Occupational Health Clinics for Ontario Workers

Centre de Santé des Travailleurs(ses) de l'Ontario

HEAT STRESS Toolkit

Time-Weighted Average (TWA) Humidex Calculations

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Humidex-Based Heat Response Plan

1. **train everyone to recognize signs & symptoms and know how to respond to them**
2. measure temperature & relative humidity & convert to Humidex
3. adjust for clothing and radiant heat (sun)
4. find response on chart

Training Outcome Items:

Training Outcome
The worker(s) / supervisor:

- ☐ can explain what heat rash is and how to treat it
- ☐ knows the symptoms of heat syncope and how to respond
- ☐ are aware of the cause of muscle cramps and know what to drink to counter these symptoms
- ☐ can recognize the symptoms of heat exhaustion – realize need for immediate medical attention
- ☐ understands the danger of heat stroke and the need to watch others for unusual behaviour or collapse
- ☐ understand that heat stroke is a life-or-death medical emergency
- ☐ knows who is responsible to contact EMS in the event of a medical emergency
- ☐ knows the heat stress limit for body temperature
- ☐ understands that heart rate can also be monitored
- ☐ knows how much water to drink
- ☐ knows how to check the adequacy of their hydration status (colour of urine)
- ☐ knows where to get water when they need it
- ☐ understands the need to drink more than by thirst alone
- ☐ knows the amount of water to drink every 20 minutes
- ☐ are aware of the emergency procedures should someone faint, collapse or become confused
- ☐ understands that the body generates heat during activity and realize that slowing down/resting will control heat stress
- ☐ realize that personal cooling options are available and need to be customized to the individual
- ☐ know the physical and health conditions that pose risk factors for heat stress

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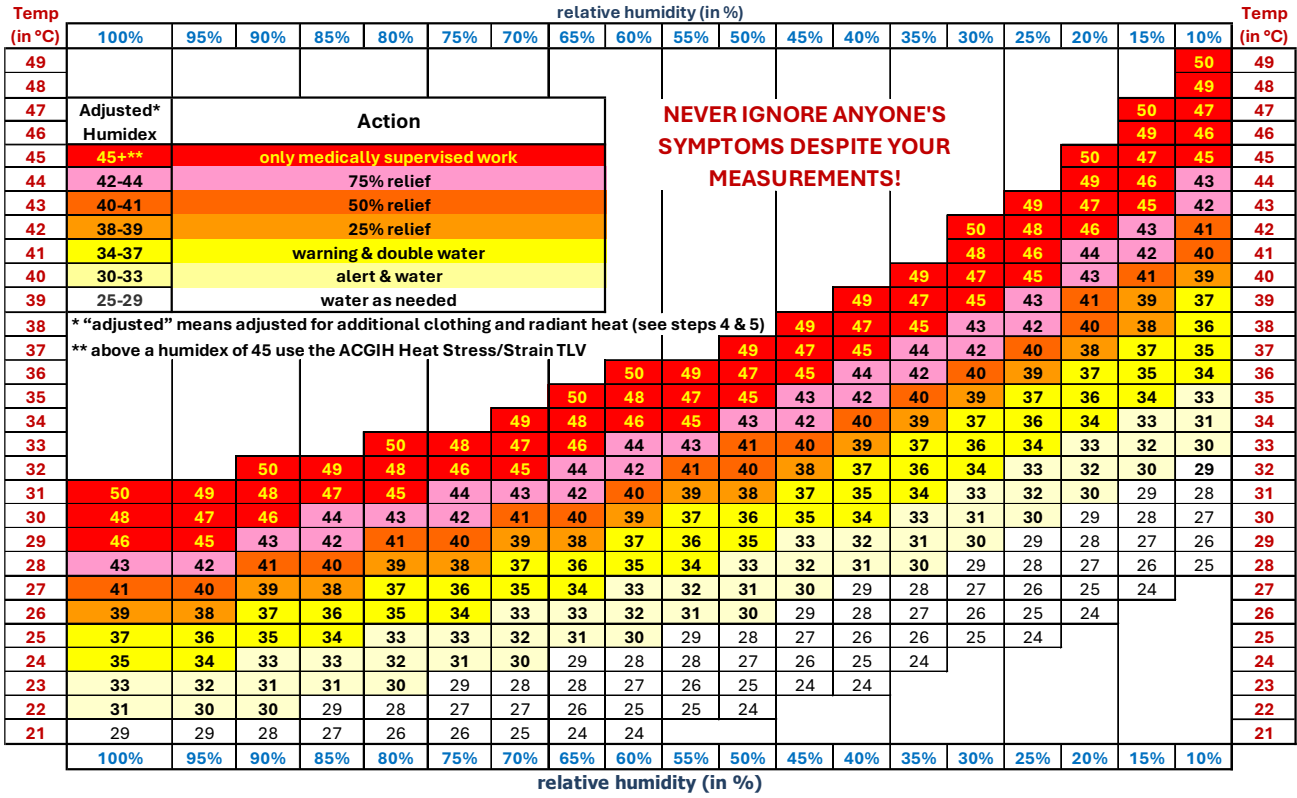


