Climate and Heat:
Occupational Concerns and NIOSH Recommendations

Brenda Jacklitsch, PhD, MS

National Institute for Occupational Safety and Health (NIOSH)

Centers for Disease Control and Prevention (CDC)

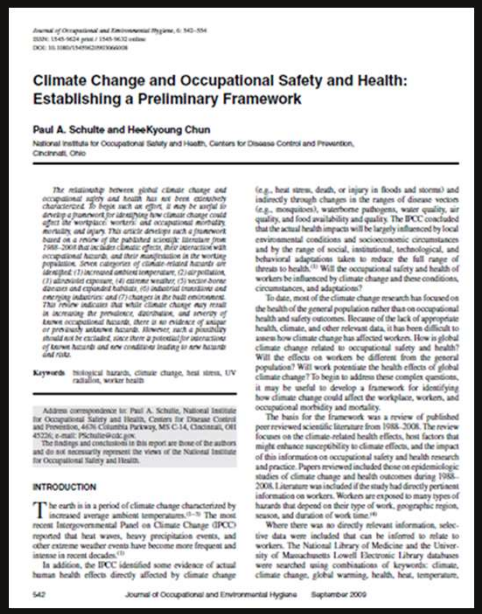
National Response Team Technical Conference
June 22, 2022

Occupational Safety and Health Impacts of Climate

Why are workers at risk from the effects from climate?

- Likely to have more and greater exposure than general public
- Employers may not be sufficiently informed or prepared to institute adequate risk management
- Workers are generally not a specific part of states' climate action plans

Climate and OSH Framework



Climate Change and Occupational Safety and Health: Establishing a Preliminary Framework

Paul A. Schulte and HeeKyoung Chun

National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio

The relationship between global climate change and occupational safety and health has not been extensively characterized. To begin such an effort, it may be useful to develop a framework for identifying how climate change could affect the workplace, workers and occupational morbidity, mortality, and injury. This article develops such a framework based on a review of the published scientific literature from 1988–2008 that includes climatic effects, their interaction with occupational hazards, and their manifestation in the working population. Seven categories of climate-related hazards are identified: (1) increased ambient temperature, (2) air pollution, (3) ultraviolet exposure, (4) extreme weather, (5) vector-borne diseases and expanded habitats, (6) industrial transitions and emerging industries and (7) changes in the built environment. This review indicates that while climate change may result in increasing the prevalence, distribution, and severity of known occupational hazards, there is no evidence of unique or previously unknown hazards. However, such a possibility should not be excluded, since there is potential for interactions of known hazards and new conditions leading to new hazards and risks.

Keywords biological hazards, climate change, heat stress, UV radiation, worker health

Address correspondence to: Paul A. Schulte, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, 4676 Columbia Parkway, MS C-14, Cincinnati, OH 45226; e-mail: PSchulte@cdc.gov.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

INTRODUCTION

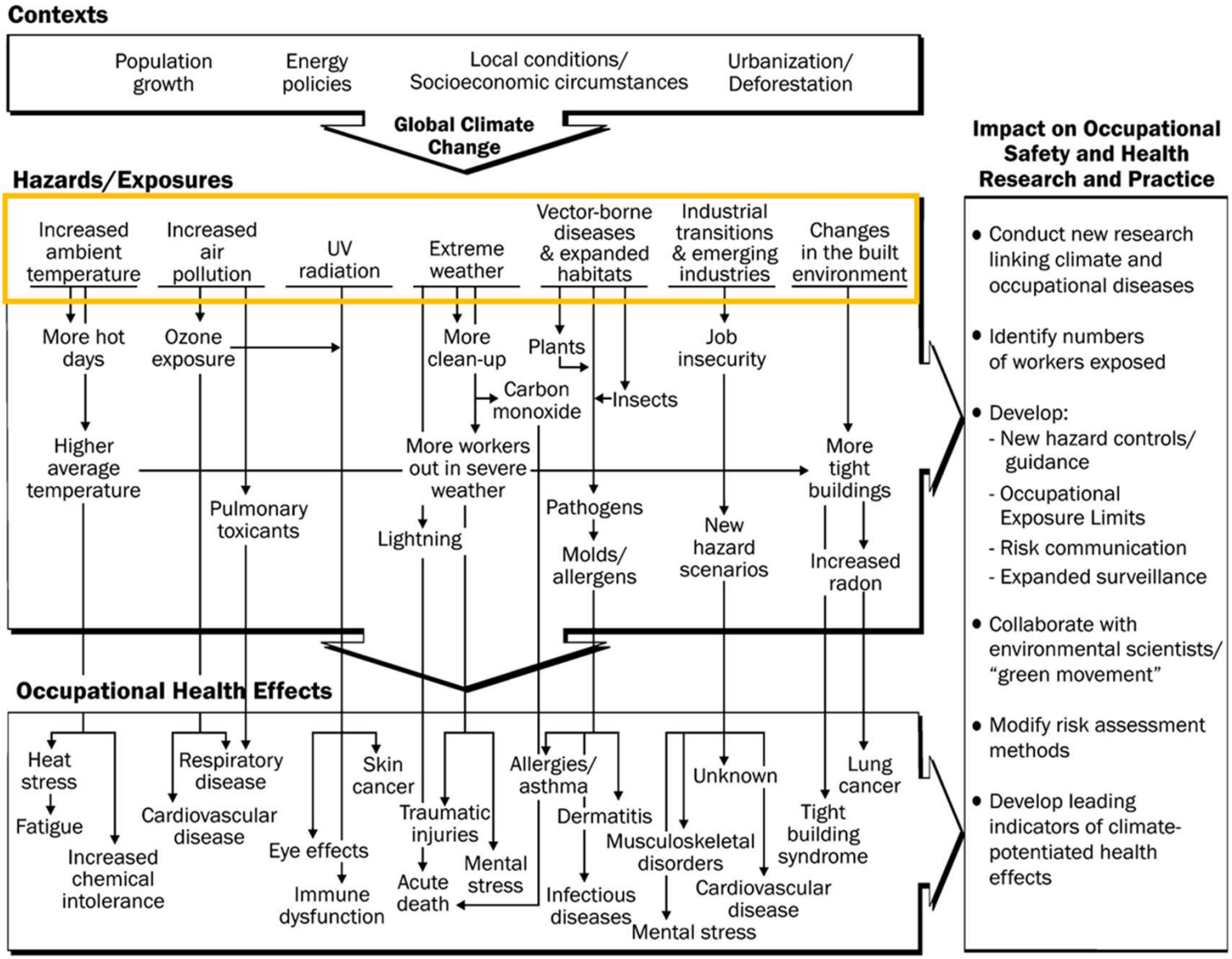
The earth is in a period of climate change characterized by increased average ambient temperatures.[1–3] The most recent Intergovernmental Panel on Climate Change (IPCC) reported that heat waves, heavy precipitation events, and other extreme weather events have become more frequent and intense in recent decades.[3]

