



Protecting Workers from the Dangers of Heat: Evidence-based Approaches to Heat Stress Management

Margaret C. Morrissey, PhD

President of Occupational Safety and the Heat Safety & Performance Coalition, Korey Stringer Institute

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Overview

Negative effects of heat stress on health, safety, and productivity

Federal heat stress standard considerations

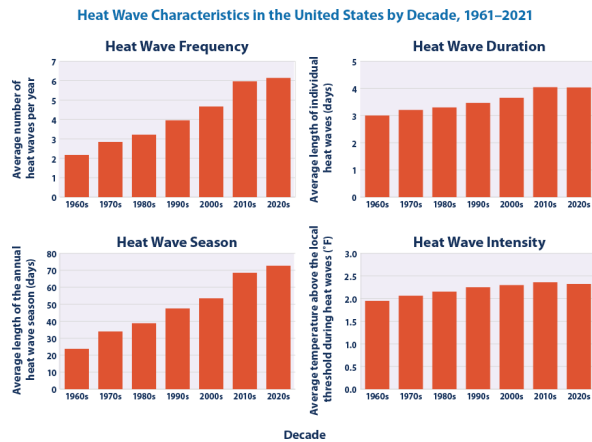
Prevention strategies to include in heat stress management plan

Emergency procedures for heat-related emergencies (exertional heat stroke)

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Climate Change

During the 2020s, the average heat wave has been 2.3°F above the local threshold



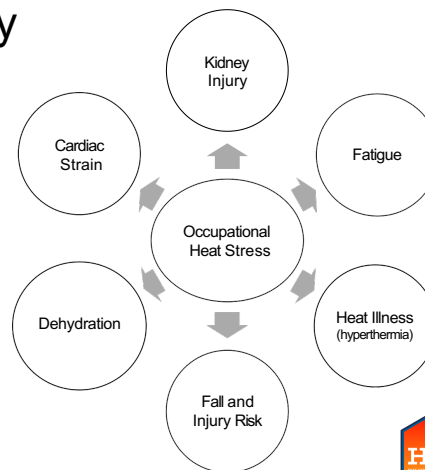
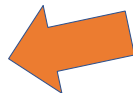
NOAA (National Oceanic and Atmospheric Administration), 2022



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Effects on Health & Safety

**Organ Damage
Low Heat Tolerance**
Long term health effects of heat stroke victims




NIOSH Recommendation Document 2016




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Current Data on Heat Effects are Underreported




OSHA REPORTED DATA
31,600 workers suffered heat-related illness between 2011-2019 (3,511 per year)



Additional 20,000 heat-related workplace injuries each year in California alone that are not accounted for.
Extrapolation to all U.S: **170,000 heat related injuries**

170,000 each year




Bureau of Labor Statistics, Park et al. 2021

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Average Number of Events or Exposures Causing Days Away From Work in the U.S

	Event or Exposure†	Cases
1	Overexertion involving outside sources	240,998
2	Falls on same level	185,724
	Exposure to environmental heat	170,000*
3	Struck by object or equipment	151,116
4	Other exertions or bodily reaction	85,119
5	Exposure to other harmful substances	65,344^
6	Falls to lower level	58,155
7	Struck against object or equipment	57,993
8	Slip or trip without fall	45,909
9	Roadway incidents involving motorized land vehicle	43,031
10	Caught in or compressed by equipment or objects	36,314

TOP 3
CAUSE
OF
INJURY!



Bureau of Labor Statistics and Public Citizen

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More than Just Heat Illnesses!