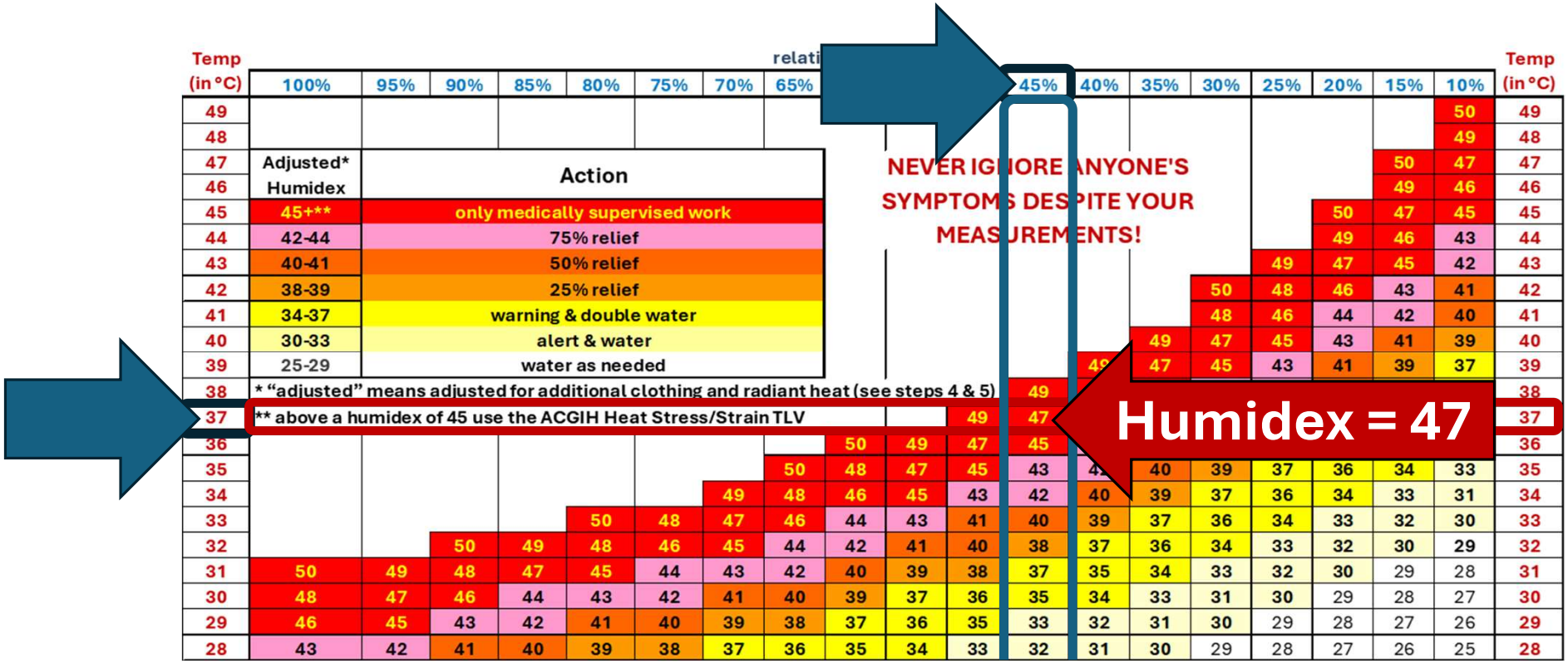
Temp (in °C)	relative humidity (in %)																		Temp (in °C)
	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	
49																			50	49
48																			49	48
47	Adjusted* Humidex	Action																50	47	47
46																		49	46	46
45	45+**	only medically supervised work															50	47	45	45
44	42-44	75% relief															49	46	43	44
43	40-41	50% relief														49	47	45	42	43
42	38-39	25% relief													50	48	46	43	41	42
41	34-37	warning & double water													48	46	44	42	40	41
40	30-33	alert & water												49	47	45	43	41	39	40
39	25-29	water as needed											49	47	45	43	41	39	37	39
38	* "adjusted" means adjusted for additional clothing and radiant heat (see steps 4 & 5)											49	47	45	43	42	40	38	36	38
37	** above a humidex of 45 use the ACGIH Heat Stress/Strain TLV										49	47	45	44	42	40	38	37	35	37
36									50	49	47	45	44	42	40	39	37	35	34	36
35								50	48	47	45	43	42	40	39	37	36	34	33	35
34							49	48	46	45	43	42	40	39	37	36	34	33	31	34
33					50	48	47	46	44	43	41	40	39	37	36	34	33	32	30	33
32			50	49	48	46	45	44	42	41	40	38	37	36	34	33	32	30	29	32
31	50	49	48	47	45	44	43	42	40	39	38	37	35	34	33	32	30	29	28	31
30	48	47	46	44	43	42	41	40	39	37	36	35	34	33	31	30	29	28	27	30
29	46	45	43	42	41	40	39	38	37	36	35	33	32	31	30	29	28	27	26	29
28	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	28
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24		27
26	39	38	37	36	35	34	33	33	32	31	30	29	28	27	26	25	24			26
25	37	36	35	34	33	33	32	31	30	29	28	27	26	26	25	24				25
24	35	34	33	33	32	31	30	29	28	28	27	26	25	24						24
23	33	32	31	31	30	29	28	28	27	26	25	24	24							23
22	31	30	30	29	28	27	27	26	25	25	24									22
21	29	29	28	27	26	26	25	24	24											21
	100%	95%	90%	85%	80%	75%	70%	65%	60%	55%	50%	45%	40%	35%	30%	25%	20%	15%	10%	

relative humidity (in %)

NEVER IGNORE ANYONE'S SYMPTOMS DESPITE YOUR MEASUREMENTS!

Let's try an extreme example:

The temperature is **37°C** and the relative humidity is **45%**, what's the Humidex?



Humidex-Based Heat Response Plan

1. train everyone to recognize signs & symptoms and know how to respond to them
2. measure temperature & relative humidity & convert to Humidex
3. **adjust for clothing and radiant heat (sun)**
4. find response on chart

ACGIH clothing adjustment values	Humidex
Short Sleeves and Pants of Woven Material	-2
Work Clothes (Long Sleeve Shirt and Pants)	0
Cloth (woven material) Coveralls over underwear	0
thin disposable SMS Polypropylene Coveralls over underwear	+1
disposable polyolefin (Tyvek) coveralls over underwear	+2
Adding a Hood (Full Head and Neck Covering; not Face)	+2
Double Layer Woven Clothing (e.g., coveralls over work clothes)	+6
Limited-Use Vapor-Barrier Coveralls with Hood	+22

derived clothing adjustment values	Humidex
impervious gloves	+0.4
impervious apron	+0.6
additional protective sleeves	+0.4
leather welding jacket	+3.0
medical mask	+0.1
N95 disposable respirator	+0.2
half face piece elastomeric demand respirator	+0.4
ear muffs	+0.2
toque	+1.2
hard hat	+0.4
goggles	+0.2
face shield	+0.2
woven fabric hospital gown	+3.0

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4. **find response on chart**

Adjusted* Humidex	Response
25 – 29	supply water to workers on an "as needed" basis
30 – 33	post Heat Stress Alert notice; encourage workers to drink extra water; start recording hourly temperature and relative humidity
34 – 37	post Heat Stress Warning notice; notify workers that they need to drink extra water; ensure workers are trained to recognize symptoms
38 – 39	work with 15 minutes relief per hour can continue; provide adequate cool (10-15°C) water; at least 1 cup (240 mL) of water every 20 minutes worker with symptoms should seek medical attention
40 – 41	work with 30 minutes relief per hour can continue in addition to the provisions listed previously
42 – 44	if feasible, work with 45 minutes relief per hour can continue in addition to the provisions listed above
45** or over	only medically supervised work can continue

