

# Heat Resilience for Human Health and Potential

**Jason KW LEE Ph.D., FACSM**

Director, Heat Resilience & Performance Centre  
Chair, WHO-WMO GHHIN Southeast Asia Heat Health Hub



Heat Resilience & Performance Centre  
Yong Loo Lin School of Medicine

---

# EXTREME HEAT AND SOCIO-ECONOMIC DISPARITIES

## Case Study: Shoemaking factory in Vietnam (Project HeatSafe)

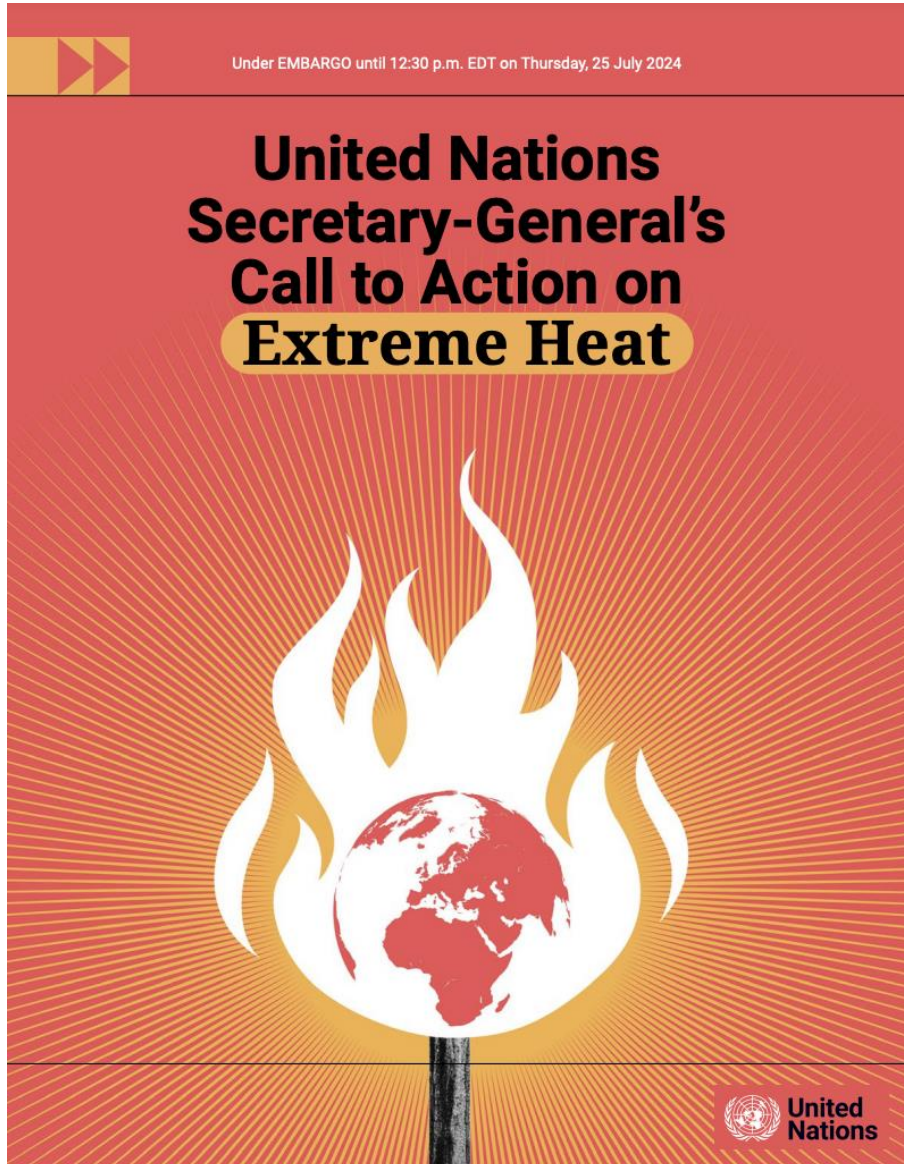




**“The era of global  
boiling has arrived.”**

United Nations Secretary-General  
António Guterres  
July 2023





## The 2024 report of the Lancet Countdown on health and climate change: facing record-breaking threats from delayed action