Heat Illness

Impaired Cognitive Function

Impaired Neurologic Performance

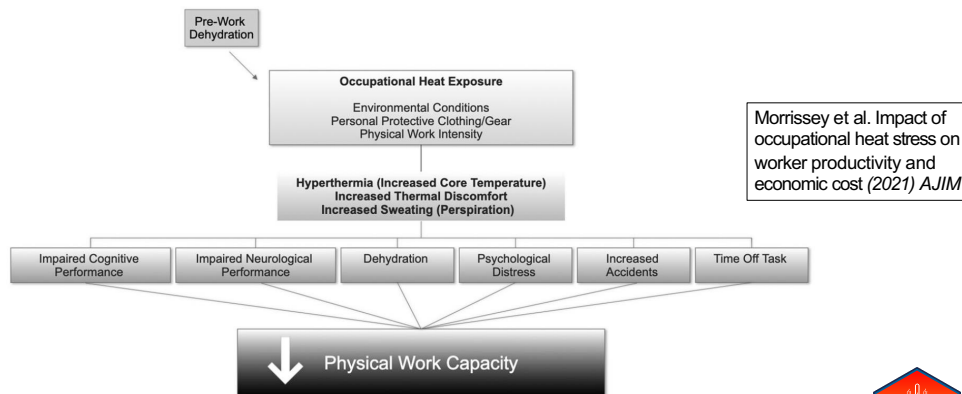
Increased Accidents and Injuries

Cardiac Events



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Heat Stress Influences Productivity



Morrissey et al. Impact of occupational heat stress on worker productivity and economic cost (2021) *AJIM*



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Heat Stress Regulations- Where are We Now?

BRIEFING ROOM

FACT SHEET: Biden Administration Mobilizes to Protect Workers and Communities from Extreme Heat

SEPTEMBER 20, 2021 • STATEMENTS AND RELEASES

Advance Notice of Proposed Rulemaking (ANPRM) on heat illness prevention in outdoor and indoor work settings was launched

We submitted a 56-page document with recommendations



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OSHA Rule Ripple Effect



Thermal Stress Working Group

- Secretary and members
- Leading efforts to write a white paper on physiological monitoring to assess heat strain
- Selected to represent AIHA in presentation with OSHA and NIOSH



Proposed Standard on Heat Stress (A10.50) in final stages

- On committee for proposed standard



Specification standard in development and heat stress working group



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GeoHealth

Research Article | [Open Access](#) |


Heat Safety in the Workplace: Modified Delphi Consensus to Establish Strategies and Resources to Protect the US Workers

Margaret C. Morrissey , Douglas J. Casa, Gabrielle J. Brewer, William M. Adams, Yuri Hosokawa, Courtney L. Benjamin, Andrew J. Grundstein, David Hostler, Brendon P. McDermott, Meredith L. McQuerry, Rebecca L. Stearns, Erica M. Filep, David W. DeGroot, Juley Fulcher, Andreas D. Flouris, Robert A. Huggins, Brenda L. Jacklitsch, John F. Jardine, Rebecca M. Lopez, Ronda B. McCarthy, Yannis Pitslaidis, Riana R. Pryor, Zachary J. Schlader, Caroline J. Smith, Denise L. Smith, June T. Spector, Jennifer K. Vanos, W. Jon Williams, Nicole T. Vargas, Susan W. Yeargin ... [See fewer authors](#) ^

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51 Experts at Roundtable


29 scientists with expertise in fields of occupational health (2), thermal physiology (25), human biometeorology (2)

5 representatives from governing bodies: NIOSH (2), US Army (2), US Air Force (1)

One worker health and safety advocate

12 safety managers responsible for safety initiatives

3 clinicians specializing in occupational medicine and/or heat-related illness



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Heat Stress Prevention Strategies

- Heat Hygiene Practices
- Hydration
- Heat Acclimatization
- Environmental Monitoring
- Physiological Monitoring
- Body Cooling
- Textiles/Personal Protective Equipment
- Emergency Action Plan Implementation



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Heat Safety Education and Training

- Risk factors of heat-related illnesses and Injury
- Effects of heat to health, safety, productivity
- Heat-related illness prevention strategies
- First aid
- Emergency response procedures for heat illnesses

Onboarding & Annual!



