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User-friendly tool for heat-related risk assessment of the working environment in health facilities

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USER-FRIENDLY TOOL FOR HEAT-RELATED RISK ASSESSMENT OF THE WORKING ENVIRONMENT IN HEALTH FACILITIES

Deliverable 2.9

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User-friendly tool for heat-related risk assessment of the working environment in health facilities

HIGH HORIZONS – D2.9

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Author(s)	Jørn Toftum
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Type	Demonstrator** **This report provides a practical and systematic procedure to identify and assess risks caused by working in high temperatures in healthcare settings, with the goal to prevent or reduce heat-related health risks, improve workers' health and well-being, and ultimately the quality of care. The tool/demonstrator itself is a separate checklist to conduct the risk assessment.
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Partners in the project

Partners involved in developing the guideline:

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- Centre for healthy Indoor Environments, Ergonomics and Aerosol Technology, Lund University performs research on human thermal environments, climate change and health, heat and cold stress, thermophysiology and thermal comfort.

Abbreviations

Abbreviation	Definition/Description
AT	Apparent Temperature
CAV	Clothing Adjustment Value
EC	Exposure Class
IEQ	Indoor environmental quality
ISO	International Organisation for Standardization
PHS	Predicted Heat Strain
PMV	Predicted Mean Vote
PPD	Predicted Percentage of Dissatisfied
RH	Relative humidity of the air
WBGT	Wet Bulb Globe Temperature (a heat stress index)

Definitions

Term	Definition
Air humidity	The concentration of water vapor present in the air is known as 'absolute humidity' or 'humidity ratio'. It can be referred to as 'specific' (mass of water vapor in a unit mass of moist or dry air), as the partial water vapour pressure, or 'relative' (the ratio of the partial to the saturated water vapour pressure at the same temperature and absolute pressure - percent or fraction).
Air temperature, t_a	The temperature of the atmosphere which represents the average kinetic energy of the molecular motion in a small region and is defined in terms of a standard or calibrated thermometer in thermal equilibrium with the air (^oC).
CAV	Clothing Adjustment Value. Adjustment of the WBGT to account for the effects of clothing that has different thermal properties than standard work clothing (ISO 7243-2017) (^oC).
Clothing insulation, I_{cl}	Thermal insulation provided by clothing in clo or m^2 K W^{-1}.
D_{lim}	Duration Limited Exposure. Duration of exposure after which either the accumulated sweating exceeds 3% of the body weight of an average worker or the core temperature reaches 38^oC (ISO 7933-2023). (minutes).
EC	Exposure Class (Table X) (ISO 8025-2024).
Heat Stress index	Integrated index used to assess heat stress by comparing the required with the maximum heat loss under the given climatic conditions (-).

Term	Definition
Metabolic rate, M	Total energy production in a human in unit time, commonly expressed in biometeorological studies based on the total body surface of a human in W m^{-2}. The standard ISO 8996:2021 outlines the method for the estimation of metabolic heat production (W m^{-2}).
Predicted Mean Vote, PMV	Predicts the mean value of the thermal sensation of a large group of persons as a function of their physical activity (metabolic rate), clothing insulation and the four environmental parameters air temperature, mean radiant temperature, air velocity and air humidity. The PMV is evaluated on a scale ranging from –3 (cold), -2 (cool), -1 (slightly cool), 0 (neutral), 1 (slightly warm), 2 (warm), 3 (hot).
Predicted Percentage of Dissatisfied, PPD	Index used to evaluate dissatisfaction in comfortable thermal environments (%) (Fanger 1970, ISO 7730-2006). Derived from PMV.
Predicted Heat Strain, PHS	Method for analytical determination and interpretation of heat stress (ISO 7933-2023). Predicts the water loss and core temperature and uses these to set limits for heat exposure.
Relative Humidity of the air, RH	The ratio of the partial to the saturated water vapour pressure at the same temperature and absolute pressure (% or fraction).
Wet Bulb Globe Temperature, WBGT	A simple index of the environment that is considered along with metabolic rate and clothing insulation to assess the potential for heat stress among those exposed to hot conditions (^{o}C).

1 Introduction

Persons working in hot environments may be at risk of heat stress and strain. Heat stress is the net heat load to which a worker may be exposed from the combination of metabolic heat, environmental factors, and clothing (Heat-tlv 2024). Heat strain is the physiological response resulting from heat stress. Heat may increase the risk of injuries or reduce mental or physical performance, creating additional hazards. Failure to appreciate the risks is often a contributory factor (Parsons 2014). An important measure to safeguard workers in hot environments is therefore to carefully evaluate the factors related with the work, the individual or the surrounding environment that affect the risk of stressful thermal exposures.

1.1 Objectives

This report provides a practical and systematic procedure to identify and assess risks caused by working in high temperatures in healthcare settings, with the goal to prevent or reduce heat-related health risks, improve workers' health and well-being, and ultimately the quality of care. The scope is health facilities in hot climate regions. Using the procedure requires knowledge of some of the terms and definitions that are relevant for assessing occupational heat stress, although expert knowledge should not be required.

