Occupational heat stress and Health implications – Evidence from LMICs

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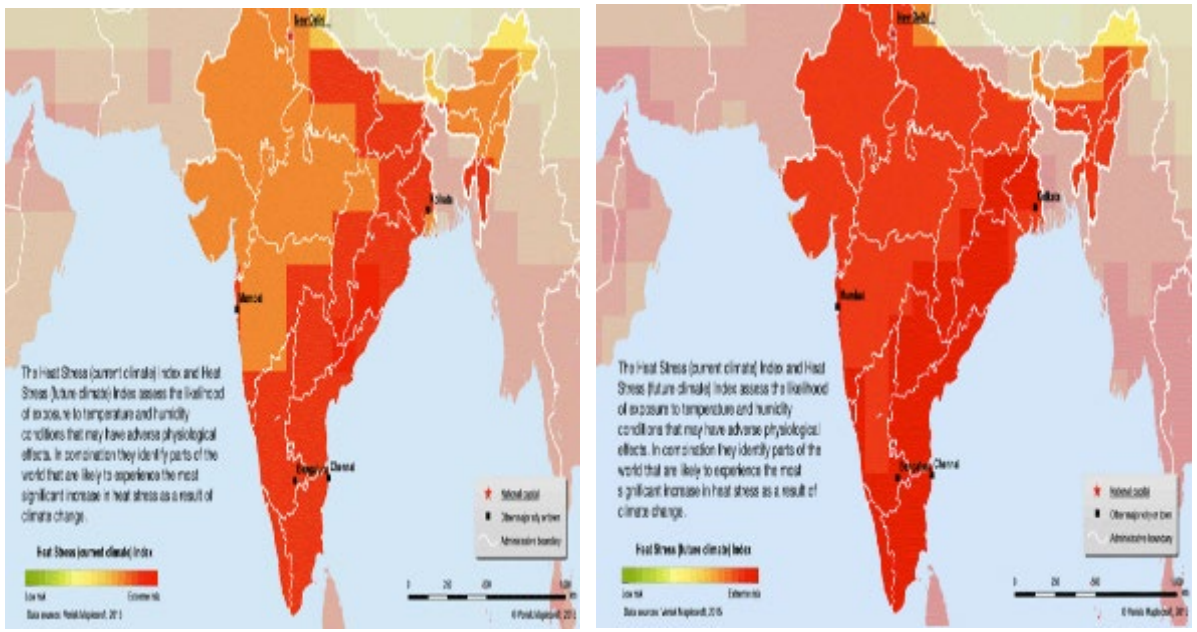
The need for heat-impacts evidence…

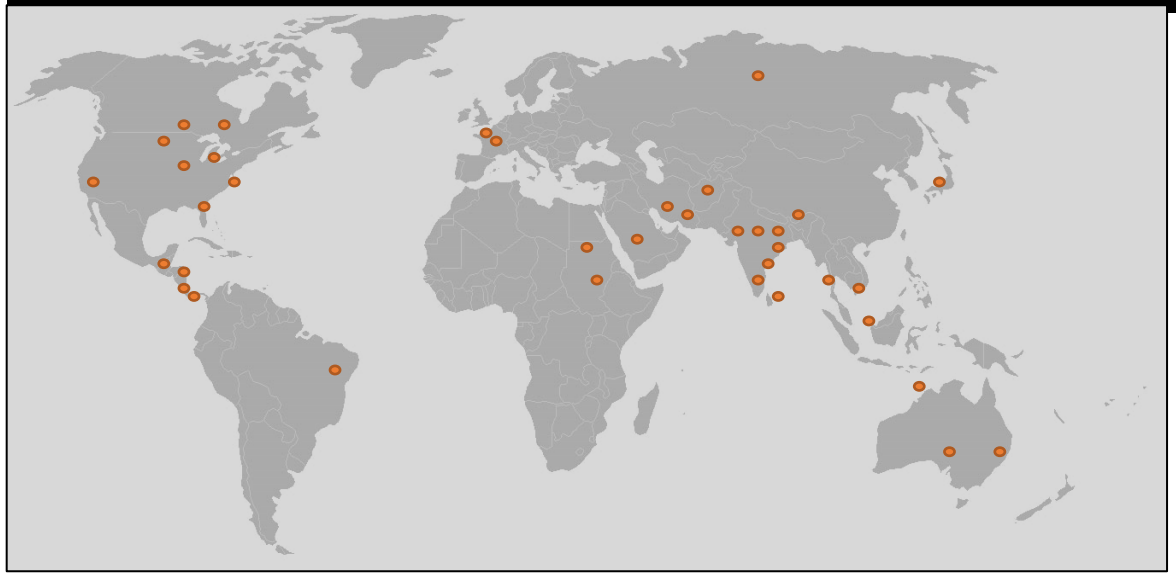
- **Global warming has increased Earth's temperature by 1.2°C, driving extreme heat and climate risks.**
- **Increasing heat leads to heat stress, dehydration, and other health problems, especially among workers.**
- **Projections: By 2030, India will lose 34 million jobs due to heat *(IPCC, 2022).***
- **WHO / ILO: projected productivity loss of $2.4 trillion due to heat by 2030.**
- **ILO reported that about 1.6% of total working hours are lost annually due to heat stress.**

CURRENT **2080**



Future heat stress status for India

Reported sites with heat stress & health impacts



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Who is most impacted - Rising heat & workers….

- Climate change is increasing the **frequency, intensity, and duration of heatwaves**, straining vulnerable populations *(Margolis et al., 2020).*
- Heat Stress poses a major challenges to **Occupational health and safety**.
- Work is central to livelihoods → *exposure is unavoidable,* which directly impacts workers' **health, productivity, and safety**.
- Workers exerting in **outdoor/non-airconditioned workspaces**, face the brunt of rising temperatures.

Key Insight:

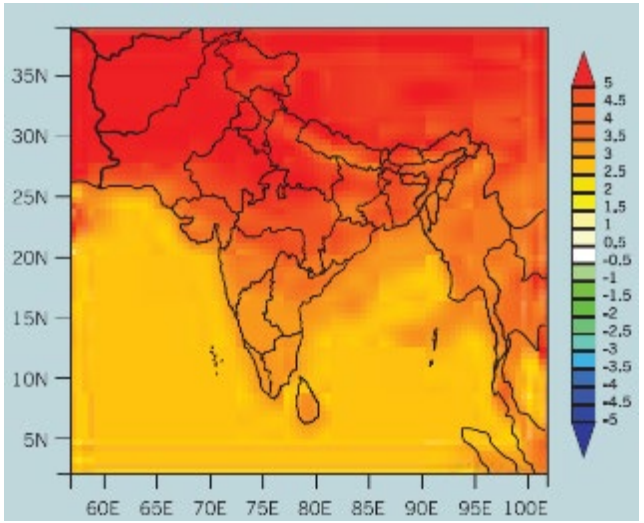
The frequency of extreme heat days (above 35°C/95°F) is projected to increase 3-5 -fold in many regions by 2050.

Evidence from India:

- ✓ Average WBGT: **38–46°C** with 40–80% humidity.
- ✓ **91%** workers reported heat-related illnesses *(Venugopal et al., 2022).*

In 2024, India recorded its highest number of intense heatwaves:

- ✓ **37 cities exceeded 45°C.**
- ✓ **670 million workers** depend on heat-exposed labor, many in life-threatening conditions.



Change in annual mean surface temperature by the 2080s compared to 1961-1990, from the IPCC A2 scenario. Source: IPCC

Heat Stress: A Common Occupational Hazard in Tropical Settings

Rice fie

rker near cokeoven

- ILO: Nearly **81%** of India's workforce is employed in the **informal sector.**
- **50%** of workers contribute to **India's national income.**
- **Physical work remains high** across occupational sectors with minimal automation, cooling, and welfare provisions.
- Rising **kidney diseases** reported in mining and agricultural communities.

