ቀጥተኛ ጥቅም ባይኖርም፣ የእርስዎ ተሳትፎ ከሙቀት ጋር የተያያዙ የጤና አደጋዎችን ለመረዳት እና በተመሳሳይ አካባቢ ላሉ ሰራተኞች የስራ ቦታ ሁኔታን ለማሻሻል አስተዋፅኦ ያደርጋል።

**ምስጢራዊነት፡** የእርስዎ ምላሾች ሚስጥራዊ ይሆናሉ። የግል ዝርዝሮች ስማቸው አይገለጽም, እና ግኝቶቹ የትኛውንም ተሳታፊ ሳይገልጹ ይቀርባሉ. ከፈለጉ፣ ከጥናቱ በኋላ የውጤቶቹን ማጠቃለያ መጠየቅ ይችላሉ።

**በፈቃደኝነት ተሳትፎ፡** ተሳትፎ በፈቃደኝነት ነው። በማንኛውም ጊዜ ያለ ቅጣት ማውጣት ይችላሉ፣ እና ማንኛውም የተሰበሰበ መረጃ ከተጠየቀ ይጠፋል።

**የጥናቱ ውጤቶች፡** የጥናቱ ውጤት ፖሊሲ አውጪዎችን እና የስራ ቦታ አስተዳዳሪዎችን ስለ ሙቀት ስጋቶች ያሳውቃል እና የሰራተኞችን ጤና እና ደህንነት ለመጠበቅ ስልቶችን ለማዘጋጀት ይረዳል። ውጤቶቹ በስብሰባዎች ላይ ሊታተሙ ወይም ሊቀርቡ ይችላሉ።

**ለመሳተፍ ስምምነት፡** ለመሳተፍ ከተስማሙ ቃለ መጠይቁ ከመጀመሩ በፊት የስምምነት ፎርም ይፈርማሉ። በማንኛውም ጊዜ ማውጣት ይችላሉ።

**Annex III: Consent Form**

**Study Title:** Assessment of heat stress exposure level and heat related illness among workers in Lemi Injera Baking Center, Addis Ababa.

**Principal Investigator**: Belay Gezahegn Chamo, MPH Candidate, School of Public Health, Addis Ababa University.

I have been informed of the study, that is, its aim, methodology, potential risk and benefit. I know that I am participating voluntarily, and I may stop the study at any time without a penalty.

I know that all information I will submit to the system will be kept confidential and my identity will be withheld from reports or publications. And by signing below, I agree to participate in this study and know that at any time I can ask any question about the research.

Participant's Signature: ________________________________

Date: ____________________________________________

Interviewer Name: ________________________________

Signature: ________________________________________

Date: ____________________________________________

## Annex IV: Consent Form (Amharic Version)

**የጥናት ርዕስ**፡- በለሚ እንጀራ መጋገሪያ ማዕከል፣ አዲስ አበባ፣ የሰራተኞች የሙቀት ጭንቀት ተጋላጭነት ደረጃ እና ከሙቀት ጋር የተያያዘ ህመም ግምገማ

**ዋና መርማሪ**፡- በላይ ገዛኸኝ ጫሞ፣ ሁለተኛ ዲግሪ እጩ፣ የህብረተሰብ ጤና ትምህርት ቤት በአዲስ አበባ ዩኒቨርሲቲ

**ስለ ጥናቱ ዓላማ**፣ አካሄዶች፣ ስጋቶች እና ጥቅማ ጥቅሞችን ጨምሮ ስለ ጥናቱ መረጃ ተሰጥቶኛል። የእኔ ተሳትፎ በፈቃደኝነት እንደሆነ እና በማንኛውም ጊዜ ያለ ምንም ቅጣት ከጥናቱ መውጣት እንደምችል ተረድቻለሁ።

የማቀርበው መረጃ ሁሉ ሚስጥራዊ እንደሚሆን እና ማንነቴ በማንኛውም ዘገባ ወይም ህትመቶች ላይ እንደማይገለጽ ተረድቻለሁ። ከዚህ በታች በመፈረም በዚህ ጥናት ለመሳተፍ ተስማምቻለሁ እናም ጥናቱን በሚመለከት ማንኛውንም ጥያቄ በማንኛውም ጊዜ እንደምጠይቅ ተረድቻለሁ።