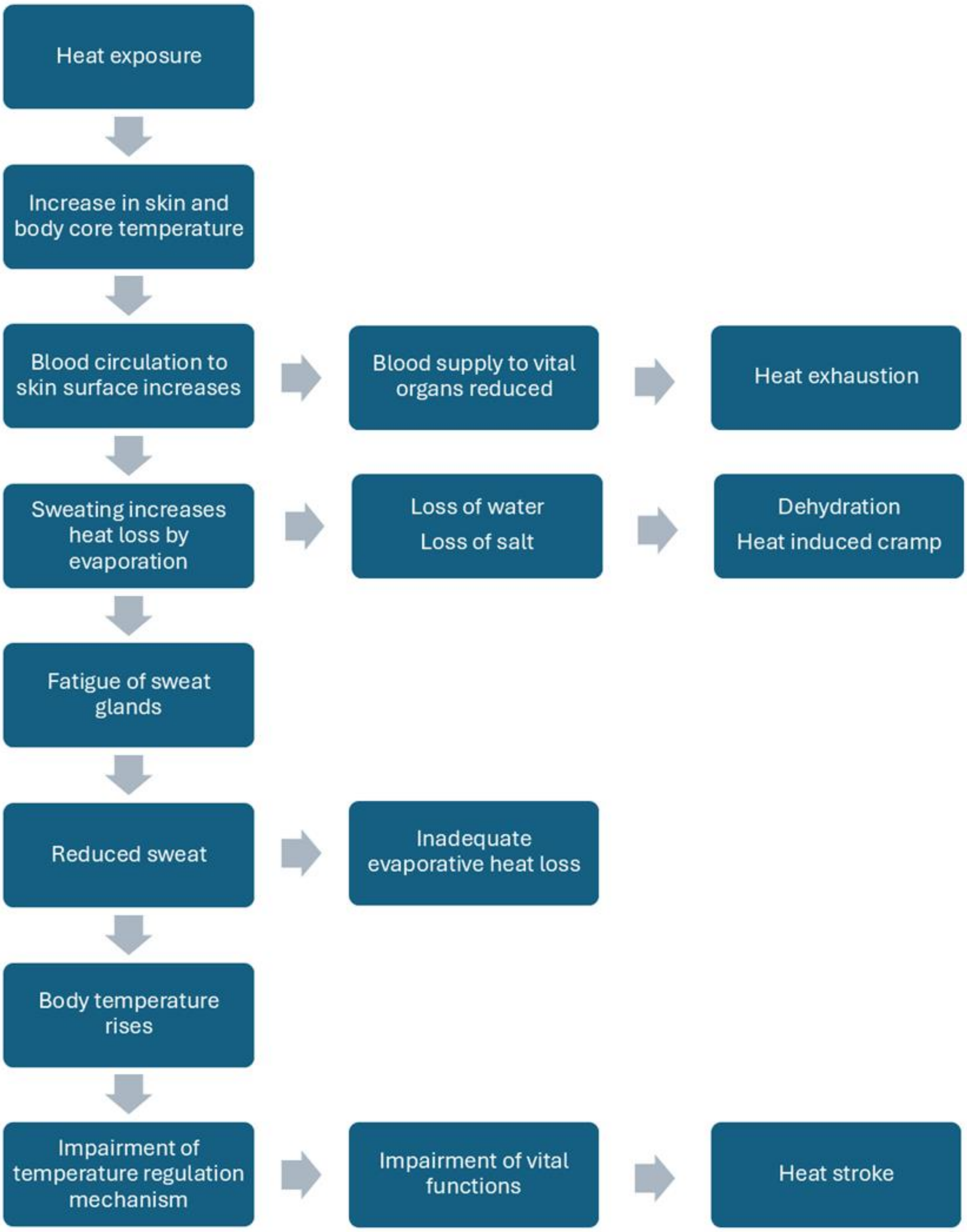
To a large degree, the suggested procedure relies on international standard ISO 8025 "Ergonomics of the thermal environment – management of working conditions in hot environments" (2024). This document describes the methods and practices for organizing the management of hot working environments and the supervision of the exposed persons. In addition, emphasis is placed on evaluating building-related features that may influence the heat exposure of the employees, and which may be modified to alleviate the heat stress. The procedure is not intended to perform a detailed, analytical evaluation of the risks involved in working in heat that may include measurement of both physical and physiological parameters. Actions involved in a more detailed, in-depth analysis are described in ISO 8025 (2024). Rather, the target group includes people with an engagement in occupational health, such as generalists, or employers with a responsibility of securing an appropriate work environment. Also, if they wish, employees can use the procedure to do a screening and assessment of their own working environment.

The report first briefly describes the effects of heat on people and then the connection between different risk factors and heat strain. Eventually, a checklist is suggested to assess and quantify the risk factors. The checklist may be used to evaluate the actions that may be necessary to alleviate heat stress for the employees in a particular healthcare facility. The checklist is also available as stand-alone document (Toftum 2025 & annex 1).

1.2 The body's response to heat

Humans are homeothermic and attempt to maintain an internal body temperature around 37°C (Parsons 2014). To do this, the body relies on both the thermoregulatory system and on behavioural actions. The autonomous thermoregulatory system may increase heat loss from the body by controlling blood circulation and sweating. In heat, the venous blood circulates near the skin to increase the potential for heat transfer from the core of the body to the environment (vasodilation). Behavioural actions in heat could be to remove clothing when feeling warm, or indoors to open a window to increase the air speed induced by natural ventilation airflow or reduce the ambient temperature. When behavioural and physiological mechanisms are insufficient to maintain a balance between the metabolic heat produced in the body and heat lost to the environment, heat stress will occur. With increasing severity, Figure 1 shows effects of heat stress (Manitoba 2007).