Marina Romanello, Maria Walawender, Shih-Che Hsu, Annalyse Moskeland, Yasna Palmeiro-Silva, Daniel Scamman, Zakari Ali, Nadia Ameli, Denitsa Angelova, Sonja Ayeb-Karlsson, Sara Basart, Jessica Beagley, Paul J Beggs, Luciana Blanco-Villafuerte, Wenjia Cai, Max Callaghan, Diarmid Campbell-Lendrum, Jonathan D Chambers, Victoria Chicmana-Zapata, Lingzhi Chu, Troy J Cross, Kim R van Daalen, Carole Dalin, Niheer Dasandi, Shouro Dasgupta, Michael Davies, Robert Dubrow, Matthew J Eckelman, James D Ford, Chris Freyberg, Olga Gasparyan, Georgiana Gordon-Strachan, Michael Grubb, Samuel H Gunther, Ian Hamilton, Yun Hang, Risto Hänninen, Stella Hartinger, Kehan He, Julian Heidecke, Jeremy J Hess, Louis Jamart, Slava Jankin, Harshavardhan Jatkar, Ollie Jay, Ilan Kelman, Harry Kennard, Gregor Kiesewetter, Patrick Kinney, Dominic Kniveton, Rostislav Kouznetsov, Pete Lampard, Jason K W Lee, Bruno Lemke, Bo Li, Yang Liu, Zhao Liu, Alba Llabrés-Brustenga, Melissa Lott, Rachel Lowe, Jaime Martinez-Urtaza, Mark Maslin, Lucy McAllister, Celia McMichael, Zhifu Mi, James Milner, Kelton Minor, Jan Minx, Nahid Mohajeri, Natalie C Momen, Maziar Moradi-Lakeh, Karyn Morrissey, Simon Munzert, Kris A Murray, Nick Obradovich, Megan B O'Hare, Camile Oliveira, Tadj Oreszczyn, Matthias Otto, Fereidoon Owfi, Olivia L Pearman, Frank Pega, Andrew J Perishing, Ana-Catarina Pinho-Gomes, Jamie Ponmattam, Mahnaz Rabbaniha, Jamie Rickman, Elizabeth Robinson, Joacim Rocklöv, David Rojas-Rueda, Renee N Salas, Jan C Semenza, Jodi D Sherman, Joy Shumake-Guillemot, Pratik Singh, Henrik Sjödin, Jessica Slater, Mikhail Sofiev, Cecilia Sorensen, Marco Springmann, Zélie Stalhandske, Jennifer D Stowell, Meisam Tabatabaei, Jonathon Taylor, Daniel Tong, Cathryn Tonne, Marina Treskova, Joaquin A Trinanes, Andreas Uppstu, Fabian Wagner, Laura Warnecke, Hannah Whitcombe, Peng Xian, Carol Zavaleta-Cortijo, Chi Zhang, Ran Zhang, Shihui Zhang, Ying Zhang, Qiao Zhu, Peng Gong\*, Hugh Montgomery\*, Anthony Costello\*

### Record-breaking Heat-related Threats in 2023



#### Highest Count of Health-Threatening Days

In 2023, there were 50 more days in a year where heat posed a serious health risk compared to what would have been expected without climate change.



#### Highest Exposure to Heat Stress Risk During Exercise

In 2023, people exercising outdoors were exposed, on average, to 1,512 hours of at least moderate heat stress risk -- a 27.7% increase from the 1990s.