የተሳታፊ ፊርማ፡ ___________________________________

ቀን፡- _____________________________________________

የጠያቂው ስም፡- ___________________________________

ፊርማ፡ ____________________________________________________

ቀን፡- _____________________________________________

**Annex V: Data Collection Tools**

1. **English version Questionnaire**

Name of the interviewer: ______________

Form ID: __________ Date: __________ Factory: _________

**Table 9: English version Questionnaire for Heat Stress Exposure Assessment Study.**

| Parts | Questions | Responses | Remark |
|---|---|---|---|
| **Part I:** Identifiers | 1. Interviewer ID | | |
| | 2. Form ID | | |
| | 3. Date and time | | |
| **Part II: Demographic Information** | 4. In which section are you working? | a) Batter preparation<br>b) Baking<br>c) Storage<br>d) Market center | |
| | 5. How old are you? (In years) | __________years | |
| | 6. Education Level | a) No formal education<br>b) Primary education<br>c) Secondary education<br>d) College/ University<br>e) Other (specify) __________ | |
| | 7. What is your Marital Status? | a) Single<br>b) Married<br>c) Divorced<br>d) Widowed | |
| | 8. Your average monthly income | _______ETB | |
| **Part III: Physical measurement and NCD Risk factors** | 9. Body Weight | ______Kg | |
| | 10. Body Height | ______m | |
| | 11. BMI | ______$Kg/m^2$ | |
| | 12. Systolic BP | ______mmHg | |
| | 13. Diastolic BP | ______mmHg | |
| | 14. Body temperature | ______$^0C$ | |
| | 15. Smoking hx | a) Smoker<br>b) Non-Smoker<br>c) Ex-smoker | |
| | 16. History of alcohol consumption | a) Yes, regularly<br>b) Yes, sometimes<br>c) Not at all | |

| | | | |
|---|---|---|---|
| | | d) Previous drunker | |
| | 17. Do you have any chronic disease confirmed by a health professional? | a) Yes<br>b) No | |
| | 18. If yes to Q#17, which medical illness do you have? | a) Diabetes<br>b) Hypertension<br>c) Respiratory illness, specify _________<br>d) Kidney disease<br>Others, specify___________ | |
| **Part IV: Occupation-related** | 19. Do you have a previous job? | a) Yes<br>e) No | |
| | 20. If yes to Q#19, what was your previous job? | f) ____________________ | |
| | 21. How long have you been working at the center? | ________ years /month | |
| | 22. Level the type of work you are currently doing | a) Light work<br>b) Moderate work<br>c) Heavy work | |
| | 23. Are you comfortable with the workplace temperature? | a) Yes<br>b) No | |
| | 24. On a scale of 1 to 5, how would you rate the heat levels in your workplace? | 1. Very low<br>2. Low<br>3. Moderate<br>4. High<br>5. Very high | |
| | 25. Do you work near direct heat? | a) Yes<br>b) No | |
| | 26. Which shift do you usually work? | a) Morning<br>b) Afternoon<br>c) Night<br>d) Rotating shifts<br>e) No shift (full day) | |
| | 27. How many hours do you work without break time per day on average? | ___________hours | |
| | 28. Working in a hot environment affects which of these? | a) Health<br>b) Work focus<br>c) Productivity<br>d) Other (specify) ________ | |
| **Part V: Health Symptoms** | 29. Have you ever felt dizzy, fatigued, or nauseous due to heat while working? | a) Yes<br>b) No | |

| | | | |
|---|---|---|---|
| **and Conditions** | 30. If yes, how often do you feel these symptoms? | a) Frequently<br>b) Occasionally<br>c) Rarely<br>d) Never | |
| | 31. Have you ever reported symptoms of heat stress to your supervisor? | a) Yes<br>b) No | |
| | 32. If yes, what actions were taken? | a) Take a break<br>b) Replace the worker<br>c) No action taken<br>d) Other (specify)______________ | |
| | 33. Have you experienced any of the following symptoms while at work (hot day)? (Select all that apply.) | a) Excessive sweating<br>b) Fatigue or exhaustion<br>c) Muscle cramps<br>d) Headache<br>e) Nausea or vomiting<br>f) Dizziness<br>g) Rapid heartbeat<br>h) Confusion<br>i) Fainting<br>j) Skin, chest, and neck redness<br>k) No | |
| | 34. Have you ever been diagnosed with heat-related illnesses in the health facility? | a) Yes<br>b) No | |
| **Part VI: Coping Mechanisms and consequences of Heat stress** | 35. What measures do you personally take to cope with the heat at work? (Select all that you apply): | a) Drink more water<br>b) Take more breaks<br>c) Wear lighter clothing<br>d) Use a fan or other cooling device<br>e) Other (specify): ________ | |
| | 36. Does the company provide any of the following to reduce heat stress? (Select all that apply): | a) Cooling fans<br>b) Cold water<br>c) Extra breaks<br>d) Cooler workstations<br>e) Other (specify): ________ | |