Figure 1. Response of the body to excessive heat exposure (adapted from Manitoba 2007)



1.2.1 Dehydration

The evaporation of sweat from the skin is important for the thermoregulatory system to be able to control the body temperature in heat (Parsons 2014). However, prolonged sweating can result in water and electrolyte loss, which requires compensation through regular intake of water and/or salt.

Manitoba (2007) suggests that one to two cups of water per hour are required to replace fluid lost from heavy perspiration. Sugary drinks and fluids containing caffeine and alcohol should be avoided. Thirst is a usable, but not so reliable, sensitive, or valid indicator of dehydration (Parsons 2014) and therefore, workers in hot environments should be actively encouraged to drink during a work shift and drinking water should always be available.

Limits for dehydration may be set to control comfort, health, or performance (Parsons 2014). ISO 7933 (2023) uses a short-term maximum allowable water loss of 3% relative to body mass to limit the exposure duration (in addition to a requirement to rectal temperature as described in section "1.2.4 Heat stroke"). With the option to rehydrate during longer exposures, the maximum allowable water loss to protect 95% of the working population is set at 5% of body mass.

1.2.2 Heat induced cramp

Heat induced cramps may be caused by electrolyte deficit caused by failure to replace salt lost through sweating. Heat cramps may cause pain in the muscles used during work and may appear during or after work (Parsons 2014).

1.2.3 Heat exhaustion

Heat exhaustion is the result of excessive heat strain with inadequate water intake (Goldman 2001). Parsons (2014) provides a list of indicators as signs of heat exhaustion due to dehydration in order of severity: fatigue, loss of appetite, flushed skin, heat intolerance, light-headedness, small amount of dark urine, difficulty swallowing, inelastic skin, sunken eyes, dim vision, painful urination, muscle spasms, and eventually heat illness.

1.2.4 Heat stroke

Heat stroke is caused by a rectal temperature higher than around 40.5°C. Symptoms include confusion, loss of consciousness, and convulsions (Goldman

2001, Parsons 2014). Heat stroke may cause damage to or dysfunction of internal organ systems and may be fatal without treatment.

ISO 7933 (2023) uses an upper limit of the rectal temperature of t_{rec} = 38°C as a population-based average target value to limit the risk of heat stroke. The allowable exposure time, D_{lim}, is reached when either the predicted rectal temperature or the predicted cumulative water loss reaches the corresponding maximum values (ISO 7933-2023).

1.3 Risk factors for heat stress

Most knowledge on the effects of exposure to heat builds on studies with well-trained military personnel or average populations, i.e. populations that were not selected for inclusion in the studies due to their special characteristics, e.g. being particularly sensitive or resistant to heat. However, a range of vulnerabilities associated with the individual should also be accounted for when assessing heat in workplaces. Some of these are briefly described in the following.

1.3.1 Age

The thermoregulatory system of newborns is developing, and they have a higher surface area to volume ratio than adults. Also, behavioural thermoregulation can be complicated as it will rely on the interpretation by the mother or care personnel of signals from the newborn. People older than 60 years are among those affected most by heat stress, caused by a combination of comorbidities at higher age including decreased efficiency of the sweat glands, blood flow to the skin and general cardiovascular function (Kenny et al. 2010, Manitoba 2007). Maximum heart rate decreases with age and a given task may therefore be more stressful for an older than a younger individual.

1.3.2 Sex

Within the general population, women are typically shorter and lighter with a smaller surface area than men and a higher body fat percentage, which may reduce their heat tolerance (Corbett et al. 2023). Also, women appear to have lower sweat rates at higher activities. Pregnancy induces physiological changes in women causing them to be particularly vulnerable to heat due to increased mass and surface area to body volume ratio (Samuels et al. 2022). Also, there is mounting epidemiological evidence that high ambient temperatures are associated with pregnancy complications. Nevertheless, the documentation of the effect of sex on heat tolerance seems inconclusive.

1.3.3 Weight

During some activities, the weight of a person affects the metabolic conversion of energy and thus the generation of heat in the body. For example, for a person weighing 60 kg, walking at level at 5 km/h or going up stairs at a vertical speed of 15 m/minute results in a metabolic rate that is around 25% lower than for a person weighing 80 kg (ISO 8996-2021). However, to some degree the increased surface area of the heavy person compensates for the higher metabolic rate by allowing a higher heat loss to the surroundings. Nevertheless, obesity is a risk factor for heat illness (Goldman 2001) and obese persons may have lower thermal sensitivity to heat stimuli, which can increase the risk of not reacting to heat with a timely response (Kenny et al. 2010).

1.3.4 Acclimatization

Acclimatization refers to the physiological changes that take place after prolonged exposure to heat (Parsons 2014). The degree of acclimatization of an individual impacts greatly the risk of heat stress. Acclimatization is due to training of the sweat glands to produce more sweat. Non-acclimatized individuals will find it harder to perform a given (physical) task in heat than those who are well acclimatized. After 7-10 days of daily heat exposure most individuals will perform work with a lower core temperature and heart rate, and a higher sweat rate. Acclimatization increases the sweat rate and therefore the water requirement is higher, and failure to replace the water may slow or prevent acclimatization.

Absence from work in heat for a week or more may result in loss of acclimatization, but it can be regained after some days with heat exposure (CDC 2016). Acclimatization to heat appears to be better among individuals who are physically fit.

1.3.5 Physical fitness

Lack of physical fitness will reduce heat tolerance. Aerobic fitness may influence sweating and evaporative heat loss, which is lower in those with low aerobic fitness (Corbett et al. 2023). Conditioning programs may be able to increase the maximum work capacity by 15-25% (Goldman 2001). However, when workers wear clothing that inhibits evaporation of sweat (e.g. PPE), the influence of aerobic fitness level on heat tolerance is inhibited.