Stone quarry

Brick manufacturing

Construction worker

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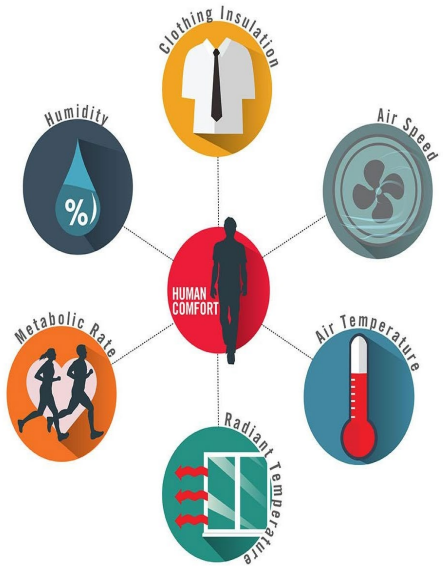
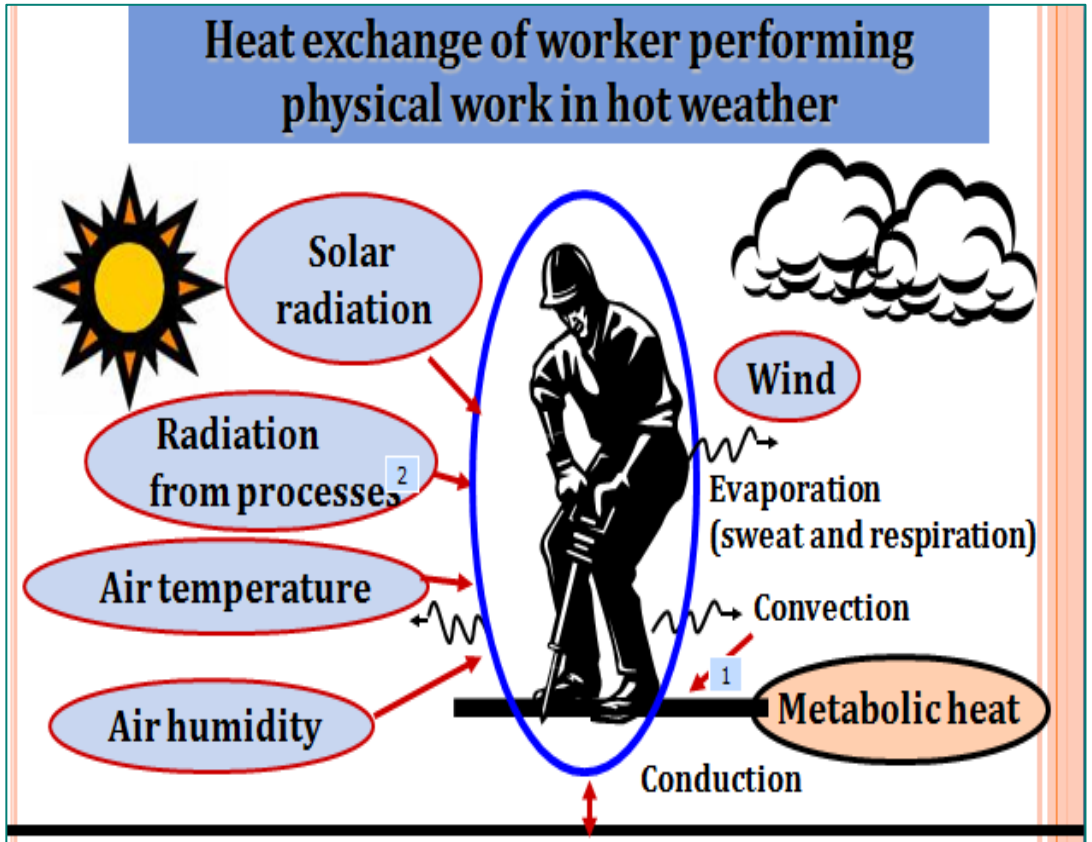
Heat stress – An overview

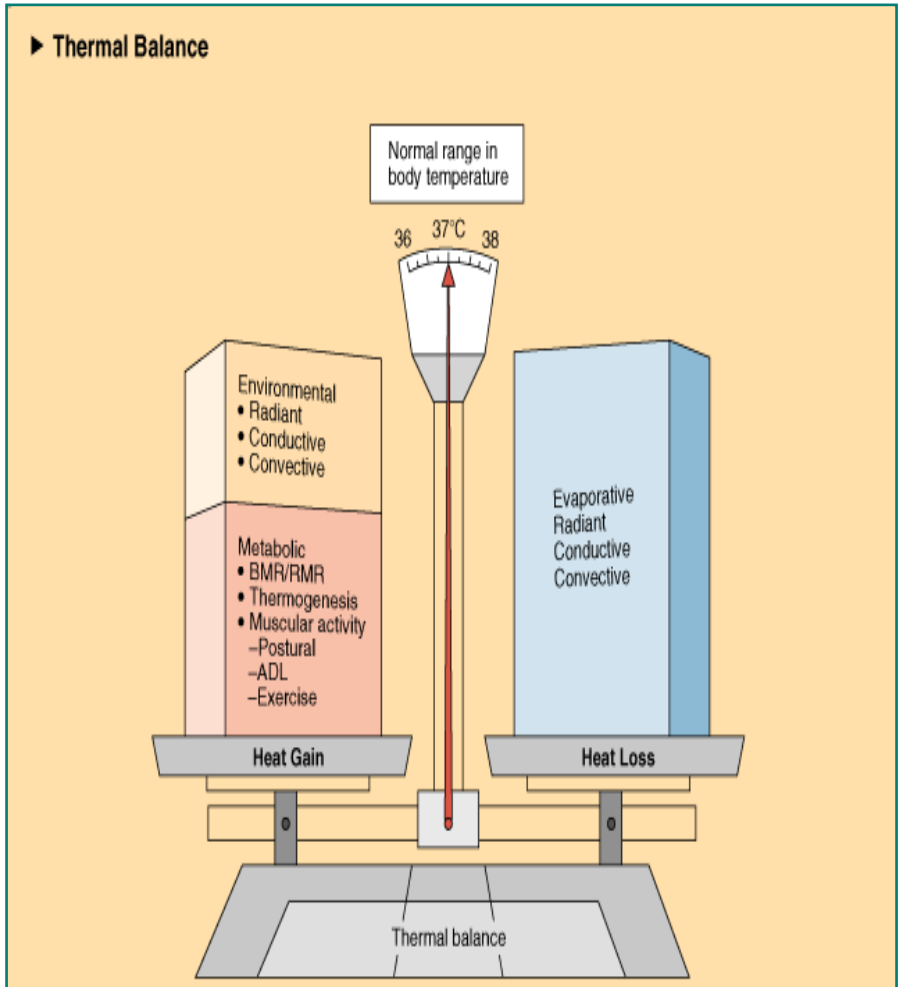


Heat stress: The combined heat load imposed on a worker from contributions of

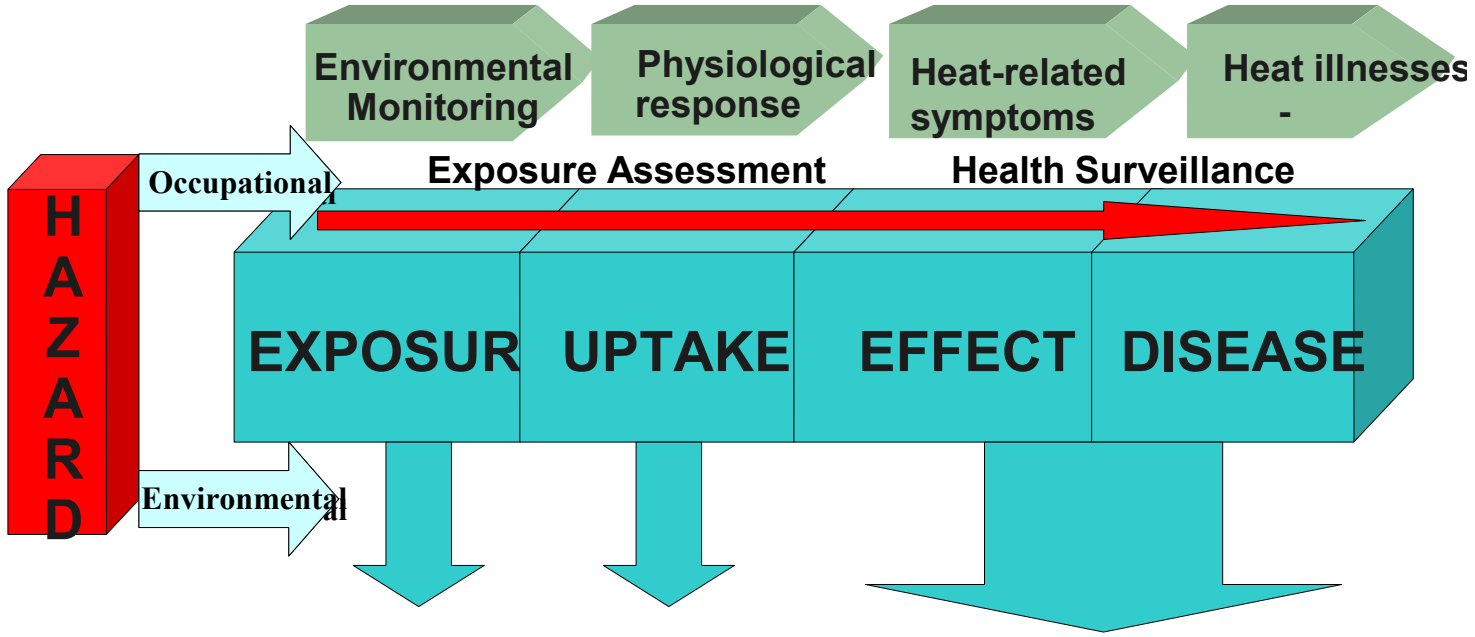
Environmental temperatures + metabolic heat + clothing.