### Delayed action puts everyone at risk

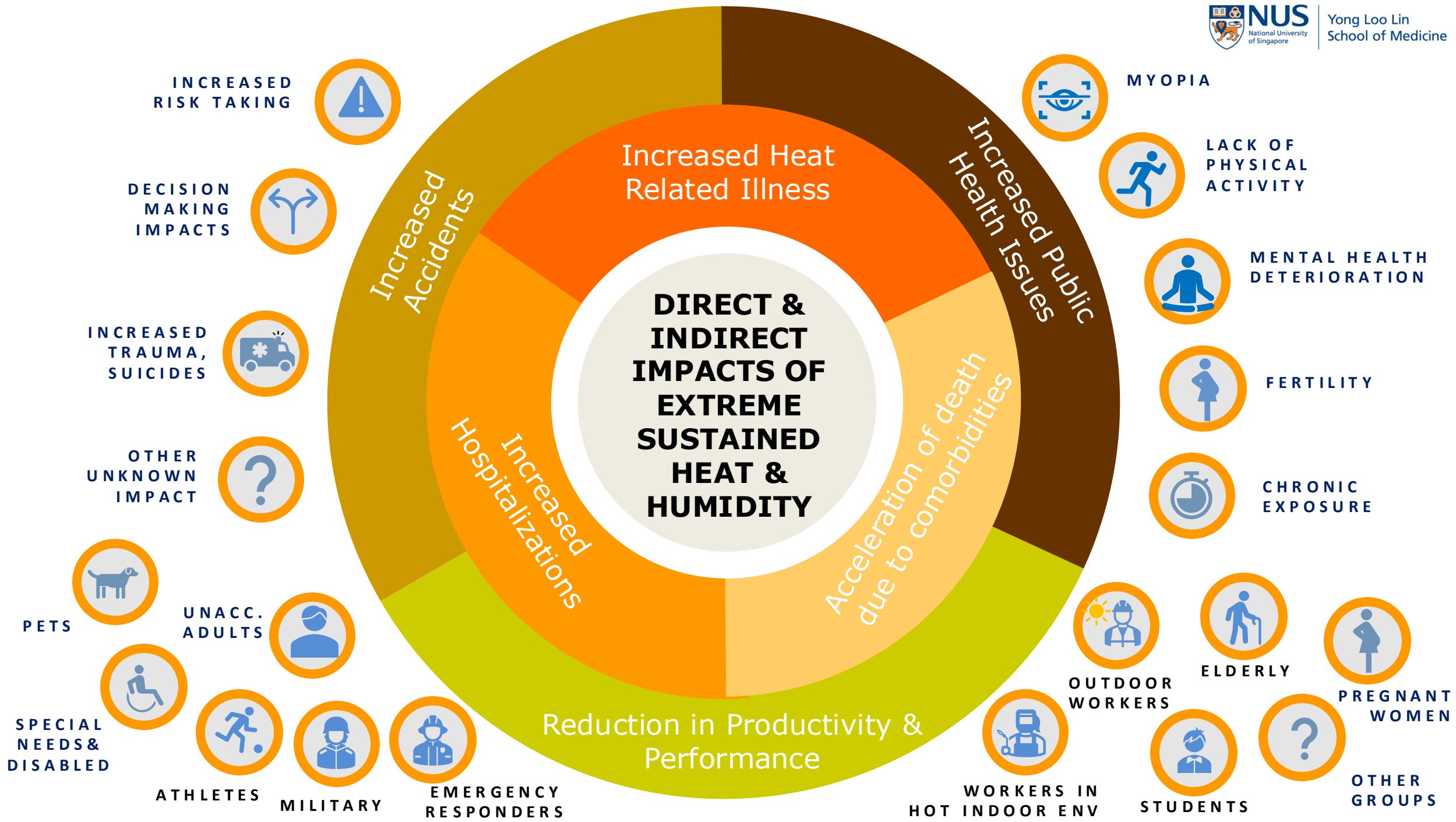
Despite the health threats brought about by climate change, progress towards net zero greenhouse gas emissions has been limited. To achieve an equitable and healthy future, resources should be urgently redirected towards efforts that benefit people's health and wellbeing.

“

Following decades of delays in climate change action, avoiding the most severe health impacts of climate change now requires aligned, structural, and sustained changes across most human systems, including energy, transportation, agriculture and health care

2024 report of the Lancet Countdown on health and climate change





# **‘HEAT-SENSITIVE’ HEALTH CONDITIONS**

Health conditions that can worsen or become more difficult to manage in high temperatures