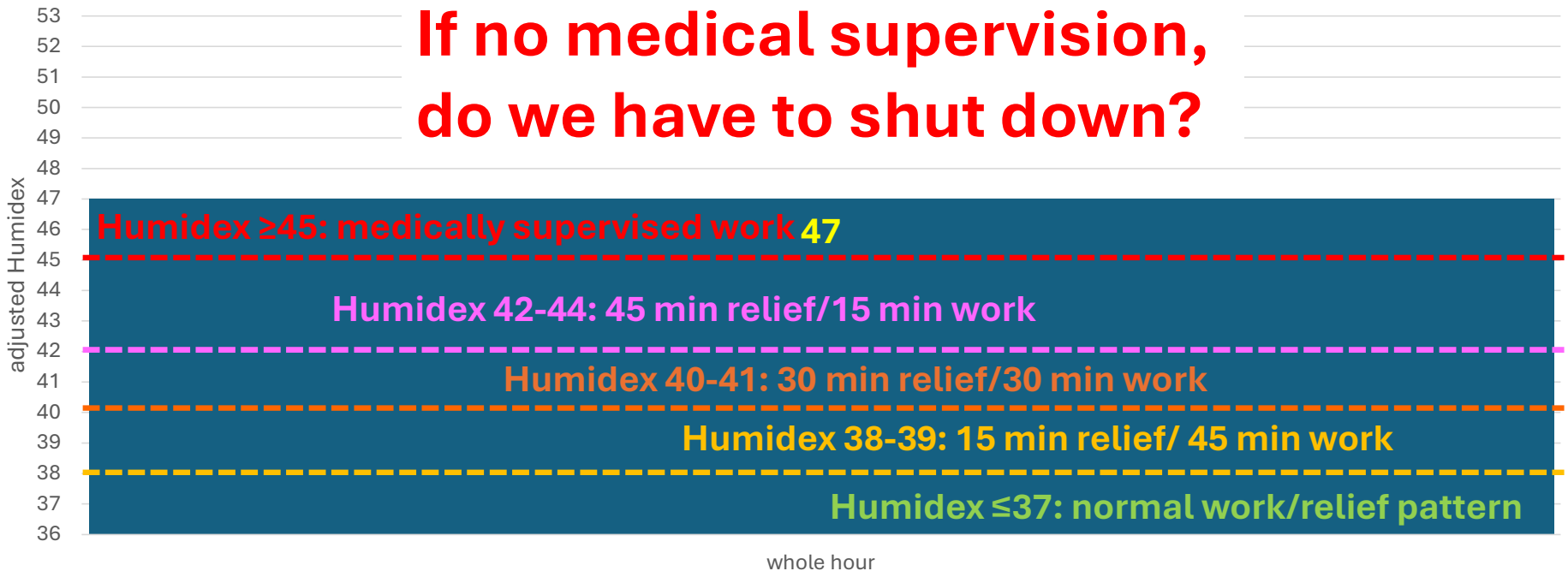
* "adjusted" means adjusted for additional clothing and radiant heat

** at Humidex above 45, heat stress to be managed as per the ACGIH TLV®

Scenario #1:

- Outdoor **Humidex 47** (37°C; 45% RH; sunny; wind speed 20 km/hr)
- Lifeguard sitting **outside** in chair guarding swimmers for **15 minutes** per hour – **no shade**, wearing: T-shirt, bathing suit, water shoes
- **Half hour heat stress break** in non-air conditioned inside lunchroom (32°C; 60% RH; Humidex = 42)
- **15 minutes working inside** cleaning up, sweeping (32°C; 60% RH; Humidex = 42)

Measured Humidex = 47 (37°C; 45% RH); assume it applies to the whole hour



… so, what does "only medically supervised work can continue" mean anyway?

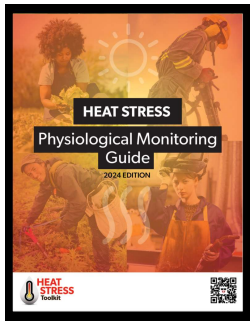
- first, we need to remember that all the advice in the Humidex plan is based on the ACGIH Heat Stress/Strain TLV assuming a **moderate** metabolic rate and **no acclimatization**
- second, the advice is based on the ACGIH TLV documentation which requires any worker who is exposed above the upper limit to have **heart rate** measurements and/or **core temperature** measurements taken regularly to ensure they don't exceed the guidelines
- taking an individual's heart rate and/or core temperature is collecting **medical information** about that **individual**
- **observing another person** (and yourself) for **signs and symptoms** of heat stress, is not medical monitoring *per se*, it is just **recommended practice** under heat stress conditions

ACGIH Body Core Temperature Limit:

"An elevated core temperature greater than 39°C normally indicates a marginal ability to tolerate greater levels of heat stress or a loss of thermal regulatory control. Core temperatures **below 38.5°C** provide a margin for measurement error and time to reduce the exposure (Bernard and Kenney 1994). Allowing for a margin of protection, **38.5°C was selected for a limiting core temperature** for physiological monitoring."

excerpt from: ACGIH® © 2022 11DOC-658-NPA Heat Stress and Strain TLV p.21

Physiological Monitoring



- If you can't control the exposure to below a Humidex of 45, then the ACGIH Heat Stress/Strain TLV suggests you need to physiologically monitor exposed individual workers during their exposure.

The **ACGIH heat strain monitoring criteria** are:

- "Sustained (several minutes) **heart rate** is in excess of 180 beats per minute (bpm) minus the individual's age in years (**180 - age**), for healthy individuals with normal cardiac response.
- Measured or estimated **core temperature** increases by more than **1°C from pre-job temperature**, if the pre-job temperature is less than 37.5°C.
- **Recovery heart rate** at one minute after a peak work effort is **greater than 120 bpm**.
- Exposure should stop with **signs and symptoms of heat exhaustion** or heat stroke or **with a request to stop** regardless of what physiological monitoring may indicate." *(ACGIH, 2022, emphasis added)*

excerpt from: ACGIH® © 2022 11DOC-658-NPA Heat Stress and Strain TLV Table 4, p.6

https://www.microlife.com/magazine/fever/how-to-measure-body-temperature-correctly

ACGIH Prescribed Physiological (Medical) Monitoring

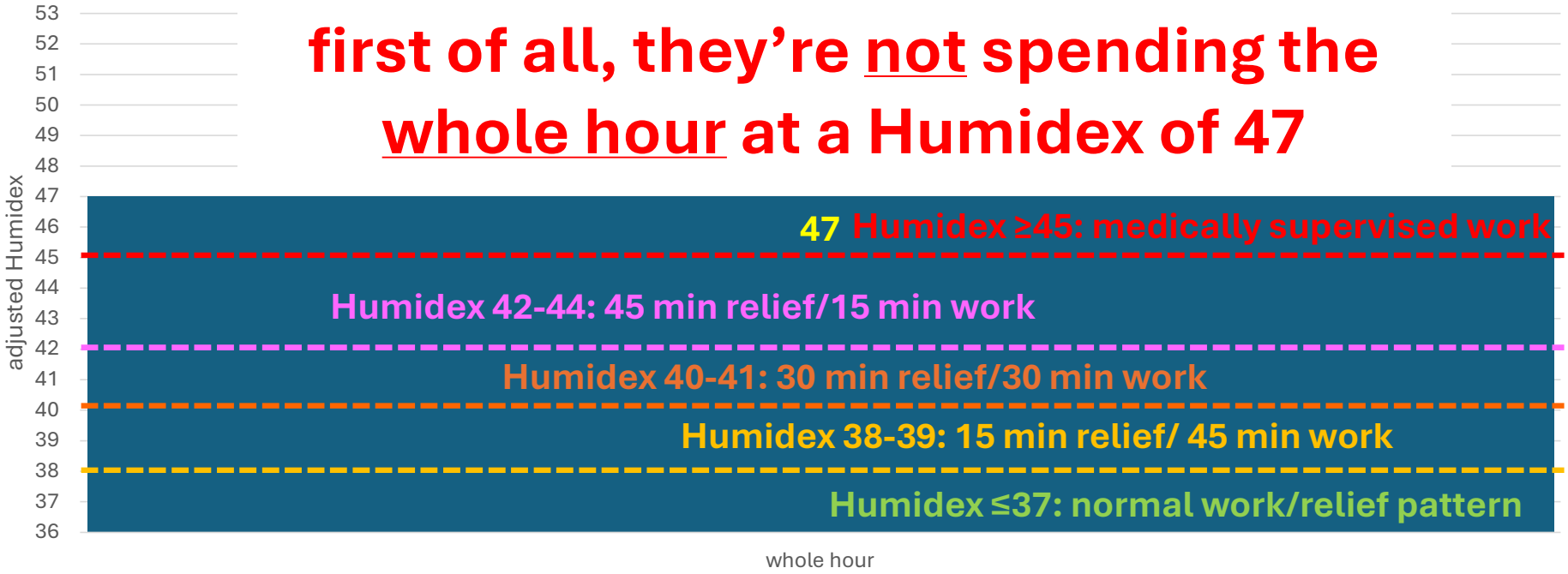
- Essentially this concerns the **collection** & **confidentiality** of **medical information**
- Persons measuring body temperature and heart rate need to **be trained** to do it properly with appropriate instruments
- Measurements need to be recorded, and this **information maintained in confidence** (as medical information)
- The results need to be **interpreted properly** with **appropriate responses**