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Recognizing Health Hazards Associated with Workers Exposure to Heat

Conditions that may be associated with heat intolerance

- Sedentary Lifestyle
- Type 1 and 2 Diabetes
- Hypertension
- Heart Disease
- Autonomic Dysfunction (dysfunction of the autonomic nervous system that is in control of automatic, unconscious, and involuntary functions of the body)
- Kidney Disease
- Medications that affect thermoregulation, central nervous system function, sodium balance
- Obesity
- Pregnancy



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Risk Factors to Heat Illnesses

- High temperature and humidity
- Low fluid consumption
- Direct Sun Exposure
- Limited Air Movement
- Heavy Physical Exertion
- Poor workplace regulations
- Bulky Protective Clothing and Equipment
- Previous Illness
- Heat Unacclimatized
- Smoking and tobacco use
- Poor Diet
- Low Fitness Level
- Use of prescribed drugs and medications
- Use of non-prescription and over the counter drugs, supplements
- Sleep Deprivation
- Excessive caffeine
- Individual characteristics (disease state, body fat)



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Prevalence of Dehydration in Workers

- Up to 70% of workers arrive dehydrated!
- 14.5% increase in urine specific gravity, marker of dehydration, during a shift in the heat compared to thermoneutral condition (e.g, no heat)



Piil et al. (2018), Flouris et al. (2018)



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Hydration: How Will I Know If I Am Hydrated?

Light-colored urine (urine color chart)

Moderate urine frequency
(>5 voids per 24 hour)

Reduced thirst sensation

Body weight changes



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Current Fluid Intake Recommendations

NIOSH Recommendation: consume 237 mL every 15-20 mins during **heavy physical exertion in the heat**

- Appropriate for electrolyte-solutions at this level of exertion in the heat
- Electrolyte composition dependent on dietary intake
- Too much intake can cause hyponatremia



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Environmental Monitoring

- Measurements of the meteorological variables within at a certain location such as air temperature, air speed, relative humidity, and radiant heat

- **Environmental monitoring is performed to:**
 - 1) create environment-based work modifications (work to rest ratios)**
 - 2) Recommend additional heat stress prevention strategy implementation**



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Heat Stress Indices

- There are many indices: Wet-bulb globe temperature (WBGT), heat index, UTCI, PET

Most popular are: **WBGT and Heat Index**

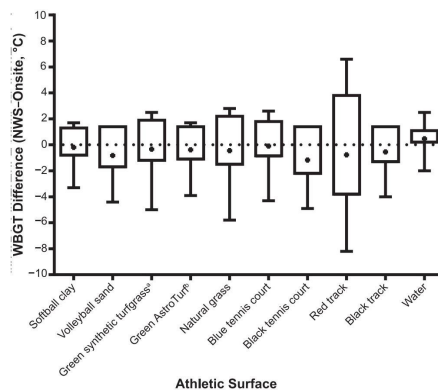
WBGT: is an environmental metric that takes into account air temperature, humidity, wind speed, and solar radiation. An equation derived from these metrics

Heat Index: is a measure of what temperature feels like to the human body when air temperature and humidity are combined. It is a heat balance model.



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On-site vs. Forecasting or Modeling Data



- National Weather Service (NWS) WBGT underestimated on-site WBGT by approximately **0.67°C** (Pryor et al. 2017), **0.58°C** (Coyle et al. 2002) and **1.98°C** (Cheuvront et al. 2015)

- Modeled NWS WBGT misclassified over **50%** of AstroTurf, red track, grass black tennis surfaces



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Heat Acclimatization: What is it?