**e.g. chronic conditions**



Cardiovascular  
disease



Renal  
disease



Pulmonary  
disease

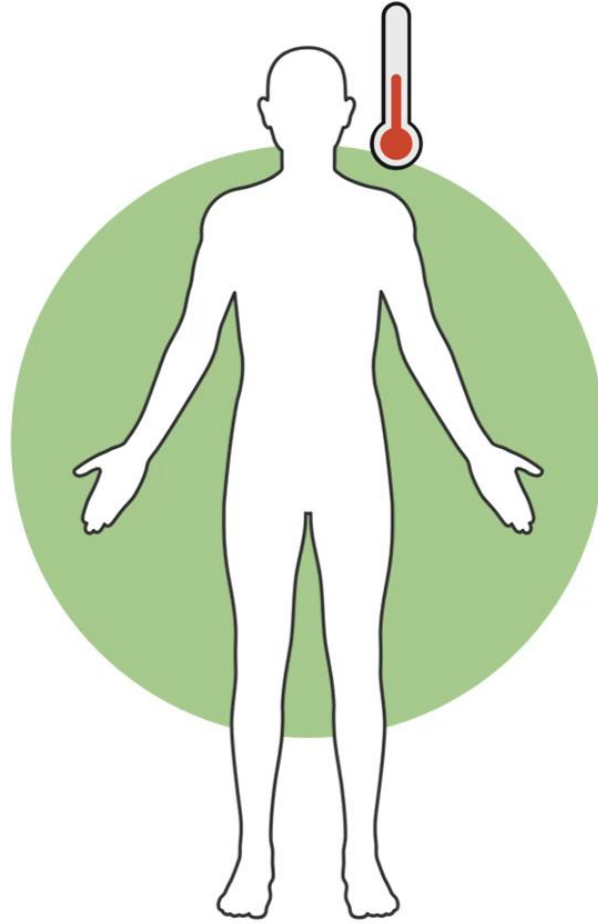


Hypertension

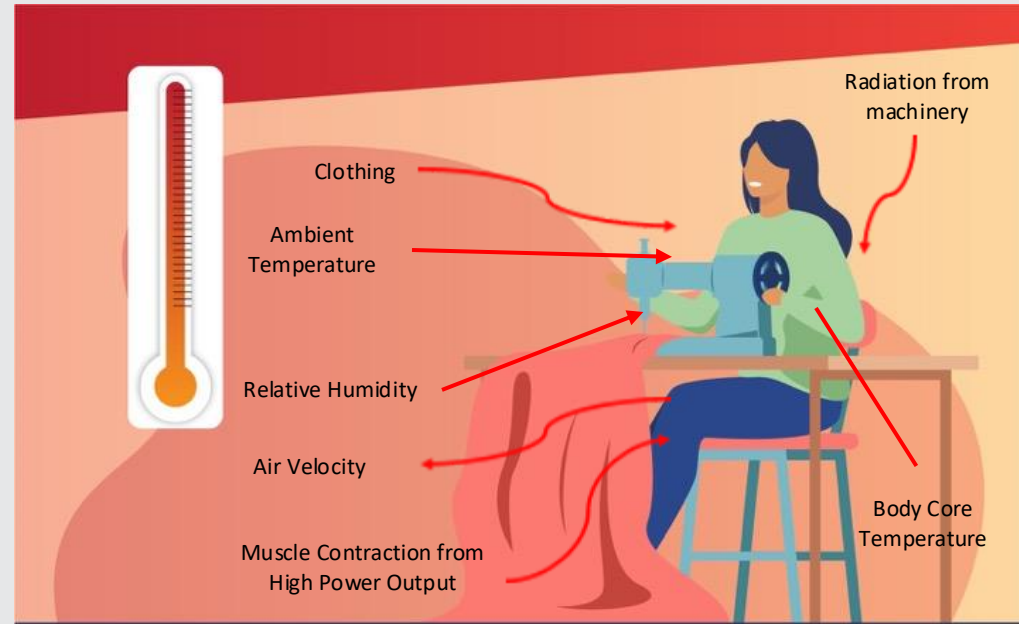
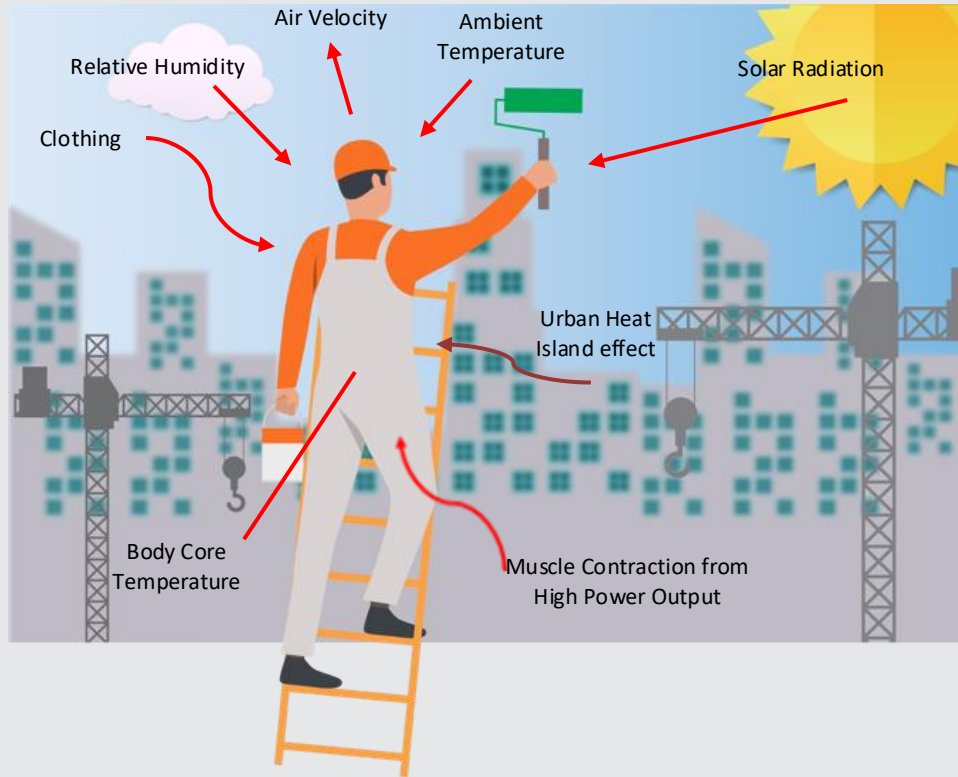
# **HOW DOES THE BODY RESPOND TO HEAT?**