Most workplaces don't have the resources to do this properly

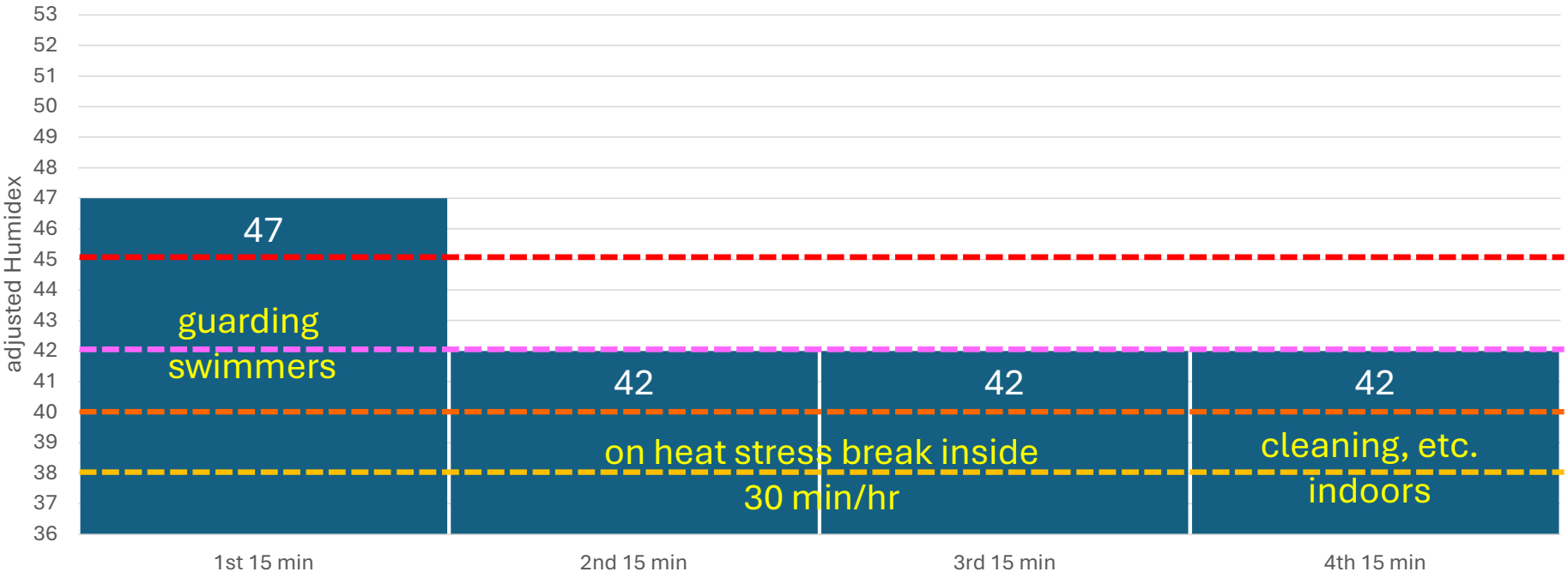
Measured Humidex = 47 (37°C; 45% RH); assume it applies to the whole hour

…let's have another look …

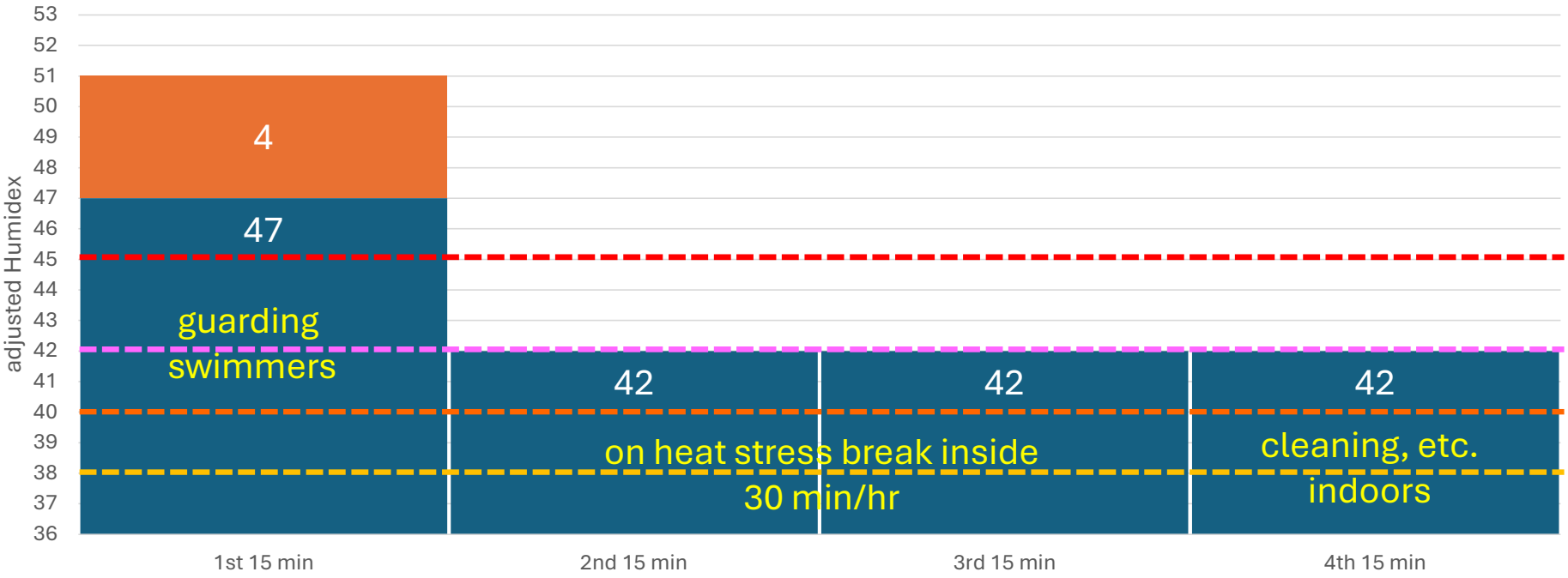
first of all, they're <u>not</u> spending the <u>whole hour</u> at a Humidex of 47