In addition, the IPCC identified some evidence of actual human health effects directly affected by climate change (e.g., heat stress, death, or injury in floods and storms) and indirectly through changes in the ranges of disease vectors (e.g., mosquitoes), waterborne pathogens, water quality, air quality, and food availability and quality. The IPCC concluded that the actual health impacts will be largely influenced by local environmental conditions and socioeconomic circumstances and by the range of social, institutional, technological, and behavioral adaptations taken to reduce the full range of threats to health.[3] Will the occupational safety and health of workers be influenced by climate change and these conditions, circumstances, and adaptations?

To date, most of the climate change research has focused on the health of the general population rather than on occupational health and safety outcomes. Because of the lack of appropriate health, climate, and other relevant data, it has been difficult to assess how climate change has affected workers. How is global climate change related to occupational safety and health? Will the effects on workers be different from the general population? Will work potentiate the health effects of global climate change? To begin to address these complex questions, it may be useful to develop a framework for identifying how climate change could affect the workplace, workers, and occupational morbidity and mortality.

The basis for the framework was a review of published peer reviewed scientific literature from 1988–2008. The review focuses on the climate-related health effects, host factors that might enhance susceptibility to climate effects, and the impact of this information on occupational safety and health research and practice. Papers reviewed included those on epidemiologic studies of climate change and health outcomes during 1988–2008. Literature was included if the study had directly pertinent information on workers. Workers are exposed to many types of hazards that depend on their type of work, geographic region, season, and duration of work time.[4]

Where there was no directly relevant information, selective data were included that can be inferred to relate to workers. The National Library of Medicine and the University of Massachusetts Lowell Electronic Library databases were searched using combinations of keywords: climate, climate change, global warming, health, heat, temperature,