1.3.6 Disease

Although findings differ between studies, conditions such as respiratory diseases, cardiovascular disease, and diabetes may increase the risk of heat stress in an individual through different mechanisms (Kenny et al. 2010). For example, with diabetes, the ability of the blood vessels in the skin to dilate may be impaired. In addition to other implications for heat tolerance of diabetes, the disease will impair the sweating response to heat.

1.3.7 Medication

Many drugs may interfere with the thermoregulatory function and therefore the tolerance to heat (CDC 2016). Some drugs inhibit dilation of the small blood vessels in the skin, which impedes sweat production. Also, alcohol intake has been associated with increased risk of heat illness.

1.4 International standardization and heat

Several guidelines and international standards provide recommendations to reduce occupational heat stress and suggest methods for the assessment and management of the risks involved in working in hot environments. The procedure suggested in this deliverable relies on these documents, which will be briefly described in this section.

1.4.1 ISO 15265 (2005) Ergonomics of the thermal environment – Risk assessment strategy for the prevention of heat stress or discomfort in thermal working conditions

ISO 15265 (2005) describes a strategy for assessing and interpreting the risk of physiological constraints to working in a given thermal context. The standard suggests a scoring system to identify if a working situation requires heat prevention measures to be taken. A somewhat similar procedure is suggested in this deliverable using partly a scoring system and partly qualitative evaluation of factors related with both the heat stress, the working situation, and the building.

1.4.2 ISO 8025 (2024) Ergonomics of the thermal environment – Management of working conditions in hot environments

ISO 8025 (2024), derived from ISO 15265 (2005), defines six exposure classes (EC) ranging from thermal comfort to immediate thermal constraint. Table 1 shows the criteria for the six exposure classes.

Table 1. Definition of six exposure classes according to ISO 8025 (2024)

Exposure class	Definition	Criterion
1	Thermal comfort	$-0.7 < PMV < 0.7$
2	Light thermal discomfort	$0.7 \leq PMV \leq 1.7$
3	Strong thermal discomfort	$1.7 \leq PMV$ and $D_{lim} \geq 480$ min
4	Thermal constraint in the long term	$120 < D_{lim} < 480$ min
5	Thermal constraint in the short term	$30 < D_{lim} < 120$ min
6	Immediate thermal constraint	$D_{lim} \leq 30$ min

ISO 8025 (2024) describes a procedure to identify as early as possible the class of risk of a given work environment, define accordingly the optimal control measures to eliminate or minimize heat related risks, organize the working situation and protect adequately the exposed persons. The standard recommends using four stages to identify situations where heat-related health problems could occur:

- Stage 1: Screening - Identifies the working situations that cause, or are likely to cause, heat stress exposures by collecting information about the working conditions, the climatic conditions, and heat sources.
- Stage 2: Observation – Reviews qualitatively the working situations that were defined in Stage 1 to define and implement measures to reduce the exposure class to at least EC 2.
- Stage 3: Analysis – Evaluates quantitatively the parameters that characterize the working situations. Thermal indices such as PMV/PPD, WBGT, or PHS may be used.
- Stage 4: Expertise – Required for evaluation of highly complex thermal working situations that require sophisticated or specific measurements.

Because stages 1 and 2 do not require expert knowledge, only these stages will be used in the suggested procedure to determine and assess risks due to thermal exposures.

2 Procedure for assessment of heat risks

The procedure will not be able to exactly express when a situation may lead to heat stress for a given individual, in particular not under conditions where warm discomfort transitions to heat stress, but it may be used to identify factors that contribute to workers' heat exposure, and which may require remediation. The procedure uses a scoring system to identify risk factors related with 1) heat exposure and heat stress at work; 2) the working situation; and 3) the building.

In health care facilities, reducing heat stress in terms of scheduled work/recovery cycles may be difficult to uphold due to the need to assist in care activities regardless of the prevailing environmental conditions. Therefore, it is so much more important to create awareness of the risks and the adaptive opportunities and appropriate behaviour among the employees.

The following scoring scales and evaluation items were adopted from ISO 8025 (2024) and supplemented with additional items regarding the building and its use. The procedure aims to identify working situations with heat-related problems. The procedure combines level screening and level observation to identify and assess risk factors. Examples of how the sheet can be completed may be found in ISO 8025 (2024). If an environment or activity is not constant in time, a representative mean value needs to be determined, e.g. as a time-weighted average over a one-hour period.

Most items in section 1 Factors related with heat exposure and heat stress can be easily scored. An overall evaluation of scores is complicated as there may be a trade-off between scores of different items, when adding up to compare with a heat risk threshold. For example, one item may be scored 3 and two others 0 leading to an average of 1, which is below any of the suggested risk thresholds. Therefore, to evaluate the heat risks caused by the factors in section 2.1 "Factors related with heat exposure and heat stress", both the accumulated score and each individual score should be considered.

The items in sections 2.2 "The working situation and 2.3 "Building features" are less feasible to score to quantify the severity of heat exposure. Instead, these sections may raise awareness of an issue that should be considered to evaluate and/or reduce heat exposure.

Some items are followed by a suggestion of potential remediation, while others are followed by a comment to clarify why it was included in the evaluation.