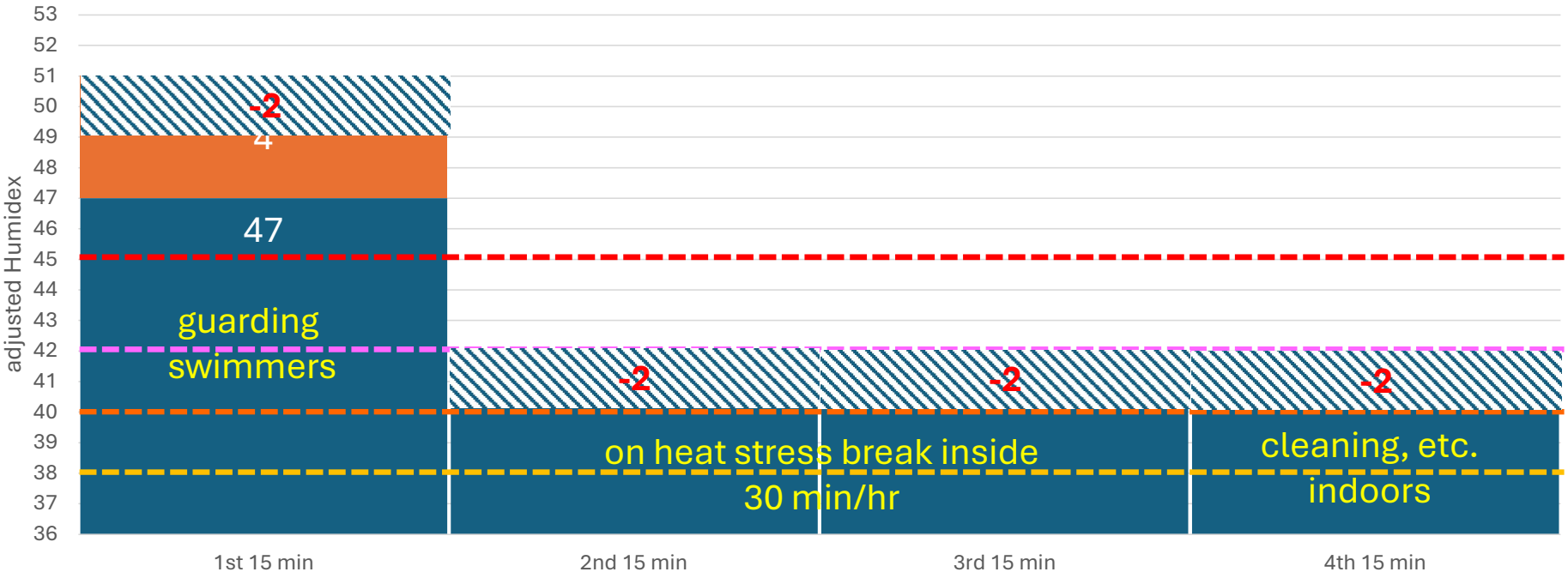
Measured outdoor Humidex (=47) and indoor Humidex (=42)



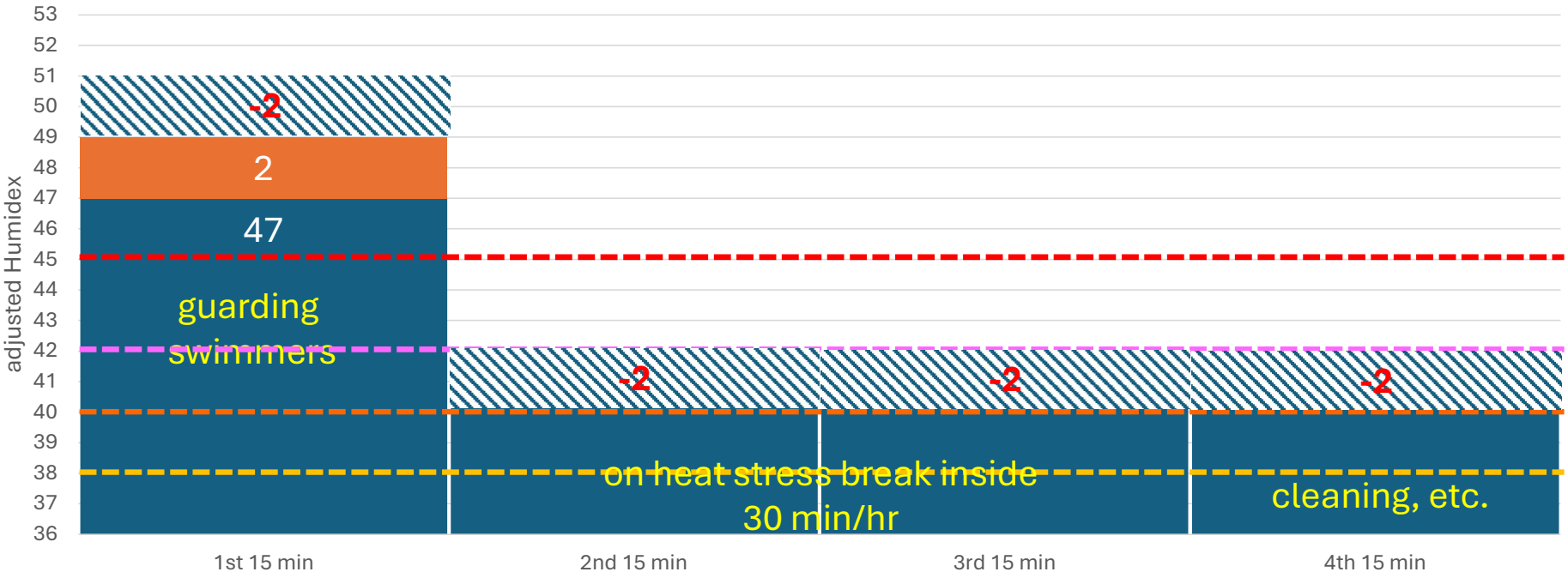
Adjust the outdoor Humidex (=47)
to include the effect of direct sun (47+4 = **51**)