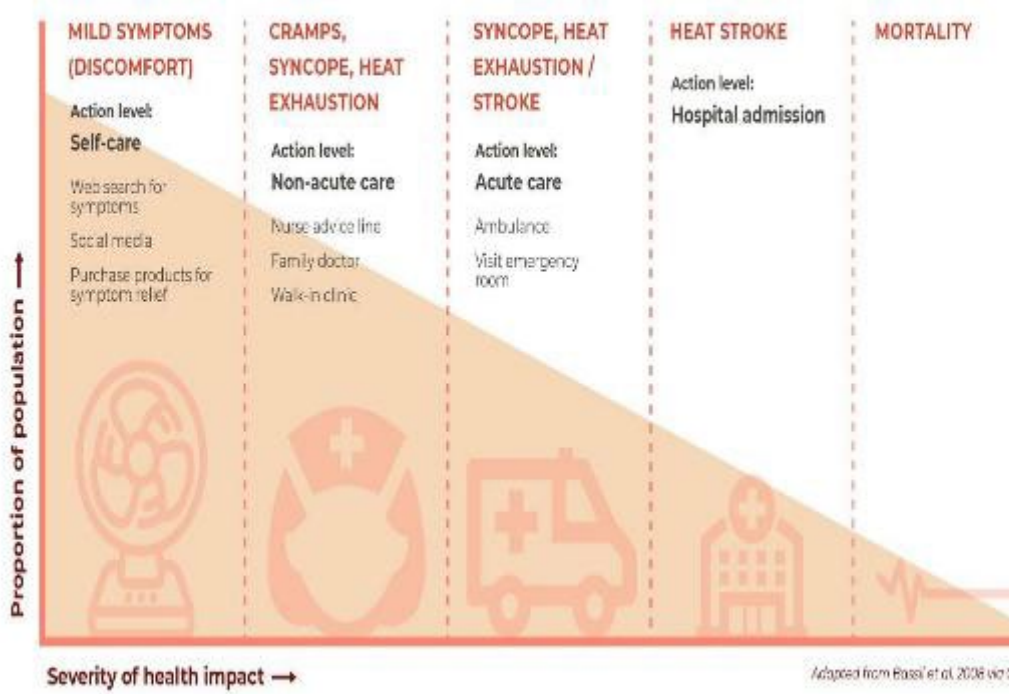


The Wet Bulb Globe Temperature (**WBGT**) is an index developed to model the heat stress imposed on a worker working in hot/sultry environments that takes into account: temperature, humidity, wind speed and solar radiation (ISO, 1989) that takes into account the clothing and the workload.



From heat exposure to HRIs





HEAT (Environmental +Metabolic)	Physiological Strain responses	Range of Heat-related illnesses

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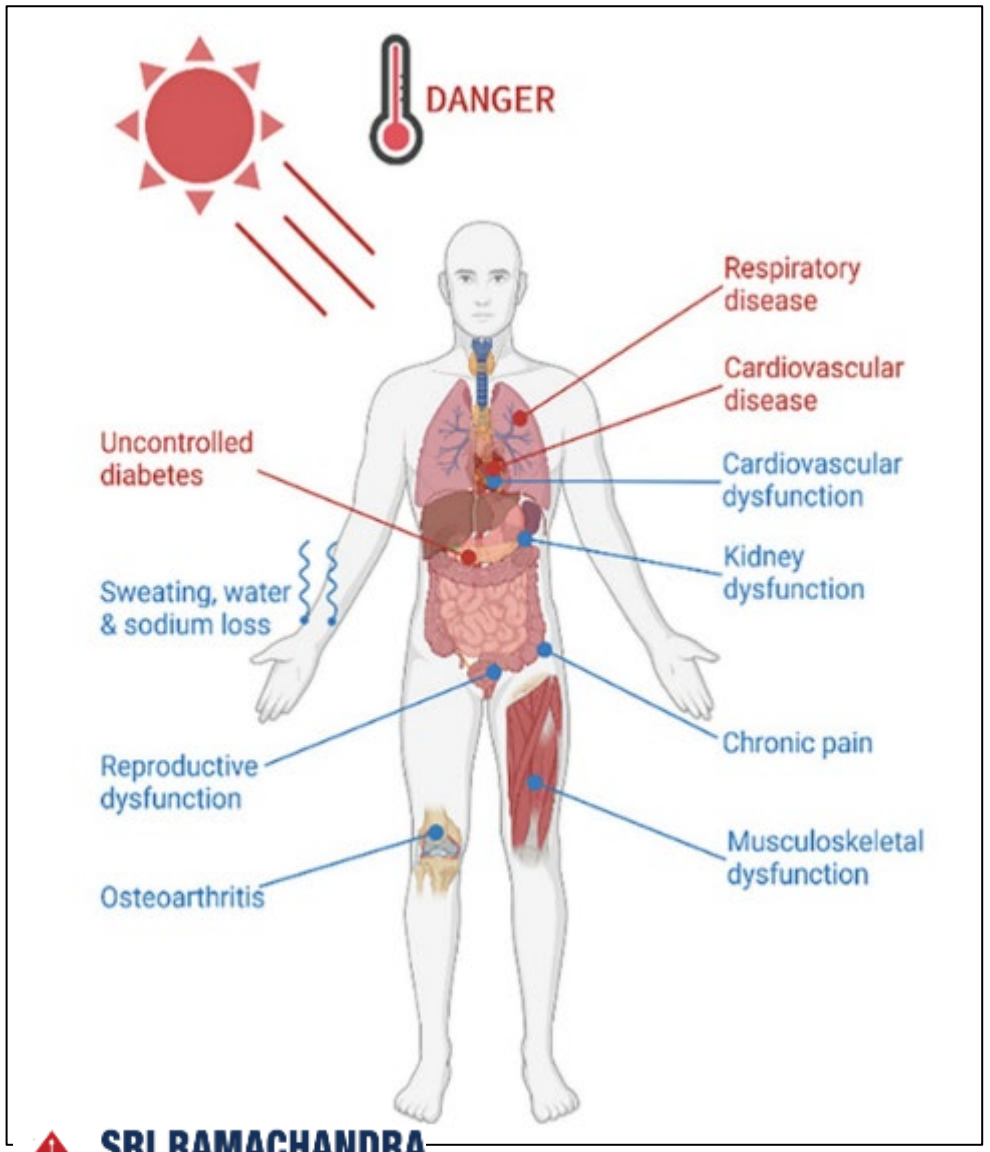
Heat stress: systemic impact