Definition: Repeated bouts of physical activity in a hot environment that induce physiological adaptations that reduce strain and improve thermal tolerance

For new workers or workers returning from prolonged absence



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↓

Initial Heat Acclimatization
 Increase heat exposure over 5-7 days.
For example:

- Day 1: ≤10 %
- Day 2: ≤20%
- Day 3: ≤30%
- Increase workload ≤10% per day.
- Day 10-14: ≤100%

↓


Re- Acclimatization
 Increase time exposed to heat over 5-7 days
For example:

- Day 1: ≤50
- Day 2: ≤60%
- Day 3: ≤80%
- Day 4: ≤100%

** Reduce workload increments for those less physically fit/untrained*

Other Questions to Consider:

Are workers required to perform the same activity daily?
 Are workers required to perform work in different locations?



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PHYSIOLOGICAL MONITORING





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Considerations for Implementation of Physiological Monitoring Systems

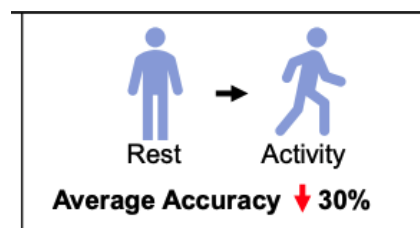
- What is the purpose?
- Do we know how to interpret it?
- Is it team-based software?
- Is it measuring what it is intended to measure?
- Is the device validated or reviewed by an external third party?



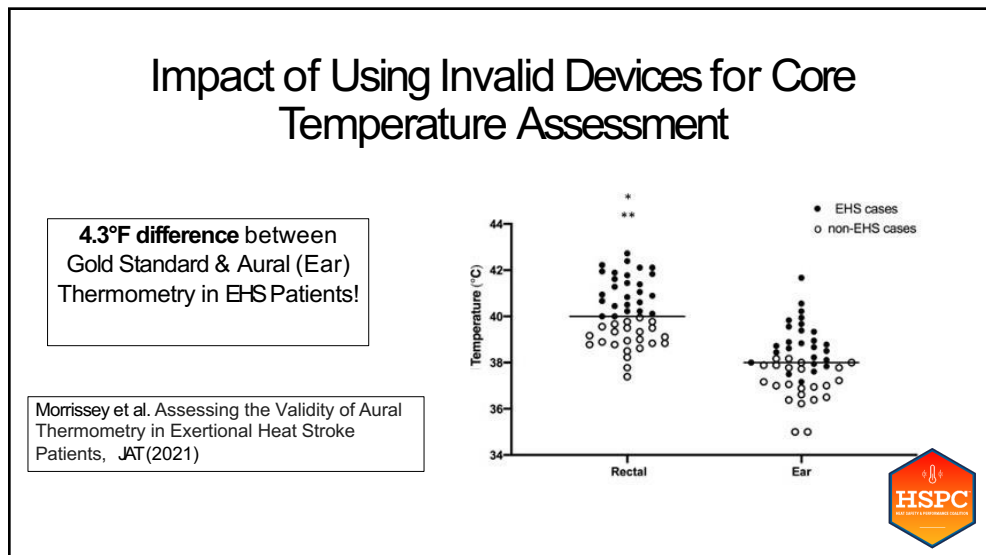
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Why is Validation so Important?

- Inaccuracy of data caused by:
 - Sweat/Heat
 - Activity
 - Anthropometric considerations
 - Work duration/ other conditions



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Physiological Monitoring Recommendations for Companies/Worksites


Recommendation #1: Reliability and Validity Study in Work Setting (small subset of workers)

-assess variability metrics from Manufacturer to validated device metrics to determine thresholds

Wearable Device Metric	Validated Metric/Device
Heart rate	H10 Polar HR, wireless ECG
Core temperature	Gastrointestinal Pill

Low variability= Can consider in safety decisions (for alerting and awareness, NOT medical diagnoses)

High variability = Do not consider in safety decisions



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Physiological Monitoring Recommendations

Recommendation #2: Compare data collected for device to:

- Heat strain symptoms
- Perception of heat strain
- Productivity Losses
- Frequency of reported heat illness

Create Alerting System and Thresholds from Data Collected!