2.1 Factors related with heat exposure and heat stress

2.1.1 Air temperature

Air temperature	Score	Criterion
Air temperature does not cause problems	0	Low (18°C to 25°C)
Air temperature might cause problems	1	Moderate (25°C to 32°C)
Air temperature definitely causes problems	2 3	High (32°C to 40°C) or Very high (higher than 40°C)
Comment: A high air temperature reduces the potential for convective heat loss from the body. if air temperature is higher than skin temperature, e.g. 40°C, in principle, the body gains heat from the environment through convective heat exchange.		
Potential remediation if 1 (at high or very high workload – see item 7. Physical workload), 2 or 3: Reduce temperature through ventilation or air-conditioning		

2.1.2 Air humidity

Air humidity	Score	Criterion
Neither too dry nor too humid	0	Normal (dry) skin
Rather too humid	1	Moist skin
Very humid (e.g. wet industrial process)	2	Skin completely wet
Comment: A high air humidity reduces the potential for evaporative heat loss from the body. At high physical activity when a high rate of evaporation is needed to cool the body, even a moderately high air humidity may inhibit evaporative heat loss. Air humidity should therefore be considered in combination with the air temperature and physical activity. Integrated indices such as the Heat Stress Index or the Wet Bulb Globe Temperature (WBGT) may be used to evaluate the combined influence on heat stress of air temperature, humidity, clothing, and activity (Belding & Hatch 1955; NIOSH 1986).		
Potential remediation if 2: Reduce humidity through ventilation or air-conditioning or exhaust vapours directly from internal sources.		

2.1.3 Thermal radiation

Thermal radiation	Score	Criterion
No additional thermal radiation	0	No radiation discernible
Medium exposure to radiating hot surfaces or to the sun	1	Warm on the face after 2-3 min
High exposure to radiating hot surfaces or to the sun	2	Unbearable on the face after 2-3 min
	3	Immediate burning sensation
Comment: Strong thermal radiation caused by the sun or hot surfaces reduces the potential for radiant heat loss from the body. It may also gradually during the day warm up the indoor environment (radiant temperature), adding to the heat stress.		
Potential remediation if 2 or 3: Shield the radiant heat at the source through insulation and reflective barriers. If solar radiation through windows, apply solar shading, preferably external.		

2.1.4 Air movement

Air movement	Score	Criterion
Air movement adjustable to individual preferences	0	Possibility to increase air movement, e.g. desk fan or open windows
Limited possibility to adjust air movement to individual preferences	1	Air movement can be adjusted in some zones or outdoor air temperature exceeds indoor air temperature
No possibility to increase air movement	2	No fan available or windows cannot be opened
Comment: When the air temperature is lower than the body surface temperature, increased air movement will increase the convective and evaporative heat loss from the body.		
Potential remediation if 2: Increase air movement if air temperature score is 1 or 2. If the air temperature is slightly higher than skin temperature (around 35-36^{o}C), increased air movement can be still beneficial for the evaporative heat loss, although the body may gain convective heat. If the air temperature is higher than 40^{o}C, increased air movement will no longer increase heat loss.		

2.1.5 Clothing

Clothing insulation	Score	Criterion
Adequate	0	Light, e.g. underwear, shirt, trousers, shoes (I_{cl} = 0.7 clo, ISO 7730-2006)
Partly inadequate (e.g. slightly too highly insulating)	1	Moderate, e.g. underwear with short sleeves and legs, shirt, trousers, jacket, socks, shoes (I_{cl} = 1 clo, ISO 7730-2006)
Inadequate (e.g. too heavy or too thick)	2	High, e.g. underwear with long sleeves and legs, shirt, trousers, sweater, jacket, socks, shoes (I_{cl}=1.3 clo, ISO 7730-2006)
Comment: High clothing insulation reduces the overall heat loss from the body. Clothing may also protect the worker from environmental exposures, e.g. thermal radiation. If the work situation allows, modifying clothing composition is a behavioural action that the worker may use to adjust to the environmental conditions.		
Potential remediation if 1 or 2: Evaluate if the clothing composition or number of layers can be reduced or differently designed garments can be used, e.g. to some that allow higher air circulation or auxiliary cooling in the clothing		

Table 2 shows examples of clothing ensembles that are used to adjust the WBGT for the effect of clothing (ISO 7243-2017).

Table 2. Classification of clothing ensembles according to their influence on the Clothing Adjustment Value used to correct WBGT for clothing insulation that differs from the reference clothing. Adopted from ISO 7243 (2017)

Criterion	Ensemble	Comment
Light	Work clothes	Work clothes made from cotton is the WBGT reference ensemble
Light	Cloth coveralls	Woven fabric that includes treated cotton
Moderate	Vapour-barrier apron with long sleeves and long length over cloth coveralls	To wrap-around apron to protect the front and sides of the body against spills from chemicals
Moderate	Double layer of woven clothing	Generally taken to be coveralls over work clothes
High or very high	Vapour-barrier coveralls as a single layer	Effect depends on the air humidity
High or very high	Vapour-barrier over cloth coveralls	

2.1.6 Personal protective equipment (body, hands, head)

	Score	Criterion
Not applicable	0	Light, flexible
Interferes to some extent (impaired protection against heat)	1	Long, heavier, may interfere with the work
Considerable interference	2	Clumsy, heavy, special for radiation or liquids
Comment: Personal protective equipment may impede body movement and inhibit evaporation of sweat.		
If 1 or 2: PPE may inhibit evaporation of sweat. Consider if the work can be organized with only short duration of PPE use or if personal cooling devices can be used (vests or other devices with ice or phase-change materials near the body).		