# THERMOREGULATION



# HEAT STRESS VS. HEAT STRAIN?



**Weather + Attire + Physiology  
(Heat Stress)**



**Heat Strain** ⚠



**THE STRAITS TIMES** SINGAPORE

# Worker who died after falling off rooftop likely disoriented from heat stress: Coroner





# Thermal Discomfort and Risk Taking



## Healthcare workers face unique risks

For healthcare workers (HCWs) responding to chemical disasters or pandemics, wearing personal protective equipment (PPE) is essential for their safety. However, PPE usage hampers heat dissipation and increases thermal strain experienced by HCWs as they execute their tasks.

**Observed Consequences of Heat Exposure**

- Increased risk-taking behaviour**  
May affect adherence to safety procedures and increase workplace accidents.
- Loss in maximal strength**  
May increase injury risks and compromise the ability of HCWs to perform lifesaving procedures that require good manual dexterity and strength.

## Managing heat strain while wearing PPE

A recent study by Alhadad et al. (2024) found that effective heat management strategies can be as straightforward as consuming an ice slurry before donning PPE and engaging in strenuous tasks:

**Key Findings & Implications**

Ambient temperature	VS	Ice slurry
 <b>Loss in maximal strength</b>		 <b>No change in maximal strength</b>
 <b>Increased risk-taking behaviour</b>		 <b>No change in risk-taking behaviour</b>

Ice slurry ingestion effectively prevented the decline in maximal strength and risk-taking behavior, indicating its potential to attenuate these adverse heat risks in thermally challenging situation.