| | | | |
|---|---|---|---|
| | 37. Which kind of PPE could you use? | a) Gauntlet gloves<br>b) Coverall<br>c) Facemask<br>d) Google<br>e) Other PPE<br>(specify)_________ | |
| | 38. Approximately how many liters of water do you drink per day in hot time? | _______L | |
| | 39. What kind of cloth do you mostly wear during your work? | a) Breathable cotton<br>b) Thick cotton overall<br>c) Rayon/Nylon<br>d) Plastic PPE<br>e) Others_________ | |
| | 40. Does the cloth exacerbate heat? | a) Yes<br>b) No | |
| | 41. Have you got any training on heat stress? | a) Yes<br>b) No | |
| | 42. If yes when? | a) Not more than 6 months<br>b) 6 months- 1year<br>c) More than 1 year | |
| | 43. Have you ever taken sick leave/permission due to heat? | a) Yes<br>b) No | |
| | 44. If yes, question 39 | How many days ____________ | |
| | 45. Have you ever been hospitalized for heat-related illness? | a) Yes<br>b) No | |
| | 46. If yes to question 46 | Approximately how many days _________ | |
| | 47. Have you lost wages or salary due to heat-related illness? | a) Yes<br>b) No | |
| | 48. If yes to question 47, how much | _____________birr | |

## 2. Amharic version of Questionnaire

የጠያቂው ስም:- _______________

የቅጹ መለያ ቁጥር:__________ ቀን: ___________ የስራ ቦታ: ___________

**Table 10: Amharic version Questionnaire for Heat Stress Exposure Assessment Study.**

| ክፍሎች | ጥያቄዎች | ምላሾች | ምርመራ |
|---|---|---|---|
| ክፍል አንድ: መለያዎች | 1. የጠያቂው መለያ | _____________ | |
| | 2. የቅጹ መለያ ቁጥር | ___________ | |
| | 3. ቀንና ሰዓት | __________ | |
| ክፍል ሁለት: የስነ ሕዝብ አወቃቀር መረጃ ክብደት | 4. በየትኛው የስራ ቡድን ነው የምትሰሪው? | a) ሊጥ ዝግጅት<br>b) በእንጀራ መጋገር<br>c) በእንጀራ ማከማቻ<br>d) ገበያ ማዓከል | |
| | 5. እድሜሽ ስንት ነው? (በአመት) | ___________ | |
| | 6. የትምህርት ደረጃ | ሀ) መደበኛ ትምህርት የለም<br>ለ) የመጀመሪያ ደረጃ ትምህርት<br>ሐ) የሁለተኛ ደረጃ ትምህርት<br>መ) ኮሌጅ / ዩኒቨርሲቲ<br>ሠ) ሌላ (ይግለጹ)___________ | |
| | 7. የጋብቻ ሁኔታሽ? | ሀ) ያላገባ<br>ለ) ያገባ<br>ሐ) የተፋታ<br>መ) ባል የሞተባት | |
| | 8. የእርስዎ አማካይ ወርሃዊ ገቢ | ________________ኢትዮጵያ ብር | |
| ክፍል ሶስት: አካላዊ ልከት እና ተላላፊ ላልሆኑ በሽታዎች አጋላጭ ሁኔታዎች | 9. ክብደት | ------ሜትር | |
| | 10. ቁመት | -------- ኪ.ግ | |
| | 11. የሰውነት ክብደት መረጃ ጠቋሚ(BMI) | ___________ኪ.ግ/ሜ² | |
| | 12. ሲስቶሊክ ቢፒ (mm Hg) | ____________ mm Hg | |
| | 13. ዲያስቶሊክ ቢፒ | ____________ mm Hg | |
| | 14. የሰውነት ሙቀት | ______________$^{0}$C | |
| | 15. ሲጋራ አጭሰዉ ታዉቅያለሽ | a) አዎ(አጫሽ)<br>b) በፍጹም አላጨስኩም<br>c) ድሮ አጨስ ነበር | |
| | 16. አልኮል መጠጥ ትጠጣለሽ? | a) አዎ<br>b) አይ በፍጹም<br>c) የቀድሞ ጠጪ | |