2.1.7 Physical workload

	Score	Criterion
Light	0	Table 3 shows criteria to evaluate the workload.
Moderate	1	
High	2	
Very high	3	
Comment: High physical workload increases the generation of heat in the body and needs to be compensated for by the heat lost to the surroundings. In the case of intermittent work, a time-weighted average shall be calculated (ISO 7243-2017). If there is doubt as to which metabolic rate to be adopted for the evaluation of heat stress, the value to be used is that corresponding to the higher metabolic rate. A time-motion study can be conducted to characterize the working situation and the corresponding workload at a specific time (ISO 8025-2024).		
Potential remediation at 2 or 3: If possible, reduce the physical exertion by modifying processes or prolong rest time.		

Table 3. Classification of levels of metabolic rate (ISO 8996-2021)

Criterion	Example
Light	Resting, sitting at ease, light manual work, slow walking
Moderate	Sustained hand and arm work, pushing or pulling lightweight carts
High	Intense arm and trunk work
Very high	Very intense activity at fast to maximum pace

2.1.8 Opinions of the workers

Condition	Score	Criterion
Comfortable	0	No thermal constraint, best comfort
Slightly warm	1	No thermal constraint, increased thermal dissatisfaction
Warm	2	No thermal constraint, high thermal dissatisfaction
Hot	3	Light sweating, thirst, very high thermal dissatisfaction
Very hot	4	Heavy sweating and thirst, slowing of the work rhythm, beyond comfort
Extremely hot	5	Excessive sweating, very painful work
Comment: The scoring is aligned with the 9-pt thermal sensation scale often used to assess thermal sensation where high heat exposure is expected.		

2.1.9 Additional factors related to heat

Factor
Duration of the heat exposure more than short periods during the workday (more than 20-30 min per hour)
Variation of the thermal exposure (e.g. moving between hot and more moderate environments)
Other factors that need to be considered but are not included int the above sections

2.1.10 Evaluation of scores

Section 2.1 includes 7 scored items for which different thresholds are suggested.

If the scores of items 1 to 7 are summed and the total is in the range from 14 to

20, heat risk severity may be high and there is a need to critically evaluate the thermal exposure at the workplace. However, even at lower totals, each individual score at or above 1, depending on the item, needs to be evaluated carefully to identify or rule out risk factors.

2.2 The working situation

Items in this section are not scored but provide a means to identify potential risk factors caused by the working situation.

2.2.1 Work-rest schedule

Is the work organized or will it be possible to organize the work in appropriate work-recovery schedules?	Yes
	No
Comment: Appropriate work-recovery schedule will depend on the thermal conditions and the physical activity. Heat-TLV (2024) suggests work-recovery cycles based on the WBGT and the physical load of the work (Table 4). Note: Evaluation of the WBGT is done under stage 3 Analysis and therefore the necessary input to table 4 may not be available in the suggested procedure for screening and observation. Work-recovery schedules in table 4 indicate the ratio of duration of heat exposure to duration of recovery (periods without heat exposure).	

Table 4. Work-recovery schedule to prevent heat stress (Adopted from Heat-TLV 2024)

	WBGT (°C)			
Allocation of work in a cycle of work and recovery	**Light**	**Moderate**	**Heavy**	**Very heavy**
75% to 100%	31.0	28.0	-	-
50% to 75%	31.0	29.0	27.5	-
25% to 50%	32.0	30.0	29.0	28.0
0% to 25%	32.5	30.5	30.5	30.0

2.2.2 Recovery after high heat exposure

Is it possible for workers to recover (cool down) after periods of high or very high activity in heat?	Yes
	No

2.2.3 Recovery after high heat exposure

If yes in 2.2.2, is it possible for workers to cool down in designated areas with a lower temperature or higher air movement?	Yes
	No
Potential remediation: Provide cooled booths, rest areas with air-conditioning or increased air movement. Increase frequency and duration of rest periods, if possible.	

2.2.4 Adaptive measures - clothing

Can workers adjust their clothing as preferred if the insulation provided is moderate, high or very high?	Yes
	No

2.2.5 Adaptive measures - workload

Can workers moderate their physical workload, if it is high or very high?	Yes
	No

2.2.6 Adaptive measures - windows

Can workers operate windows to increase air movement or reduce the indoor temperature?	Yes
	No

2.2.7 Acclimatization

Are workers acclimatized to working in heat?	Yes
	No
Comment: If No, apply a work schedule to allow for acclimatization. ISO 8025 (2024) suggests that acclimatization can be achieved by daily exposures for several hours to heat during five consecutive days of exposure according to the scheme: • For persons familiar to a task: 50% of normal hours the first day, 60% on the second day, 80% on the third day and 100% from the fourth day. • For persons newly affected by the task: 20% on the first day and then, if possible, increase by 20% each successive day. • During the acclimatization period, the workers should be monitored by someone trained to recognize early signs of heat illness.	

2.2.8 Hydration

Do workers have easy access to drinking water?	Yes
	No
Potential remediation: Offer drinking water to compensate for water lost through sweating. Depending on the EC of the working situation, allow workers to frequently drink in small quantities (150 to 200 ml) every 15-20 min (ISO 8025 -2024).	

2.2.9 Health and safety training

Are supervisors trained in recognizing signs of heat illness?	Yes
	No
Comment: ISO 8025 (2024) recommends supervisor training depending on the EC level. At high levels from 3 to 6, supervisor should be able to recognize signs of heat-related illness and focus on the need to drink regularly.	