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Body Cooling Strategies in Remote Settings



Extremity Immersion Cooling



Air Movement (Fans)



Cooling Vests (Conductive & Evaporative)



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Body Cooling Strategies in Remote Settings



Hand Cooling



Head Cooling



Cooling Towels



Water Dousing



Ice Slushy



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Body Cooling Considerations/ Tips

- **Cover as much body surface area as possible**
- Make sure your cooling product is cool! Not Hot
- ➔ Ice vest must be replaced often!

Considerations for Types of Cooling to Implement

- Do you have access to power?
- Do your workers wear PPE that would impede them from using body cooling strategy?



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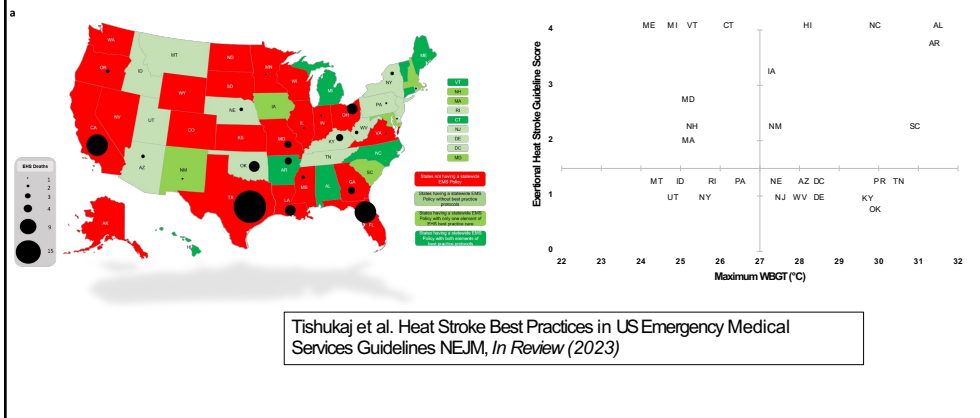
Emergency Action Plan Implementation (EAP)

- Each worksite needs an emergency action plan that addresses what will be done during medical emergencies associated with heat stress
- Must be disseminated to all staff, reviewed carefully and rehearsed
- Need to identify a supervisor and medical personnel who will create, manage, coordinate and execute the plan



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Heat Stroke Best Practices, EMS Guidelines, and Laborer Fatalities



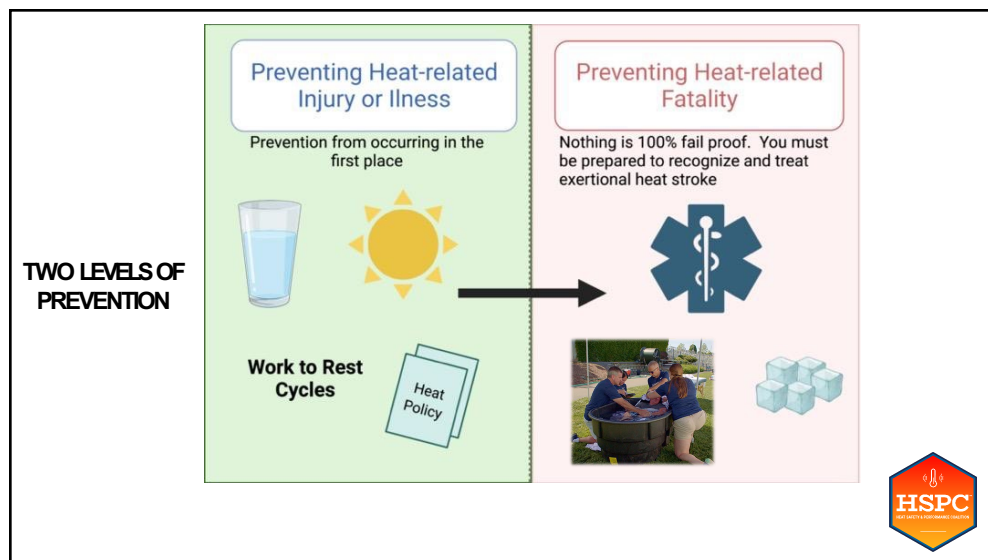
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What Should Be in Your Emergency Action Plan for Heat?