| | | | |
|---|---|---|---|
| | 17. በጤና ባለሙያ የተረጋገጠ ሥር የቆየ በሽታ (ተላላፍ ያልሆኑት) አለብሽ? | a) አዎ<br>b) አይ | |
| | 18. ጥያቄ ቁ 17 አዎ ከሆነ የትኛው? (ብዙ መልስ መምረጥ ይቻላል)? | a) የስኳር በሽታ<br>b) የደም ግፊት<br>c) የአተነፋፈስ ሕመም፣ _________ ይግለጹ<br>d) የኩላሊት በሽታ<br>e) ምንም የለኝም<br>f) ሌሎች፣ ይግለጹ_________ | |
| **ክፍል አራት፡ ከስራ ጋር የተያያዘ** | 19. ቀድሞ ለላ ሥራዎ ነበረሽ? | a) አዎ<br>b) አይደለም | |
| | 20. ጥያቄ ቁ 19 አዎ ከሆነ ስራዉ ምን ነበር? | ________________________ | |
| | 21. በዚህ ማእከል ምን ያህል ጊዜ እየሰሩ ነው? | ______________ዓመት | |
| | 22. የሥራውን ክብደት እንደት ትገልጻልሽ? | a) ቀላል ሥራ<br>b) መጠነኛ ሥራ<br>c) ከባድ ሥራ | |
| | 23. በሥራ ቦታ የሙቀት መጠን ምቾት ይሰማዎታል? | a) አዎ<br>b) አይደለም | |
| | 24. ከ 1 እስከ 5 ባለው ልኬት፣ በስራ ቦታዎ ያለውን የሙቀት መጠን እንዴት ይመዝኑታል? | 1. በጣም ዝቅተኛ<br>2. ዝቅተኛ<br>3. መካከለኛ<br>4. ከፍተኛ<br>5. በጣም ከፍተኛ | |
| | 25. በቀጥታ ሙቀት አጠገብ ይሰራሉ? | a) አዎ<br>b) አይደለም | |
| | 26. አብዛኛዉን ጊዜ የምትሠሪው በትኛውን ፈረቃ ነው? | a) ጥዋት<br>b) ከሰዓት በኋላ<br>c) ምሽት<br>d) የሚሽከረከር ፈረቃ<br>e) ፈረቃ የለም (ሙሉ ቀን) | |
| | 27. በቀን በአማካይ ምን ያክል ሰአታትን ያለ እረፍት ሰአት ይሰራሉ? | _________________ሰአታት | |
| | 28. በሞቃት አካባቢ ውስጥ መሥራት ምን ዓይነት ተጽእኖ ይኖረዋል? | a) በጤና ላይ ተጽእኖ አለው<br>b) ትኩረት በመስጠት ላይ ተጽእኖ ይኖረዋል<br>c) በምርታማነት ላይ ተፅእኖ አለው<br>d) ሌላ ይግለጹ______________________________ | |
| **ክፍል አምስት፡ የጤና ምልክቶች እና ሁኔታዎች** | 29. በሥራ ላይ እያለሽ በሙቀት ምክንያት የማዞር፣ የድካም ወይም የማቅለሽለሽ ስሜት ተሰምቶህ ያውቃል? | a) አዎ<br>b) አይደለም | |