2.2.10 Health and safety awareness

Do workers have basic knowledge about working in heat, e.g. the importance of staying hydrated or how they can compensate heat exposure?	Yes
	No
Potential remediation: Set up buddy arrangement to remind each other to drink.	

2.2.11 Previous heat illness

Has any screening for heat intolerance been performed, e.g. for previous heat illness?	Yes
	No

2.3 Building features

The following section focuses on building related features that may affect indoor temperature and heat exposure during work indoors. The section includes building features that can be observed without expert knowledge. More complex or hidden features such as building materials, extent of insulation, technical details of ventilation and cooling were therefore omitted. These items are not scored but provide a means to identify potential risk factors caused by the building design and use.

2.3.1 Window orientation

What is the main orientation of windows in the surveyed room?	North
	South
	East
	West
	Northeast
	Northwest
	Southeast
	Southwest
Comment: If the building is located on the southern hemisphere and the main orientation of the windows is north, northeast, or northwest, or the building is located on the northern hemisphere and the main orientation of the windows is south, southeast, or southwest, solar irradiation may contribute to raise the indoor heat exposure.	
Potential remediation: Solar shading can mitigate the issue, but depending on the type of solar shading, irradiation may still affect significantly the indoor heat exposure and temperature. The best shading efficiency is achieved when the shading device is located on the outside of the window.	

2.3.2 Window-to-floor-area ratio

What is the approximate window-to-floor-area ratio?	0-5%
	5-10%
	10-15%
	15-20%
	>20%
Comment: Windows are needed for daylight access but also allow radiant heat to enter the building. If the window-to-floor-area ratio is larger than 10%, solar shading should be used to reduce the solar load, in particular if the main orientation of the windows may be affected by direct solar irradiation during a large part of the day (see item above).	

2.3.3 Operable windows

Are windows operable and is it possible for workers to open windows?	Yes
	No
Comment: Operable windows are needed to enable ventilative cooling when the outdoor temperature permits. However, even though windows can be operated, access may be blocked or there may be social restrictions (colleagues, security concerns, outdoor air quality, noise) that prevent opening.	

2.3.4 One-sided or crossflow natural ventilation

Can windows be opened on only one side of the room/building or on two opposite sides	Only on one side
	On two opposite sides
Comment: If windows can be opened only on one side of the building, ventilation is restricted to come from one side, which is far less efficient than when cross-flow ventilation can be achieved with open windows in two opposite (or perpendicular) facades.	

2.3.5 Night cooling

Can windows be opened at night (at least partly) to cool down the building when the outdoor temperature is lower than during the day?	Yes
	No
Comment: Depending on the geographical location and the season, night cooling by ventilation with cool outdoor air may provide cooling also during the day, especially in buildings with high thermal mass (concrete, brick) where the temperature increase will be slower than in light buildings (e.g. wooden). However, safety issues may prevent windows from being opened at night. Depending on the geographical location, mosquitoes may present another issue.	

2.3.6 Solar shading

What type of solar shading is available?	None
	Curtains
	Blinds
	Fixed overhang
Comment: The efficiency of solar shading to reduce solar irradiation depends on its type. Curtains are least efficient, while fixed overhang may eliminate entirely direct solar irradiation depending on their depth. In general, solar shading installed on the outside of the building envelope is more efficient than on the inside.	

2.3.7 Shading objects

Are there trees or other objects near the building that provide shading?	Yes
	No
Comment: A building located far away from trees, neighbouring buildings or other objects that may provide shading can be highly exposed to solar irradiation.	

2.3.8 Ratio of room area to number of occupants

Approximately what is the ratio of the area of the room to the number of occupants?	>10 m^2 per person
	5-10 m^2 per person
	1-5 m^2 per person
Comment: People emit heat, so a high occupant density should be avoided, at least during periods with high solar load or high heat load from equipment.	

2.3.9 Heat sources

Are there strong heat sources in the room?	Yes
	No
Comment: Strong heat sources contribute to the heat exposure by emission of radiant and/or convective heat.	
Potential remediation: If the equipment produces mostly radiant heat, shield the radiant heat at the source through insulation and reflective barriers. With convective heat, exhaust warm air from the equipment to the outside.	

2.3.10 Fans

<table>
<tr><td rowspan="2">Are desk, standing or ceiling fans available?</td><td>Yes</td></tr>
<tr><td>No</td></tr>
<tr><td colspan="2">Comment: Desk or standing fans increase air movement and thus convective cooling if the air temperature does not exceed the skin temperature by too much (see comment to item 2.1.4 "Air movement").</td></tr>
</table>

2.3.11 Ventilation grilles

<table>
<tr><td rowspan="2">Does the room have ventilation grilles in the façade?</td><td>Yes</td></tr>
<tr><td>No</td></tr>
<tr><td colspan="2">Comment: Like windows, ventilation grilles may introduce outdoor air to a room and provide ventilative cooling, although considerably less than windows, which typically offer a larger opening area. Increased ventilation with unfiltered outdoor air requires an appropriate outdoor air quality.</td></tr>
</table>

2.3.12 Mechanical ventilation

<table>
<tr><td rowspan="2">Does the building have a mechanical ventilation system?</td><td>Yes</td></tr>
<tr><td>No</td></tr>
<tr><td colspan="2">Comment: If the outdoor temperature is lower than the indoor temperature, a mechanical ventilation system may be a robust way to lower the indoor temperature.</td></tr>
</table>

2.3.13 Air conditioning

<table>
<tr><td rowspan="2">Does the building have comfort cooling, e.g. a ventilation system with cooling or a split-type air conditioner on the wall?</td><td>Yes</td></tr>
<tr><td>No</td></tr>
<tr><td colspan="2">Comment: Air conditioning can provide comfortable indoor temperatures but requires energy and maintenance and has high installation cost. Sustainable use of air conditioning may require use of photovoltaics or other green energy production.</td></tr>
</table>

2.3.14 Thermal accumulation

Is the building made of light (wood) or heavy materials (concrete, brick)?	Yes
	No
Comment: Heavy building materials can accumulate more heat than light ones. Heavy materials exposed to the room can therefore absorb more heat with only moderate temperature change. If cooled at night, heavy materials can contribute to keeping a low temperature indoors for longer than light materials.	