Central Nervous system

- Headache/Dizziness
- Anxiety/depression
- Impaired cognition

Cardiovascular system

- Rapid heartbeat
- Heart attack (MI)
- Cardiovascular diseases

Renal system

- Renal Calculai
- CKDu/Kidney failure
- Kidney disorders

Respiratory system

- Increased breath
- Allergies and asthma
- Worsened COPD

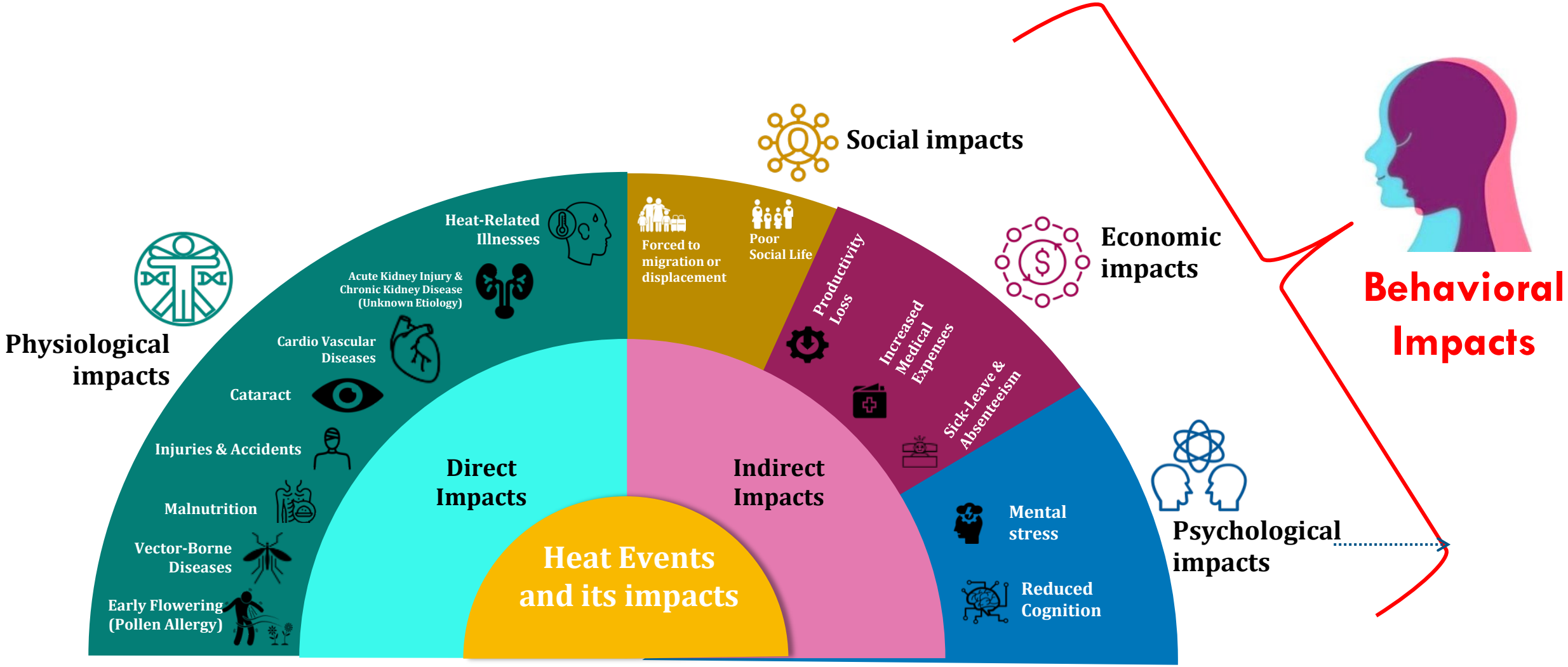
Musculo skeletal system

- Accident and reduced cognition
  - Slip/trip/ fall /Injury

Reproductive/ Endocrine disorders

- APOs
- Infertility
- Diabetes

Heat Impacts – goes beyond health…



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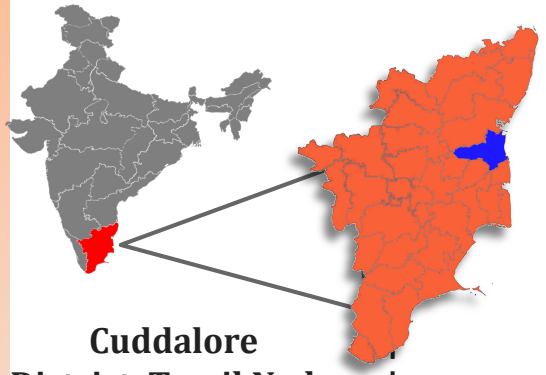
Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai, India.

Occupational heat exposures and its impacts on kidney health among cashew workers

Indoor



Cuddalore District, Tamil Nadu

5 workplaces

2020 - 2021

262 Workers

Male 56%

Female 44%

65% Exposed to heat (Above TLV) (Avg. WBGT-30.4°C±1.8°C)

Blood sample analysis

100

27% Dry mouth, & Dry throat, Excessive thirst

95% Excessive sweating, Headache, Muscle cramps, prickly heat, Nausea, Vomiting

37% Core Body temperature, Sweat rate, Urine specific gravity changes

14% Reduced kidney function

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Occupational Heat Stress and Kidney Health in Salt Pan Workers (OUTDOOR)

Cross sectional study

7 salt pans from Tamil Nadu, India

2017 to 2020 (summer-winter)

18-85 years

352 workers

Study Population & Work Conditions:

- **Heavy manual jobs**: **85%**
- **High heat stress exposure**: **87.5%** (>TLV- WBGT)

Environmental Conditions:

- **Summer WBGT**: **31.1°C ±** 1.1
- **Winter WBGT**: **29.3°C ±** 1.1
- **TLV-WBGT exceeded in 95% locations**

Health Impacts & Symptoms:

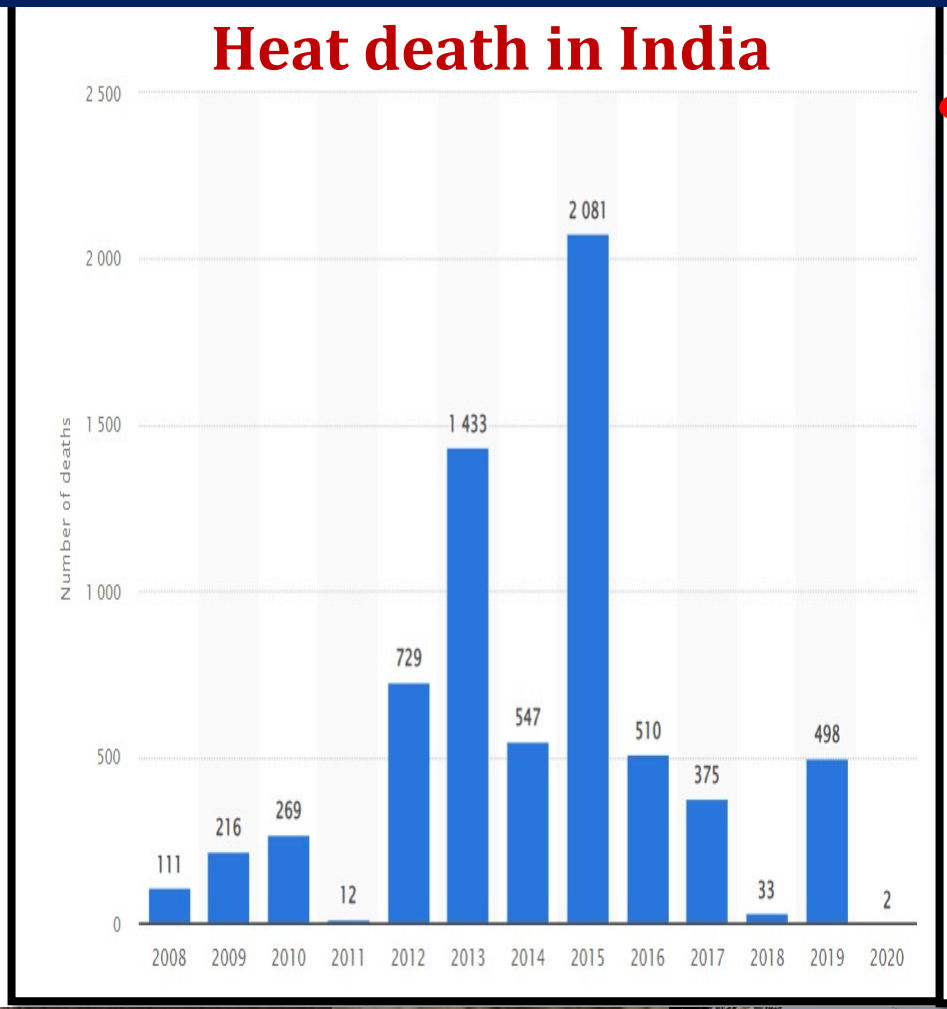
- **Heat-strain symptoms**: **93%** (sweating, thirst, cramps, dizziness)
- **Dehydration signs**: **59%** (dry mouth & throat, thirst)
- **Urinary issues**: **77%** (UTIs, burning sensation, color changes)