# HEAT RESILIENCE

## HEALTH PILLARS



Sleep



Diet



Exercise

## LIFE STAGES



Infants



Children



Adults



Elderly

## POPULATION-SPECIFIC



Occupational  
health



Children's  
development



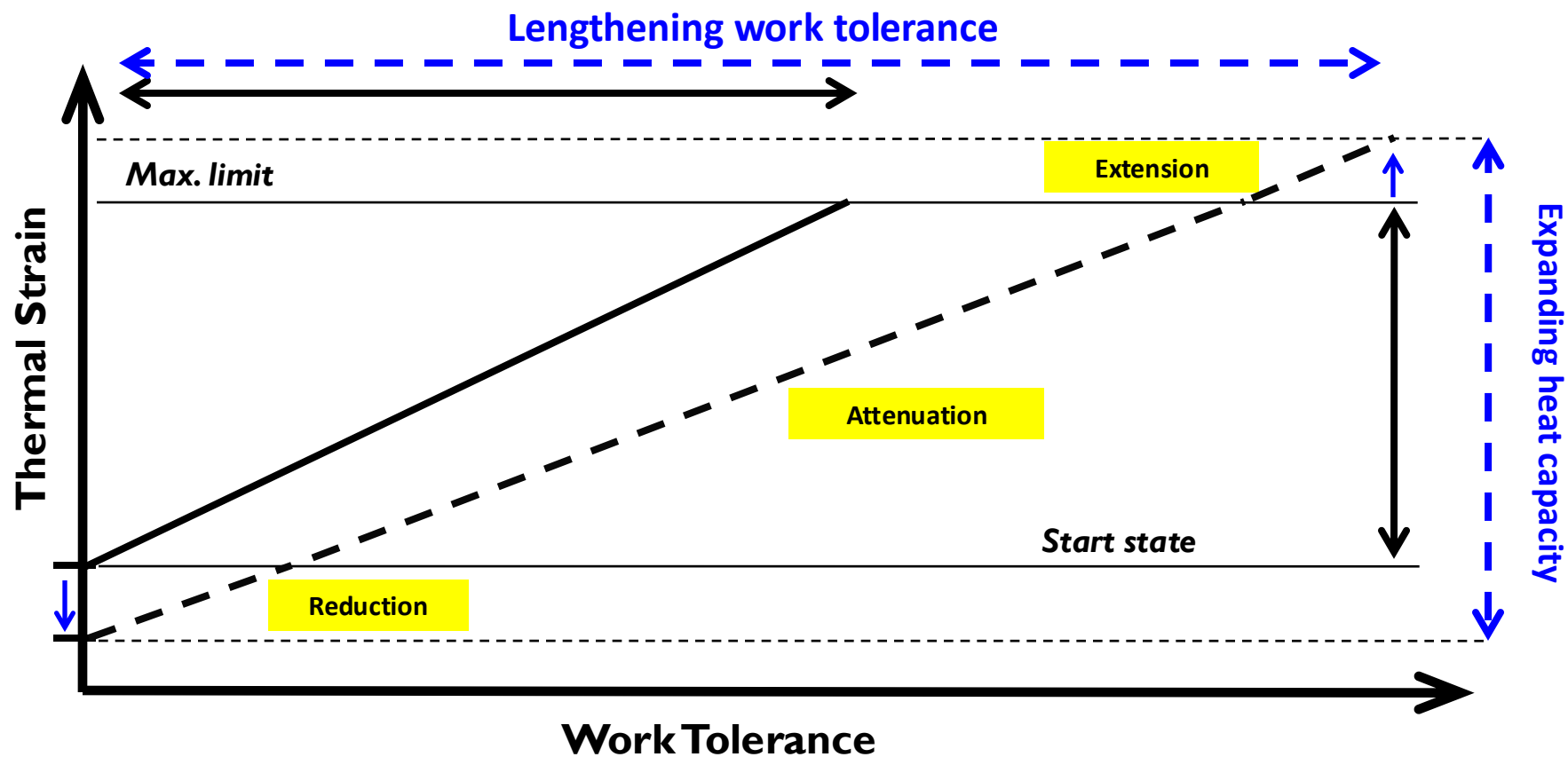
Maternal  
Health



Male  
Fertility


# MANAGING HEAT STRAIN

## PHYSIOLOGICAL SOLUTIONS



*Alhadad et al. (2019); Front. Physiol.*


# PHYSIOLOGICAL SOLUTIONS



**AEROBIC FITNESS  
CONDITIONING**

---

Reduction  
Attenuation  
Extension



**HEAT  
ACCLIMATIZATION**

---


Reduction  
Attenuation



**PRE-ACTIVITY  
COOLING**

---


Reduction



**WORK REST CYCLES**

---