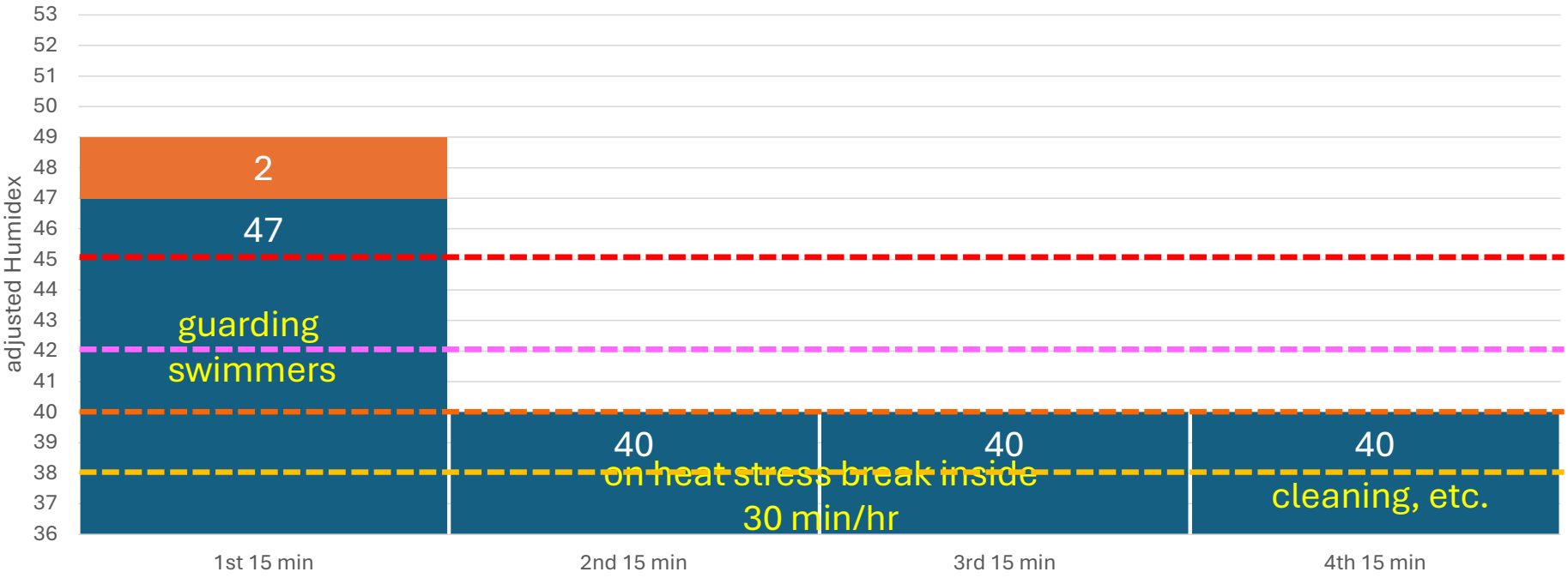
Outdoor Humidex (=47) & sunlight (47+4 = 51) but wearing shorts & T-shirt (51-2 = **49**)



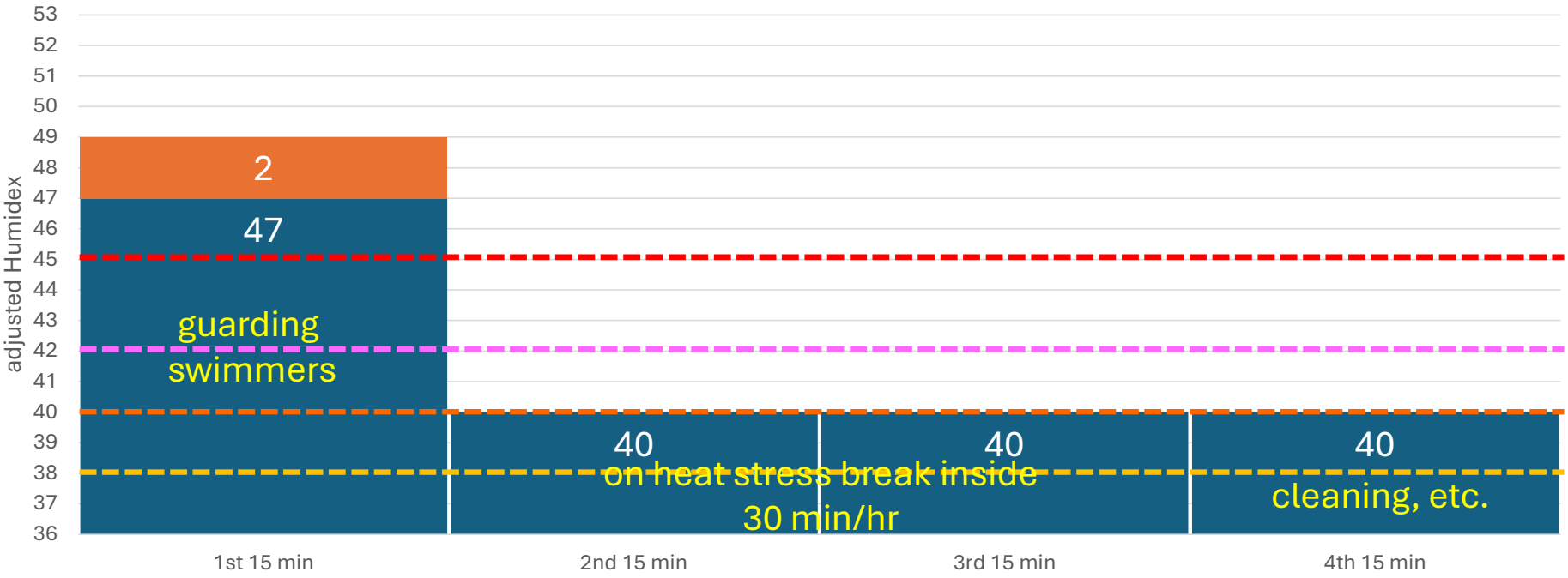
Outdoor Humidex (=47) & sunlight (47+4 = 51) but wearing shorts & T-shirt (51-2 = **49**)



Outdoor Humidex (=47) & sunlight (47+4 = 51) but wearing shorts & T-shirt (51-2 = **49**)