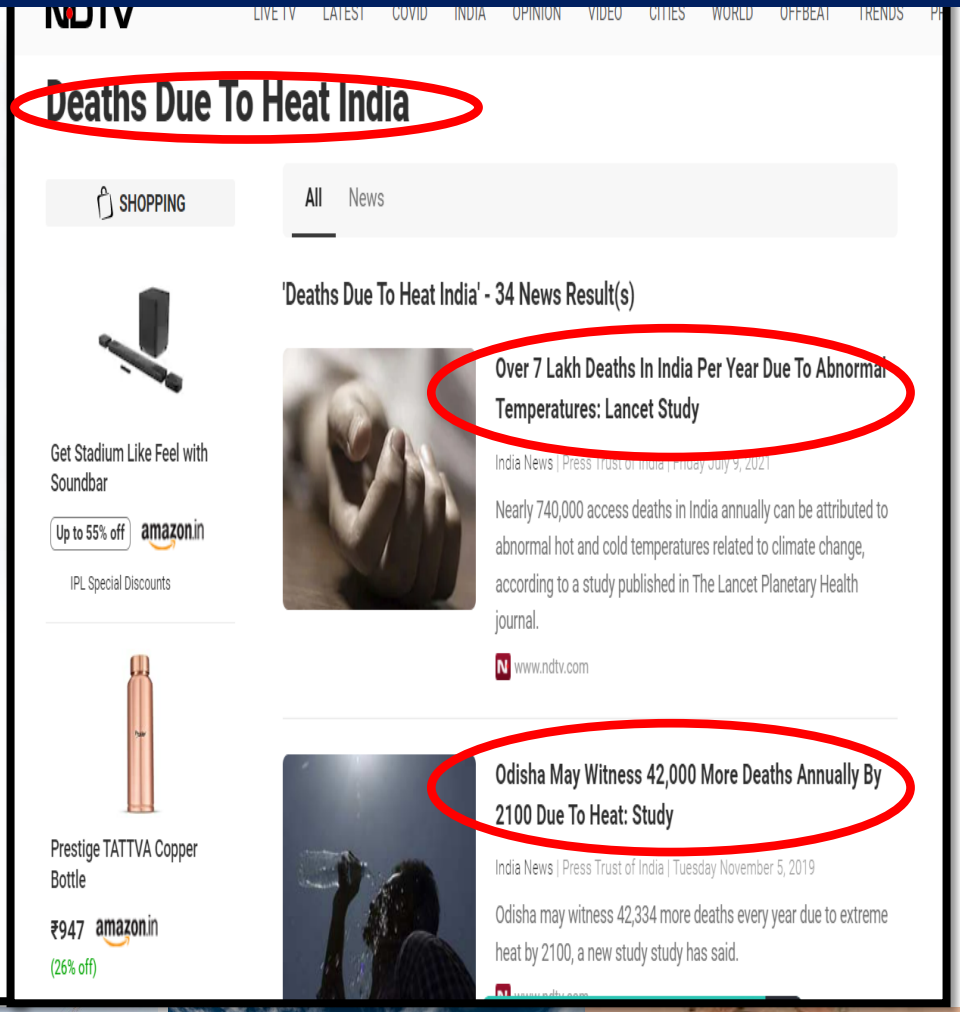
Physiological Effects:

- **Dehydration (USG ≥1.020)**: Pre-shift **10%**, Post-shift **28%**
- **Reduced kidney function (eGFR <90 mL/min/1.73m²)**: **56% men, 38% women**
- **Male workers had:**
  1.7x risk of eGFR <90 mL/min/1.73m²
  3.1x risk of eGFR <60 mL/min/1.73m²

Heat and migrant workers

Heat death in India





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Even worse for migrant women workers.....

1.7 times

Increased risk of urogenital issues (95%CI: 1.0-2.8)

1.8 times

Productivity drops significantly **(95%CI:1.1-3.0)**

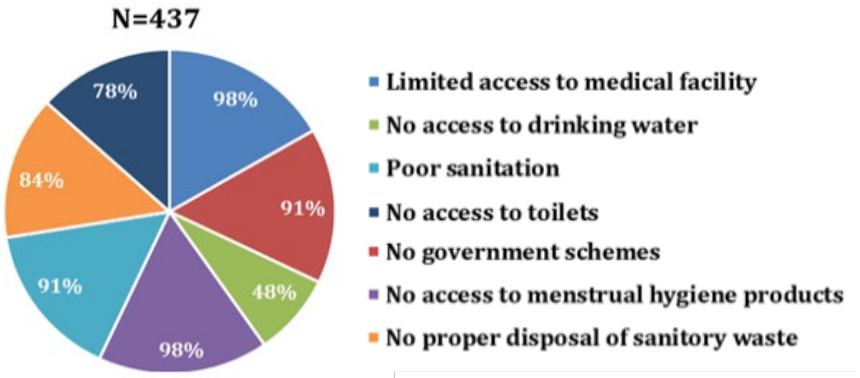
2.1 times

increased risk of Irritation/Interpersonal issues **(95%CI:1.1-4.8)**

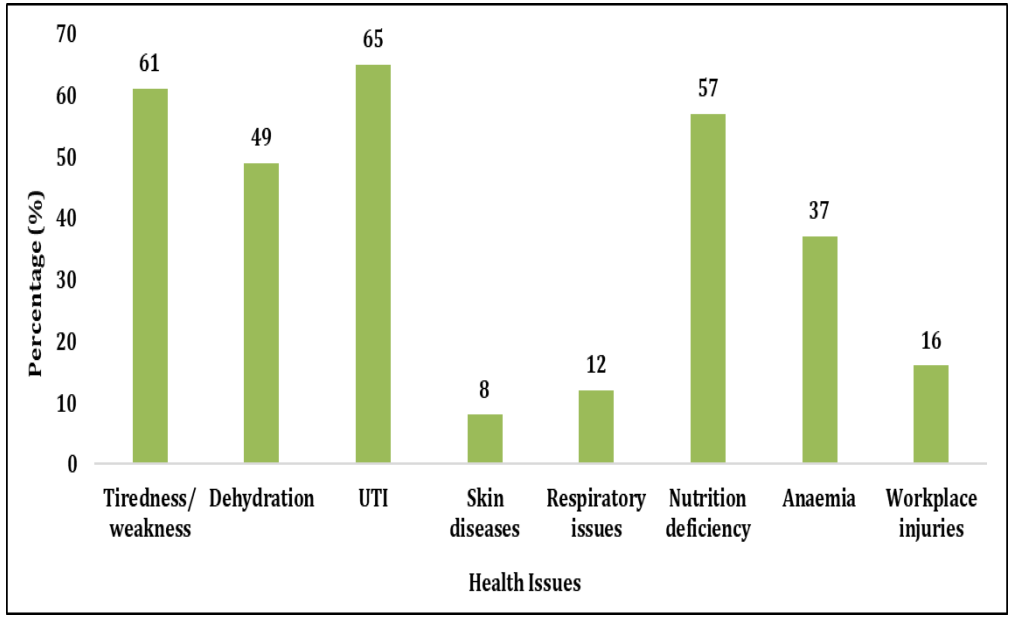
Self-reported health related illnesses

80% of migrant women workers

Access to welfare facilities at their workplace



Prevalence of Health Issues among Migrant Women Workers



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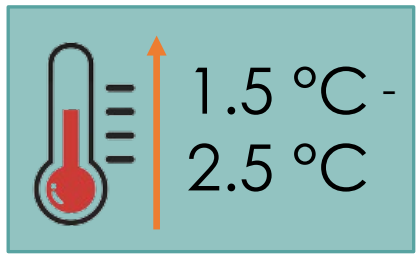
Risk of adverse pregnancy outcomes among pregnant women in workplaces - who is more susceptible?