Reduction  
Attenuation



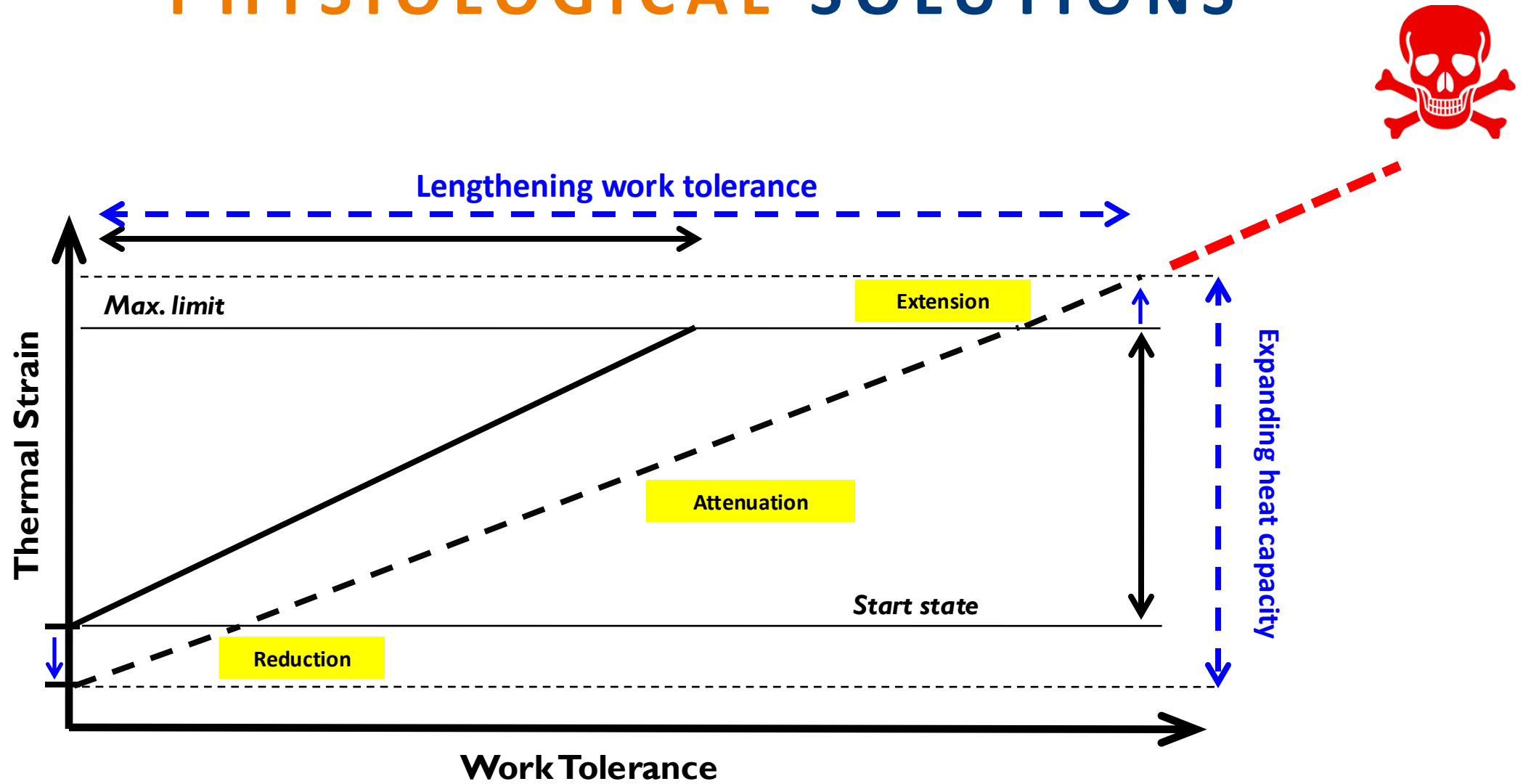
**HYDRATION**

---

Attenuation

*Alhadad et al. (2019); Front. Physiol.*

# PHYSIOLOGICAL SOLUTIONS



*Alhadad et al. (2019); Front. Physiol.*



# PROOF OF CONCEPT: REAL TIME HEAT HEALTH MONITORING



## Start of the 21 km race





# Extreme heat is a global health emergency.

Billions of people are at risk of preventable death and illness from extreme heat. The Global Heat Health Information Network is helping to increase awareness and capacity to better manage and adapt to the health risks of dangerously hot weather in a changing climate.