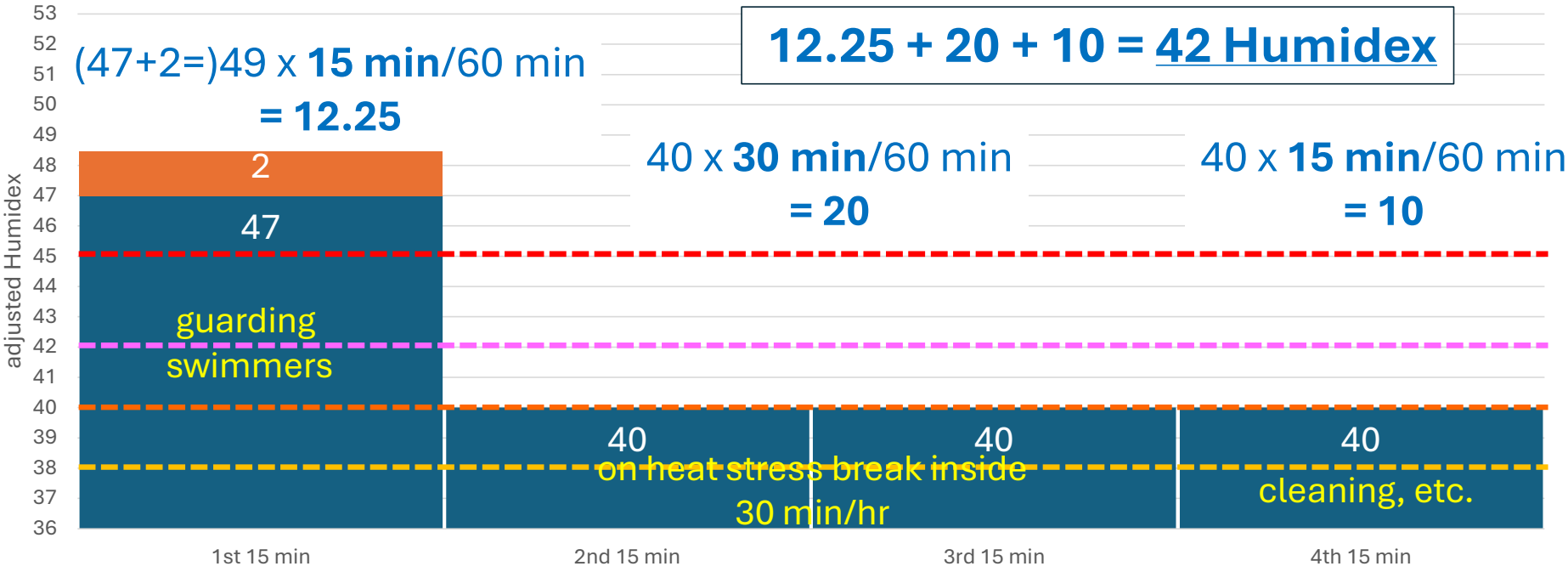


Outdoor Humidex = 49; Indoor Humidex = 40 with direct sun & wearing shorts adjustments



Outdoor Humidex = 49; Indoor Humidex = 40;

… now calculate the time-weighted average (TWA)



TWA Humidex = **42**

Find response on chart:

Adjusted* Humidex	Response
25 – 29	supply water to workers on an “as needed” basis
30 – 33	post Heat Stress Alert notice; encourage workers to drink extra water; start recording hourly temperature and relative humidity
34 – 37	post Heat Stress Warning notice; notify workers that they need to drink extra water; ensure workers are trained to recognize symptoms
38 – 39	work with 15 minutes relief per hour can continue; provide adequate cool (10-15°C) water; at least 1 cup (240 mL) of water every 20 minutes worker with symptoms should seek medical attention
40 – 41	work with 30 minutes relief per hour can continue in addition to the provisions listed previously
42 – 44	if feasible, work with 45 minutes relief per hour can continue in addition to the provisions listed above
45** or over	only medically supervised work can continue

45 min break

… but, we’re only taking 30 min breaks …

* “adjusted” means adjusted for additional clothing and radiant heat

** at Humidex above 45, heat stress to be managed as per the ACGIH TLV®

Scenario #2 (same as #1 except for last item)**:**

- Outdoor Humidex 47 (37°C; 45% RH; sunny; wind speed 20 km/hr)
- Lifeguard sitting **outside** in chair guarding swimmers for **15 minutes** per hour **– no shade**, wearing: T-shirt, bathing suit, water shoes
- **15 minutes working inside** cleaning up, sweeping (32°C; 60% RH; Humidex = 42)
- **15 min heat stress break** in non-air conditioned inside lunchroom (32°C; 60% RH; Humidex = 42)
- Jumps into the pool to cool down for 15 minutes (water temperature = 23.5°C; water cools the body faster than air (up to 25 times faster) – so we'll ignore the radiant heat from the sun and assume an equivalent Humidex value of 25-30?) – *ask Glen Kenny at the University of Ottawa if you want to be more precise*.

What does 15 minutes of submersion in 23.5°C pool water do for heat stress?

Table 4 Heat map illustrating the recommended water immersion durations based on water temperature and the promptness of treatment commencement

Study setting	Treated condition	Water temperature	Water immersion duration (min) to reduce T_{re} to safe levels (38.6°C or lower) for most people with pre-immersion T_{re} of 39.5-42.8°C											
			8	9	10	11	12	13	14	15	16	17	18	19
Lab	EH	2°C*												
Lab	EH	2°C												
Lab	EH	8°C												
Race	EHS	10°C												
Lab	EH	14-20°C												
Lab	EH	26°C												

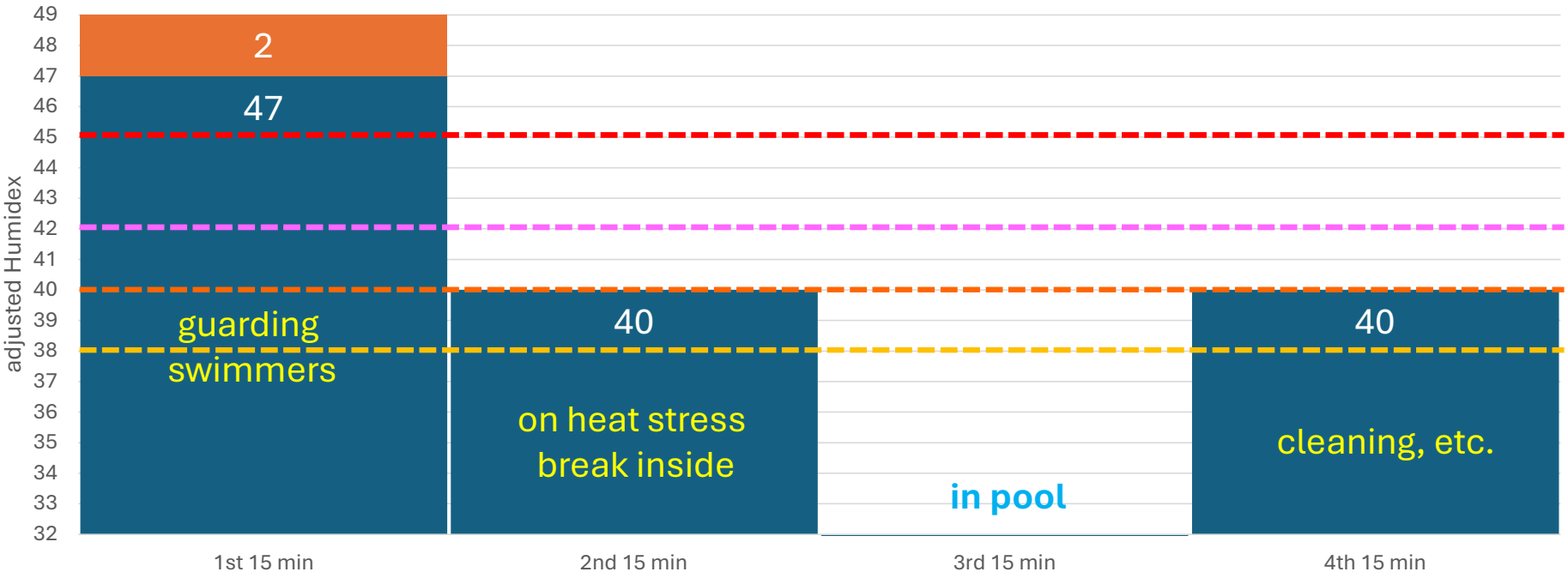
The recommended duration (in minutes) is indicated in green, satisfying the specificity criterion of ≥ 0.9. Shades of red indicate under-cooling and shades of blue indicate over-cooling. Detailed ROC curve results for each minute are shown in Table S2

T_{re} rectal temperature; *EH* exertional hyperthermia; *EHS* exertional heat stroke