| | | | |
|---|---|---|---|
| | 30. አዎ ከሆነ፣ እነዚህ ምልክቶች ምን ያህል ጊዜ ተሰምቶሻል? | a) በተደጋጋሚ<br>b) አልፎ አልፎ<br>c) አንዳንደ<br>d) በጭራሽ | |
| | 31. የሙቀት ጭንቀት(heat stress) ምልከቶችን ለተቆጣጣሪዎ ሪፖርት አድርገው ያውቃሉ? | a) አዎ<br>b) አይደለም | |
| | 32. ጥ.ቁ32 አዎ ከሆነ ምን እርምጃ ተወሰደ? | a) እረፍት ተሰጠኝ<br>b) ለላ ሰው ተተካ<br>c) ምንም<br>d) ለላ ይገለጽ ____________________ | |
| | 33. በስራ ላይ እያሉ ከሚከተሉት ምልክቶች አንዱን አጋጥመውዎታል? (የሚመለከተውን ሁሉ ይምረጡ) | a) ከመጠን በላይ ላብ<br>b) ድካም ወይም ድካም<br>c) የጡንቻ ሕመም<br>d) ራስ ምታት<br>e) ማቅለሽለሽ ወይም ማስታወክ<br>f) መፍዘዝ<br>g) ፈጣን የልብ ምት<br>h) ግራ መጋባት<br>i) ራስን መሳት<br>j) የቆዳ፣ የደረት እና የአንገት መቅላት<br>k) ከላይ ከተጠቀሱት ውስጥ አንዳቸውም አይደሉም | |
| | 34. ከሙቀት ጋር በተያያዙ ህመሞች እንዳለዎት በጠና ባለሙያ ተነግሮት ያውቃል? | a) አዎ<br>b) አይደለም | |
| **ክፍል ስድስት፡ የመቋቋሚያ ዘዴዎች እና የሙቀት ውጤቶች** | 35. በስራ ላይ ያለውን ሙቀት ለመቋቋም በግል የሚወስዷቸው እርምጃዎች የትኞቹ ናቸው? (የሚመለከተውን ሁሉ ይምረጡ) | a) ብዙ ውሃ መጠጣት<br>b) ተጨማሪ እረፍት ማድረግ<br>c) ቀላል ልብስ መልበስ<br>d) የአየር ማራገቢያ ወይም ሌላ ማቀዝቀዣ መሳሪያ መጠቀም<br>e) ሌላ (ይግለጹ)፡______________ | |
| | 36. የሚመለከተው አካል የሙቀት ጭንቀትን ለመቀነስ ከሚከተሉት ውስጥ የትኛውን ያቀርባል? (የሚመለከተውን ሁሉ ይምረጡ) | a) የአየር ማናፈሻ/ ማቀዝቀዣ<br>b) ቀዝቃዛ ውሃ<br>c) ተጨማሪ እረፍቶች<br>d) ቀዝቃዛ የሥራ ቦታዎች<br>e) ሌላ (ይግለጹ) | |
| | 37. ምን አይነት የግል መከላከያ መሳሪያ ነው የምትጠቀመው? | a) ጋውንትሌት ጓንቶች<br>b) ሙሉ ሽፋን<br>c) የፊት ጭንብል<br>d) ጎግል<br>e) ሌላ (ይግለጹ)____________________ | |
| | 38. በሞቃት ጊዜ በግምት በቀን ምን ያህል ሊትር ውሃ ይጠጣሉ? | ________ሊ | |

| | | | |
|---|---|---|---|
| | 39. በስራዎ ወቅት ምን አይነት ልብስ ይለብሳሉ? | a) አየር የሚፈቅድ ጥጥ / ቀላል ልብስ<br>b) በአጠቃላይ ወፍራም ጥጥ<br>c) ሬዮን/ናይሎን<br>d) የፕላስቲክ የግል መከላከያ መሳሪያዎች<br>e) ሌሎች________________________ | |
| | 40. ልብሱ ሙቀትን ያባብሳል? | a) አዎ<br>b) አይደለም | |
| | 41. በሙቀት ጭንቀት(heat stress) ላይ ምንም ዓይነት ስልጠና አግኝተሽ ታውቅያለሽ? | a) አዎ<br>b) አይደለም | |
| | 42. ጥ.ቁ41 አዎ ከሆነ መቼ? | ___________ | |
| | 43. ባለፈው አንድ አመት ውስጥ በሙቀት ምክንያት የሕመም እረፍት/ፈቃድ ወስደሽ ታውቃለሽ? | a) አዎ<br>b) አይደለም | |
| | 44. ለጥያቄ 43 መልስዎ አዎ ከሆነ ስንት ቀናት? | ______________ቀናት | |
| | 45. ከሙቀት ጋር በተያያዙ በሽታዎች ሆስፒታል ገብተው ተኝተው ያውቃሉ? | a) አዎ<br>b) አይደለም | |
| | 46. ለጥያቄ 45 መልስዎ አዎ ከሆነ | በግምት ስንት ቀናት __________ | |
| | 47. ከሙቀት ጋር በተገናኘ ህመም ምክንያት ደሞዝ አጥተዋል? | a) አዎ<br>b) አይደለም | |
| | 48. ለጥያቄ 47 መልስዎ አዎ ከሆነ | _______________ኢት ብር | |

### 3. Checklist for observation

**Table 11: Checklist for Heat Stress Exposure Assessment Study.**

| **Items** | | **Yes** | **No** | **Comment** |
|---|---|---|---|---|
| Working environment (Ventilation) | Is the workplace well-ventilated? | | | |
| | Are open doors and windows used to increase airflow? | | | |
| | Are fans used in poorly ventilated areas to enhance air circulation? | | | |
| PPE access | Do workers wear thin, air-permeable clothing? | | | |
| | Does the job require the use of heat-protective clothing? | | | |
| Water and rest facility | Is drinking water available in locations close to all workers? | | | |
| | Are sufficient rest or break areas equipped with cooling rooms? | | | |
| | Are showers readily accessible when needed? | | | |