Emergency Procedures for Exertional Heat stroke!



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Emergency Procedures for EHS

#1 Goal: Get their body temperature DOWN within 30 mins!!



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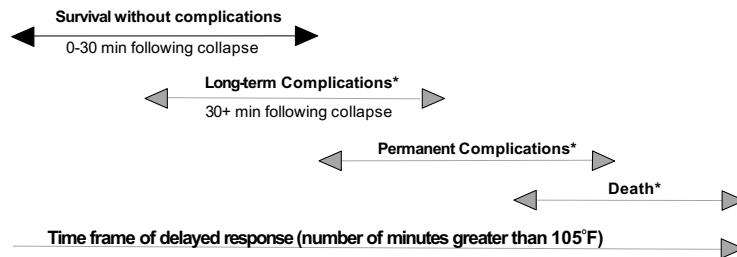
Signs & Symptoms of Exertional Heat Stroke

Signs	Symptoms
Extreme Hyperthermia (greater than 105°F)	Dizziness
Altered Consciousness	Headache
Disorientation	Nausea
Confusion; Look "out of it"	Muscle Cramps
Vomiting	Dehydration
Staggering	Irritability/Combative
Decreased Performance	Muscle Weakness
Profuse Sweating	Irrational Behavior



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Complications due to Delayed Treatment of EHS



*The prognosis spectrum ranges from survival without complications, if cooling is initiated within the first 30 minutes following collapse, to death, if cooling is significantly delayed.



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Treatment for EHS in Remote Settings



3/4 as effective
as a cold tub!

Remote Setting Alternative: Ice Towels Covering Body Surface Area and Replaced FREQUENTLY!



Hosokawa et al. (2017) Annals of Emergency Medicine

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margaret.morrissey@uconn.edu



www.heatsafetycoalition.com



@HeatSafety



@Mag_Morrissey

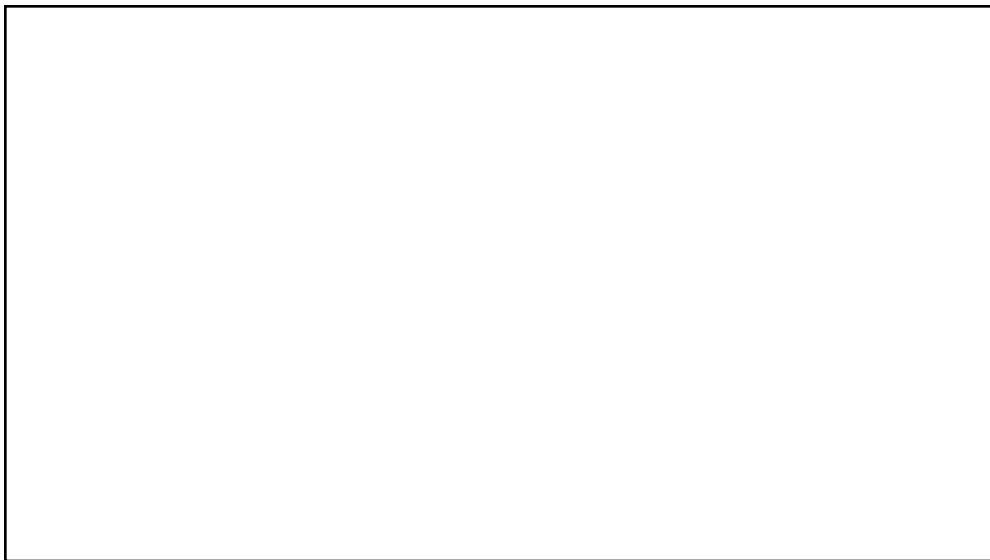


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