*cooling start with up to 40 min delay; pre-immersion T_{re} in the lab studies ranged from 39.5 to 40.0 °C; pre-immersion T_{re} in the race ranged from 40.0 to 42.8 °C

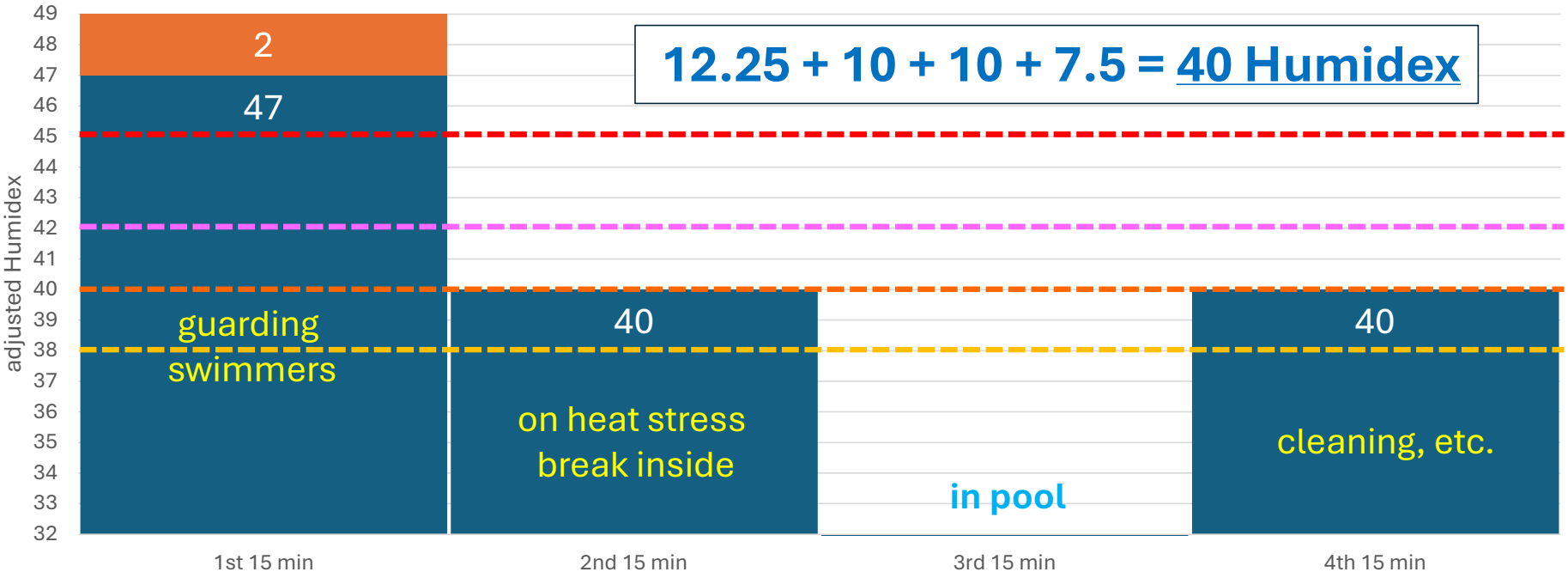
Flouris, Andreas D., Sean R. Notley, Rebecca L. Stearns, Douglas J. Casa, and Glen P. Kenny. "Recommended water immersion duration for the field treatment of exertional heat stroke when rectal temperature is unavailable." *European Journal of Applied Physiology* 124, no. 2 (2024): 479-490. https://link.springer.com/article/10.1007/s00421-023-05290-5

Outdoor Humidex (with sunlight & wearing shorts) = 49; Indoor Humidex = 40; Pool equivalent Humidex = 25-30?



Outdoor Humidex (with sunlight & wearing shorts) = 49; Indoor Humidex = 40; Pool equivalent Humidex = 25-30?

calculate time-weighted average (TWA)



49 x 15 min/60 min **= 12.25**

40 x 15 min/60 min **= 10**

30 x 15 min/60 min **= 7.5**

40 x 15 min/60 min **= 10**

TWA Humidex = **40**

Find response on chart:

Adjusted* Humidex	Response
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30 – 33	post Heat Stress Alert notice; encourage workers to drink extra water; start recording hourly temperature and relative humidity
34 – 37	post Heat Stress Warning notice; notify workers that they need to drink extra water; ensure workers are trained to recognize symptoms
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40 – 41	work with 30 minutes relief per hour can continue in addition to the provisions listed previously
42 – 44	if feasible, work with 45 minutes relief per hour can continue in addition to the provisions listed above
45** or over	only medically supervised work can continue

30 min break

… now we’re consistent with taking 30 min breaks …

* “adjusted” means adjusted for additional clothing and radiant heat

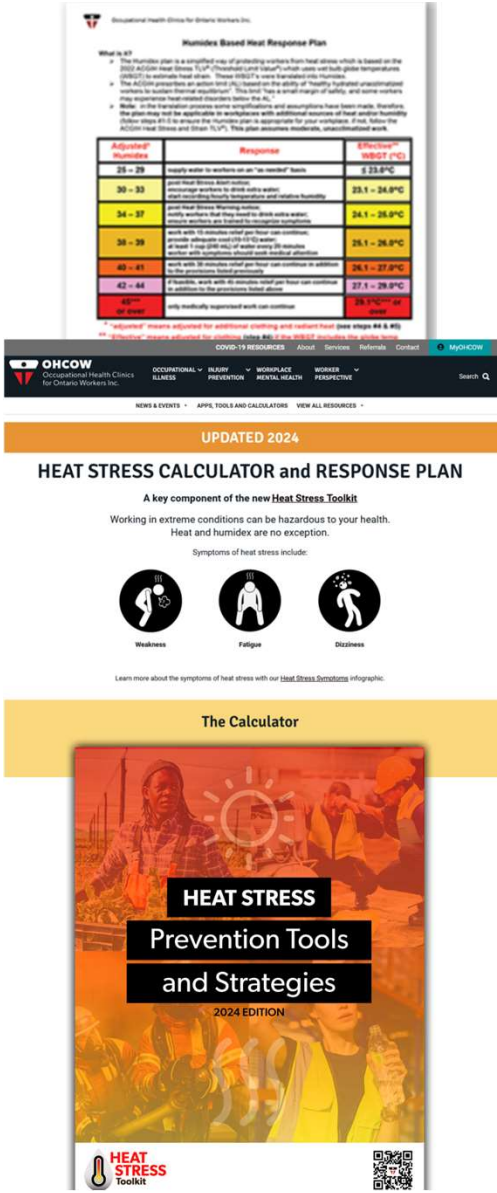
** at Humidex above 45, heat stress to be managed as per the ACGIH TLV®

Resources:

Humidex-Based Heat Response Plan: https://www.ohcow.on.ca/wp-content/uploads/2024/06/HumidexBasedHeatResponsePlan_July2024.pdf

Calculator: https://www.ohcow.on.ca/resources/apps-tools-calculators/heat-stress-calculator/

Practical Guide: https://www.ohcow.on.ca/wp-content/uploads/2024/05/hst-prevention-toolsandstrategies.pdf



Questions, comments, ...

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