Half the women were working above the standard threshold limit value (heat exposure)

Double the times of risk for heat exposed women

Risk of poor birth outcomes

- Stillbirth
- Preterm birth
- Neurological problems
- Low birth weight
- Birth defects

&

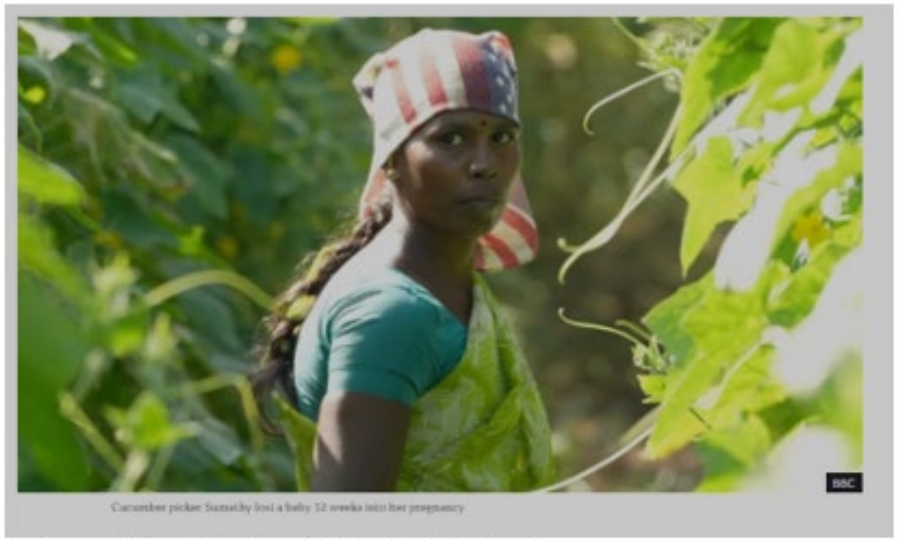
Risk of spontaneous abortion

2 times higher risk of conception in hotter season than cooler season

BBC

Extreme heat at work can double stillbirth risk, India study finds

22 March 2024

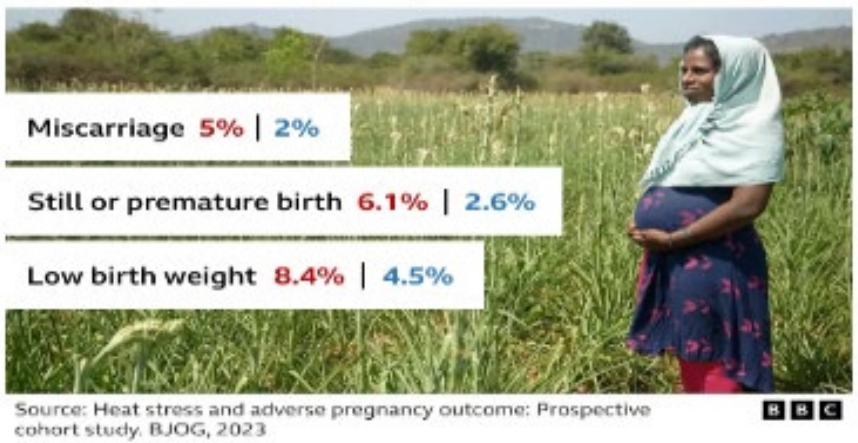


Cucumber picker Sumathy lost a baby 32 weeks into her pregnancy

By Tulip Mazumdar, Global health correspondent

Working in extreme heat can double the risk of stillbirth and miscarriage for pregnant women, according to new research from India.

Women like Sandhiya make up the backbone of India's informal workforce



Occupational heat exposure doubles risk of miscarriages or stillbirths

Most heat-exposed workers had urogenital symptoms, which might be associated with pregnancy-related complications

By Seema Prasad
Published: Friday 22 March 2024

TIMES CITY

HC to decide legality of 'counter-case' cultur

Heat exposure linked to pregnancy outcomes: Study

Examined Impact On 800 Pregnant Women

KEY FINDINGS OF STUDY

Rekha Shanmugam measures the daytime heat in sugar cane fields in Tiruvannamalai

Impacts of heat on sleep quality among heat-exposed workers: a systematic review

The Korean Society of Occupational and Environmental Medicine

Ann Occup Environ Med. 2026;38:e3

7,108 Records Screened

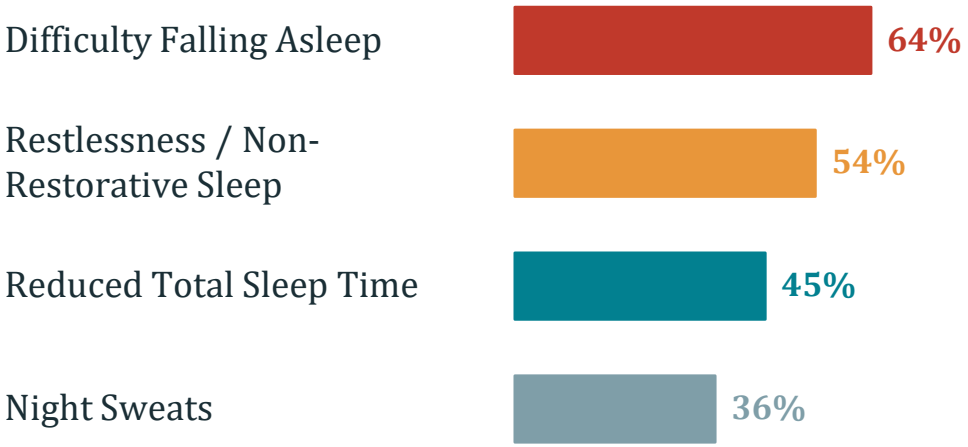
11 Studies Included

70% Workers face dangerous heat globally

>25°C Night temp that increases sleep loss by 3.5%

−14 min Sleep lost on very hot nights (>30°C)

Key Sleep Complaints



How Heat Disrupts Sleep

- High night temp → body can't cool down
- Core temp stays elevated → delayed sleep onset
- Less slow-wave & REM sleep
- Poor recovery → fatigue cycle next day

Most Vulnerable Groups

- Shift workers
- Steel & petrochem workers
- Women & older adults
- Low-income / no AC access

Recommendations

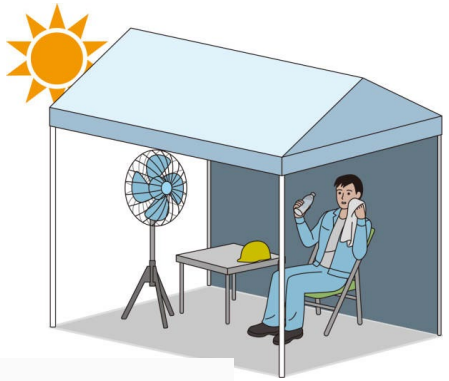
- Add sleep metrics to heat safety guidelines
- Cooling: AC access & ventilated housing
- Shift schedules to cooler hours
- Monitor women, elderly & shift workers

Conclusion: Occupational heat exposure significantly disrupts sleep integrating sleep into heat safety programs is urgently needed as climate change intensifies.

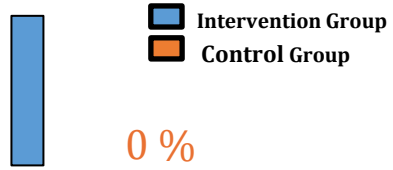
FINDING FEASIBLE SOLUTIONS FOR LMICs

Water Rest and Shade (WRS) Intervention (Outdoor workers)

The **Water, Rest, and Shade (WRS) intervention** heat mitigation strategy was tailored to Indian settings – Feasibility and sustainability studied.