3 Example (adapted from ISO 8025-2024)

The following example intends to demonstrate how the procedure can be used in an imaginary healthcare facility located on the southern hemisphere.

Work activity: *Nurse in neonatal care*

Description of the working areas and activities: *Monitoring, assisting mothers with nursing activities*

Item	Present score	Comment	Expected score after remediation
1.1 Air temperature	2: High (32°C - 40°C)	Increase ventilation by opening windows in several facades	1: Moderately high (25°C -32°C)
1.2 Air humidity	2: Skin completely wet	Increase ventilation by opening windows in several facades	1. Moist skin
1.3 Thermal radiation	1: Warm on the face after 2-3 min	Apply solar shading consistently. Move work from areas with direct solar radiation	0: No discernible radiation
1.4 Air movement	2: No air movement	Increase ventilation by opening windows in several facades. Use desk or standing fans.	0: Air movement adjustable to individual preferences
1.5 Clothing	0: Light	-	0: Light
1.6 PPE	-	-	-
1.7 Physical workload	1: Moderate	-	1: Moderate

Item	Present score	Comment	Expected score after remediation
1.8 Workers opinion	1: Slightly hot	This item will be affected by the remediation actions for the other items	0: No thermal constraint
1.9 Duration / Variation / Other	-	Factors appropriate	
Total	9	Total indicates that some items score lower than critical range, even though there is a possibility of improvement through remediation. In particular, modifying air temperature, air humidity, and air movement can lower the total score. The Expected score after remediation indicates that conditions may be warmer than comfortable, but not close to being critical.	3
2.1 Work-rest schedule	Yes	Work not too physically demanding and the workload varies over a shift	
2.2 Recovery after high heat exposure	No	Prepare zones with lower temperature (air conditioning) or increased air movement	Yes
2.3 Adaptive measures - clothing	Yes	Current uniform is light and allows air circulation near the body	
2.4 Adaptive measures - workload	(Yes)	Physical workload not high or very high	
2.5 Adaptive measures - windows	(Yes)	Windows openable during the day	
2.6 Acclimatization	Yes	Staff generally well adapted to heat exposure	

Item	Present score	Comment	Expected score after remediation
2.7 Hydration	No	Drinking water available from central taps. More possibilities for drinking water should be available	Yes
2.8 Health and safety training	Yes	Due to the nature of the workplace (health facility), there is good knowledge of symptoms related with heat illness	
2.9 Health and safety training	Yes	Same as above	
2.10 Previous heart illness	Yes	Same as above	
3.1 Window orientation	North	Facility located on southern hemisphere, so solar shading should be used to block direct radiation during midday	
3.2 Window-to-floor-area ratio	Approximately 10%	On the limit to a large glazed area that allows a high degree of solar irradiation. Use of solar shading should be observed	
3.3 Operable windows	Yes	See comment 2.5	
3.4 One-sided or crossflow ventilation	Only on one side	Consider adding apertures for ventilation in internal walls and external walls opposite windows	On two opposite sides
3.5 Night cooling	No	Security issues restrict opening windows at night. Adding ventilation grilles may allow higher air circulation at night without compromising security	Yes
3.6 Solar shading	Yes	Overhang blocks the direct solar radiation	
3.7 Shading objects	Yes	Trees and neighbouring buildings contribute to block direct solar irradiation	

Item	Present score	Comment	Expected score after remediation
3.8 Ratio of room area to number of occupants	>10 m^2 per person	Occupant density is low and occupants do not cause high heat load	
3.9 Heat sources	No	No strong heat sources in the room	
3.10 Fans	No	Fans should be available to increase air movement (see also 1.4)	Yes
3.11 Ventilation grilles	No	Install ventilation grilles to increase air movement	Yes
3.12 Mechanical ventilation	No	Install a ventilation system to replace or dilute indoor air with outdoor air. May provide lower air temperature and increased air movement	Yes
3.13 Air conditioning	No	Install an air conditioning system to control temperature as desired	Yes
3.14 Thermal accumulation	No	Building made of concrete/brick with high thermal accumulation. Night cooling could contribute to lower the temperature during the day	

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5 Annexes

5.1 Annex 1: Checklist v1.0 (February 2025)

Version 1.0 of the stand-alone checklist is available on Zenodo: https://doi.org/10.5281/zenodo.14943973.

This version is being tested in health facilities in hot climate regions, and will be updated afterwards.

Full reference:

Toftum J, HIGH Horizons Study Group. HIGH Horizons - User-friendly tool for heat-related risk assessment of the working environment in health facilities - CHECKLIST. Zenodo; 2025.

5.2 Annex 2: Lessons learned from field testing

The above checklist is being tested at health facilities in Zimbabwe in the period March – July 2025. Lessons learned from applying the checklist will be included in August 2025.