# GHHIN Southeast Asia Hub

A platform for Southeast Asia to collectively prepare for and protect populations from the health impacts of extreme heat



GLOBAL HEAT HEALTH  
INFORMATION NETWORK  
**SOUTHEAST ASIA**

## OUR GOALS

### PEOPLE

Connect people and institutions form multi-disciplinary partnerships to reduce heat risks

### SCIENCE & INFO

Accelerate the generation of evidence, actionable knowledge, standardised guidance, risk metrics, and effective communication

### ACTION

Catalyse regional, national and local policy and action to minimize societal consequences of heat impacts

## REGIONAL FOCUS AREAS



Urban Heat



Heat at Work



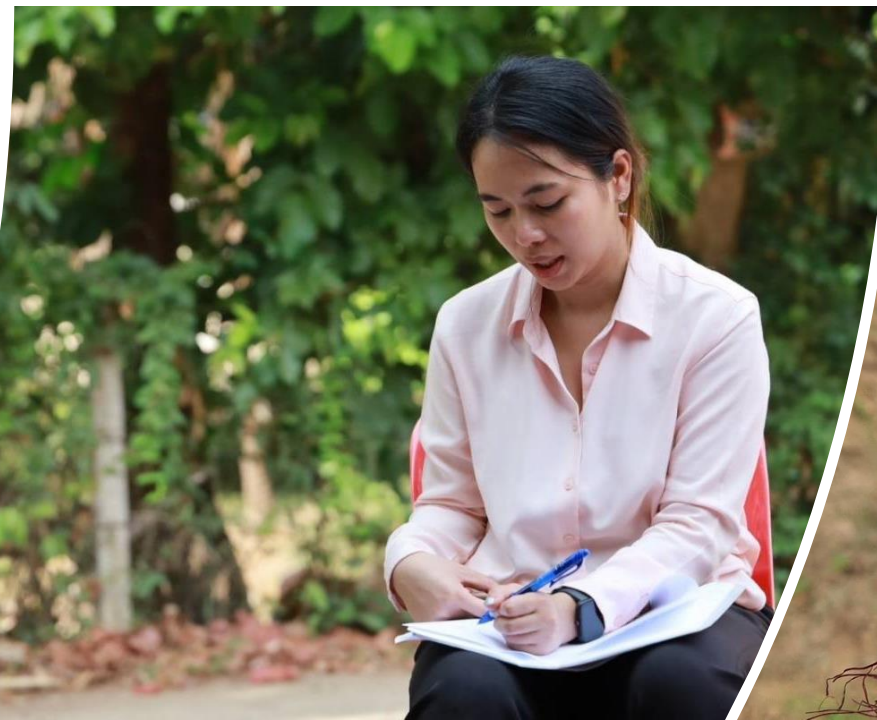
Traditional &  
Cultural Practices

## JOIN US

Connect to the Hub & Global Heat Health Digest



Remember  
them





# HEAT RESILIENCE & PERFORMANCE CENTRE

A globally-connected, first-class  
research centre enabling humans to  
thrive in a warming world

[www.medicine.nus.sg/hrpc](http://www.medicine.nus.sg/hrpc)



Heat Resilience & Performance Centre  
Yong Loo Lin School of Medicine

## OUR RESEARCH FOCUS



### DISCOVER

Discovery of  
Heat  
Mechanisms



### DETECT

Ensuring Heat  
Health  
Readiness



### STRENGTHEN

Optimising  
Heat  
Resilience

## SOUTHEAST ASIA REGIONAL HEAT HEALTH HUB



GLOBAL HEAT HEALTH  
INFORMATION NETWORK



WORLD  
METEOROLOGICAL  
ORGANIZATION



World Health  
Organization