Our Study Evidence

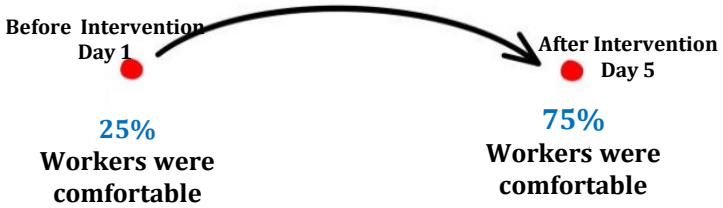


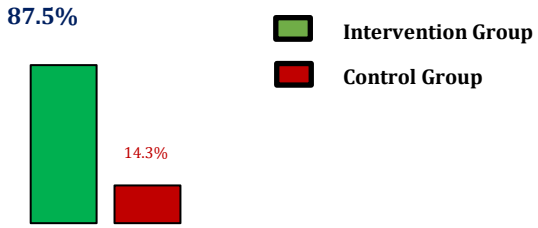
Statistically significant p = 0.010 · OR = 2.667 · 95% CI: 1.090–6.524

Intervention group	Control group	Odds ratio
62.5% showed reduction	0% showed reduction	2.667 (95% CI: 1.090–6.524)

Reduction of Core Body Temperature

Self-Reported Comfortability to Work

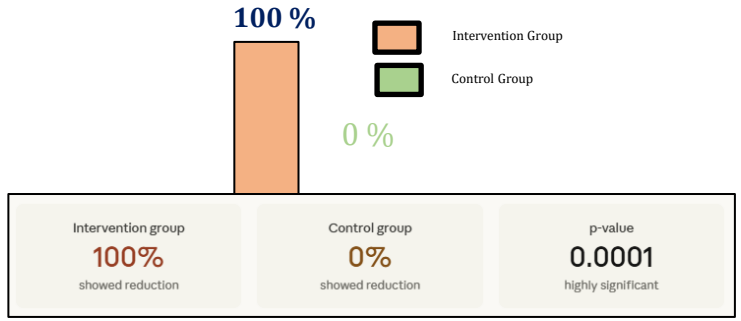




Statistically significant p < 0.05 · COR (95% CI) = 21

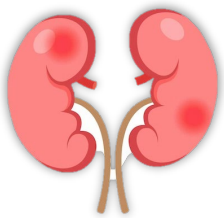
Intervention group	Control group	Crude OR
87.5% showed reduction	14.3% showed reduction	21 (95% CI)

Reduction of Heart Rate



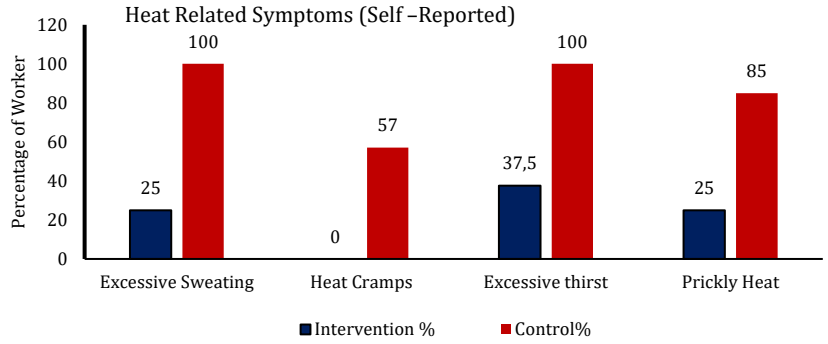
Intervention group	Control group	p-value
100% showed reduction	0% showed reduction	0.0001 highly significant

Reduction of Urine Specific Gravity



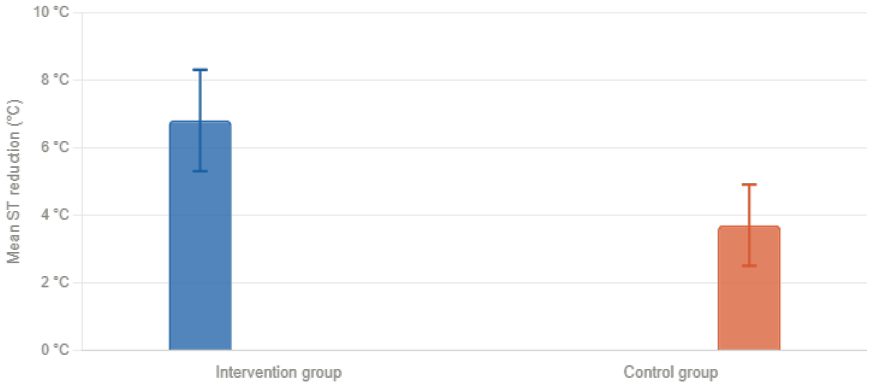
2.3 times higher

renal impairment in Control Group When compared with Intervention Group (95% CI: 0.251–20.131)



Cooling Vest Intervention
(Indoor workers)

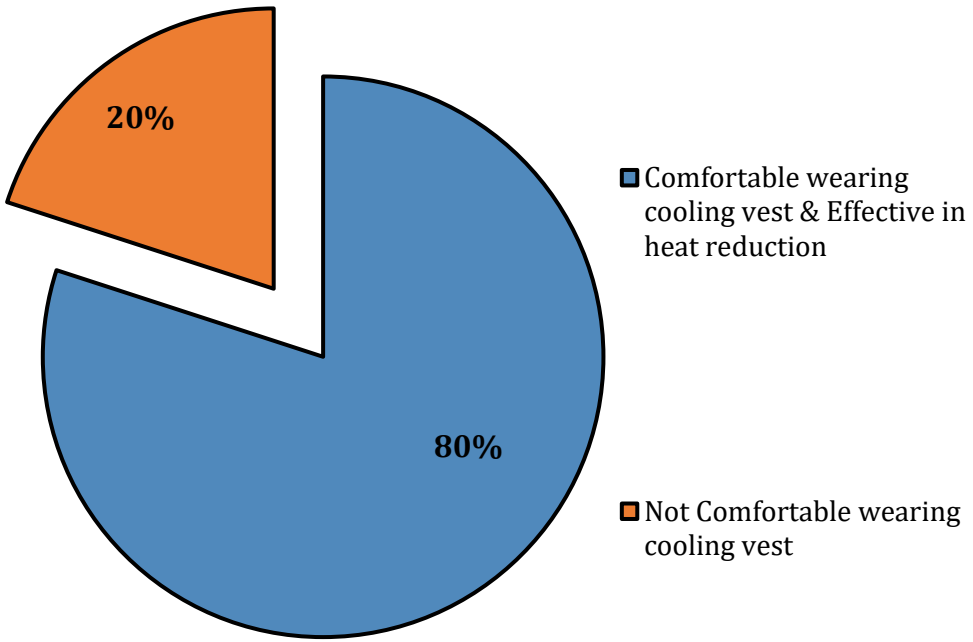
Cooling vests use evaporative and/or phase change materials (PCM) to regulate body temperature. These materials absorb excess heat from the body and provide a cooling effect, especially in hot and humid environments, improving thermal comfort.



Skin Temperature Difference

Core Body Temperature Difference

Comfortable & Effectiveness



Thermal Camera (FLIR E6 XT)

WBGT

Feedback Questionnaire

Infrared Thermometer

Traditional Body Cooling Foods Intervention

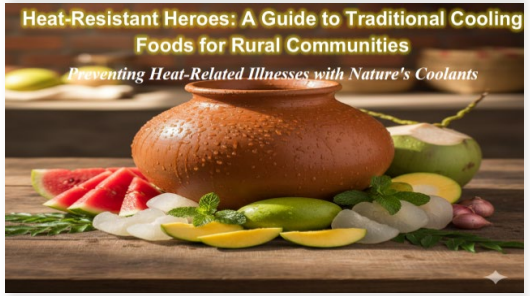
BEAT THE SUMMER HEAT

The best cost-effective personal cooling strategy

Heat wave awareness

40%

Educational awareness intervention materials

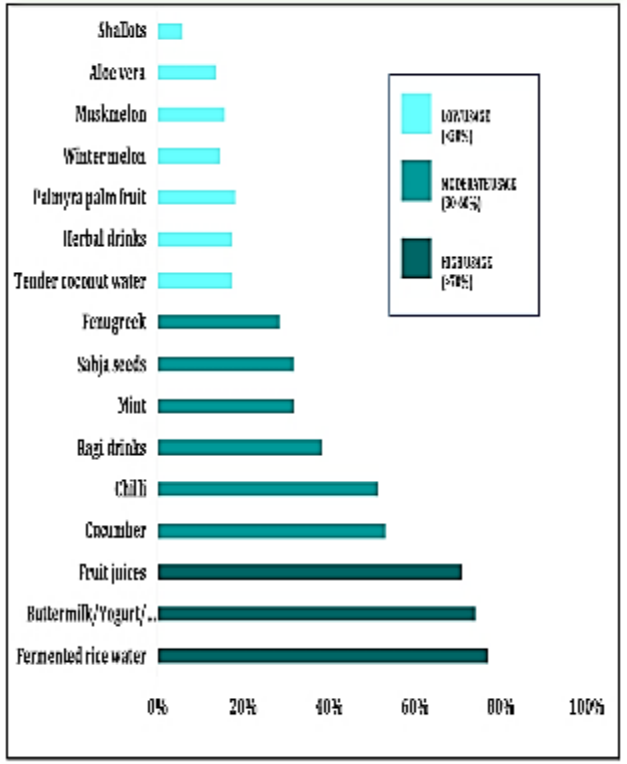


Booklet

WhatsApp messages

Pamphlets and Posters in local languages

TBCFs usage



Expressed strong interest in heat educational awareness.

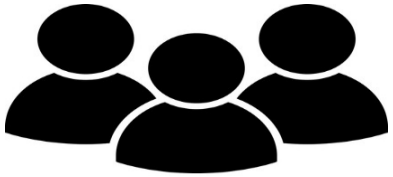
83%

Reported loss of traditional cooling food knowledge

60%

Heat and Sleep disturbance

Heat Exposure Profile



Participants Mean age:

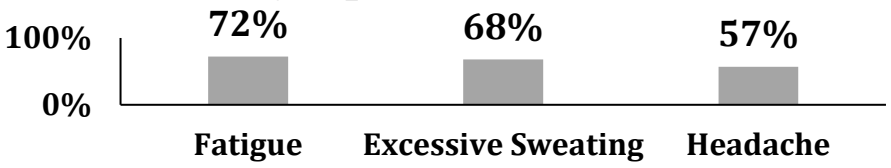
39.8 ± 8.2 yrs

(61% are male)

93.7%
exposed above recommended limit (≥27.5°C)

~40% exposed to extreme heat (≥30 °C).

Common Heat Related Symptoms

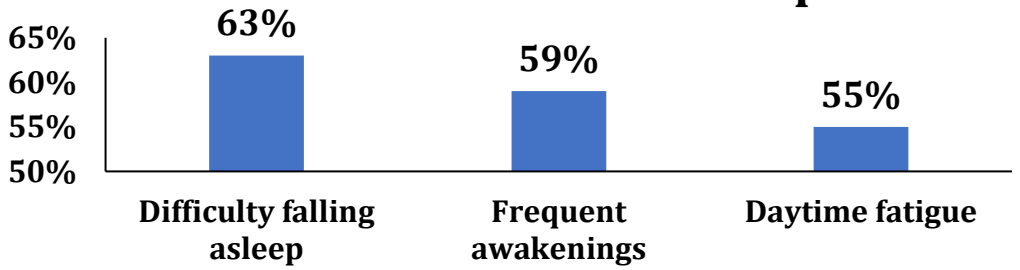


1.9× higher odds of heat-related symptoms (AOR = 1.89, 95% CI: 1.06–3.36)

Sleep Quality Findings

- **85% reported Poor sleep quality (95% CI: 80.8–88.2%) & their**
- **Mean PSQI: 8.6 ± 3.2** (cut-off >5 = poor sleep)

Common Heat Related sleep issues



Statistical analysis

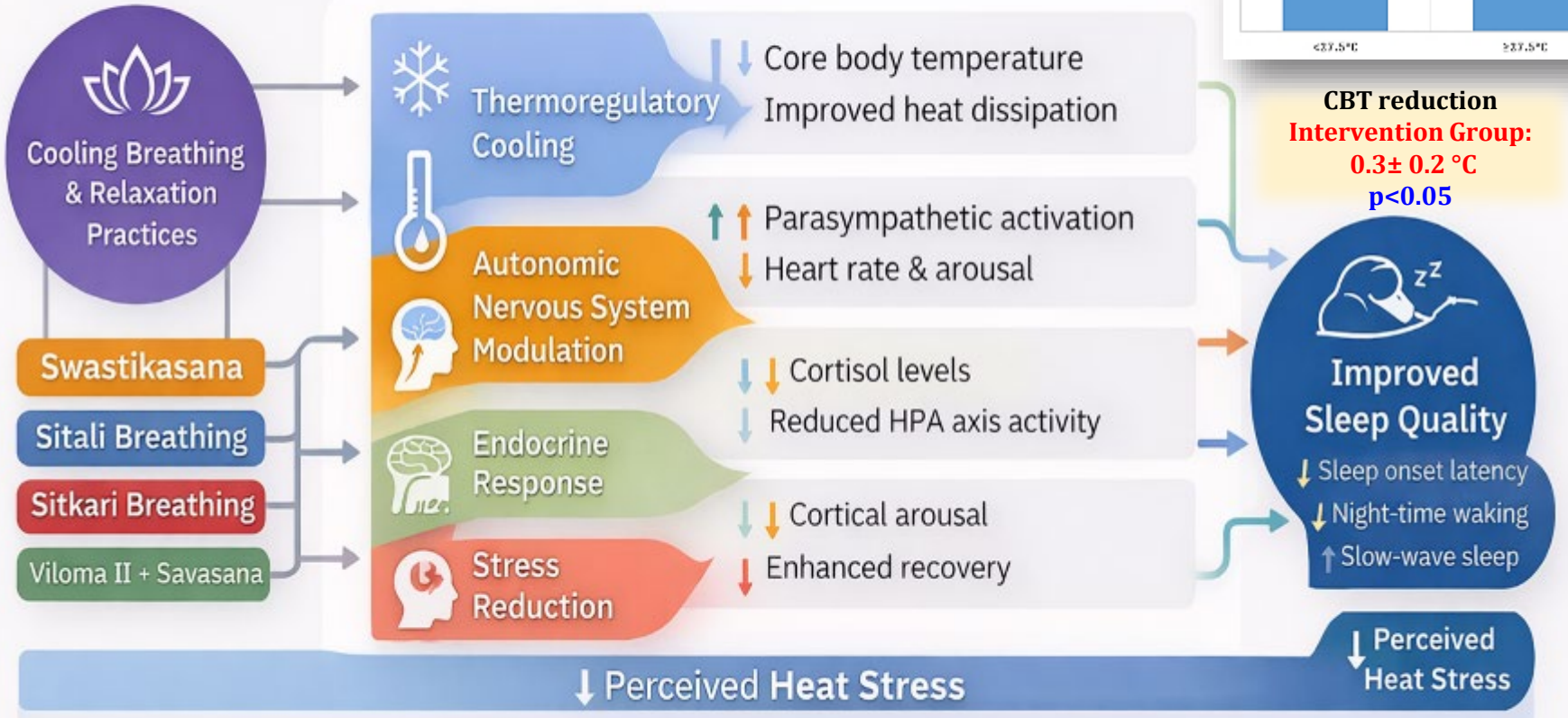
- ✓ **Workers in extreme heat more likely to report poor sleep,**
  - **85.8% vs. 69.6%**
  - **OR: 2.63 (95% CI: 1.03–6.73).**

- ✓ **1°C rise in WBGT → 18% higher odds of sleep disturbance (aOR = 1.18, 95% CI: 1.05–1.33)**

- ✓ **2× higher odds of productivity loss (aOR = 1.95, 95% CI: 1.03–3.68)**

Sleep and Yoga as an intervention

Physiological Mechanisms of the Yoga Protocol in Reducing Heat Stress and Improving Sleep Quality



CBT reduction
Intervention Group:
0.3± 0.2 °C
p<0.05

Breaking the cycle of heat strain & sleep disturbance

Proactive Heat Protection for Workers

Unprotected Workers

Vulnerable to heat-related illnesses

Regular Health Checks

Monitor hydration, cardiovascular strain, sleep

First Aid Readiness

Train staff, stock supplies, referral system

Employer Accountability

Implement plans, audits, compliance checks

Protected Workers

Resilient to heat-related illnesses

Workers Awareness Campaigns

Heat stress is hazardous!

வெப்ப அழுத்தம் ஆபத்தானது!

Find ways to keep cool!


thank you