Climate and OSH

Ambient Temperature

Heat Stress

Chemical Intolerance

Air Pollution

Respiratory Disease

Cardiovascular Disease

UV Radiation

Skin Cancer

Eye Effects

Extreme Weather

Traumatic Injury

Mental Stress

Vector-borne Diseases & Expanded Habitats

Infectious Disease

Dermatitis

Industrial Transitions & Emerging Industries

Musculoskeletal Disorders

Many Unknowns

Changes in the Built Environment

Tight Building Syndrome

Lung Cancer

Increased Ambient Temperature

Global mean surface air temperature increased in the last 100 years

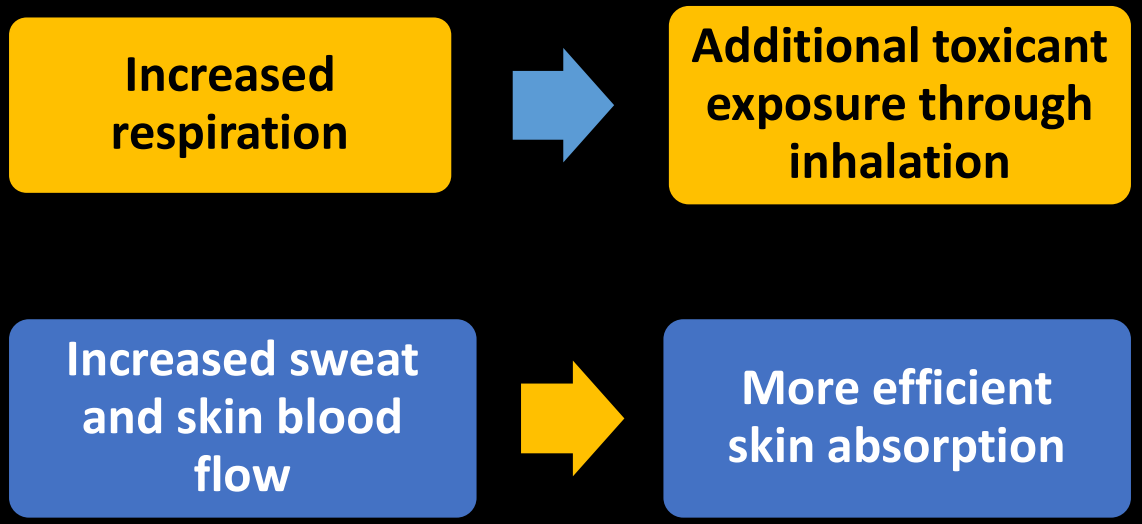
Heat Often a Concern During Emergency Response Activities

Oil spills, hurricanes, tornadoes, infectious disease outbreaks, etc.

1. Environmental heat
2. Metabolic heat
3. Clothing/PPE

Heat Stress and Toxicology

- Changes to core temperature can alter absorption, distribution, metabolism, and excretion of toxicants
- High temperatures accelerate dispersion and increase the density of airborne particles
- Less use or correct use of PPE
- Other airborne pollutants result in additional strain or exacerbated health effects



Chronic Kidney Disease

- First major epidemic which may be due to climate change
- 2nd leading cause of death among men in El Salvador
- Young men of working age: 20,000 dead
- Farmers and sugar cane workers, construction workers, corn and rice farmers, cotton plantation workers, and miners
- Affected countries include Sri Lanka, India, Saudi Arabia, Bangladesh, Egypt, Mexico, Costa Rica, El Salvador, Nicaragua, Honduras, Thailand
- Dehydration and heat stress

  Heat stress→ dehydration→ higher concentrations of toxicants in serum and kidney

Increased Air Pollution

- Air pollution and climate change have complex reciprocal relationship
  - Various air pollutants increase global warming
  - Global warming leads to formation of various pollutants
- Ground level ozone created by chemical reactions (oxides of nitrogen and volatile organic compounds) plus rising temperatures
  - Trigger variety of health problems; reduces lung function; exacerbates asthma and risk of premature mortality
  - 2-8 ppb increases in summertime
- Increase in length and severity of pollen season

Impact on Workers from Air Pollution

- Not assessed comprehensively
- Still being assessed
  - Generally, air pollution increases respiratory and cardiovascular mortality
  - Can infer risks to workers by geographical areas
  - Combustion a main source
    - Increased frequency of wildland fires
- Policy makers face challenge in developing optimal control strategies presented by changing climate base lines (Kinney 2008)

Ultraviolet Radiation

- Complex interaction of green-house gases, climate change, and stratospheric ozone depletion -> Result in increased UV radiation
- Affects all people but particularly outdoor workers
- Results in skin cancer, eye damage, immune suppression

Extreme Weather

- Increasingly extreme weather events are more frequent and intense
  - Storms, floods, landslides, droughts, wildfires
  - Outdoor workers and emergency responders
  - 1992-2006: 307 workers died from natural disasters
- Hazards depend on the disaster
  - Damage to infrastructure and destruction of service networks
  - Model prediction: US lighting strikes at 50% greater frequency over 21st Century
- Physical fatigue and long work hours
- Mental fatigue and stress

Vector-borne Diseases and Expanded Habitats

- Vector habitats are expanding:
  - Insects
  - Lyme disease, Chikungunya, West Nile Virus, Zika
  - Number of counties high-risk for Lyme disease increased 320% in last 20 years
- Non-vector expansion:
  - Airborne allergens/molds
  - Poisonous plants
  - Reptiles

Expanded Habitats

- Impacted length and severity of pollen season
  - Warmer conditions favor airborne allergens
  - Rise in prevalence and severity of allergic disorders
- Increased pesticide and herbicide use

Industrial Transitions and Emerging Industries

- Climate change may result in extensive shifts in industrial investments
- Some industries will deteriorate
  - Job insecurity
- Emerging industries
  - Solar
  - Wind
  - Biodiesel
  - Nuclear
- Recycling
- Green jobs

Unintended Consequences

- 1-Bromopropane was selected as alternative to ozone-depleting solvents

- Health effects in workers
  - Neurologic effects
  - Carcinogenic and reproductive hazard

Changes in the Built Environment

- High temperatures increase -> need for tighter climate-controlled buildings
  - Tight building syndrome
  - Radon
- Construction of hard structures in coastal areas
  - New settings
- Leadership in Energy and Environmental Design (LEED)
  - Incorporate worker protection standards in LEED Criteria

Additional Considerations

Mental Health

Economic Burden

Health Equity

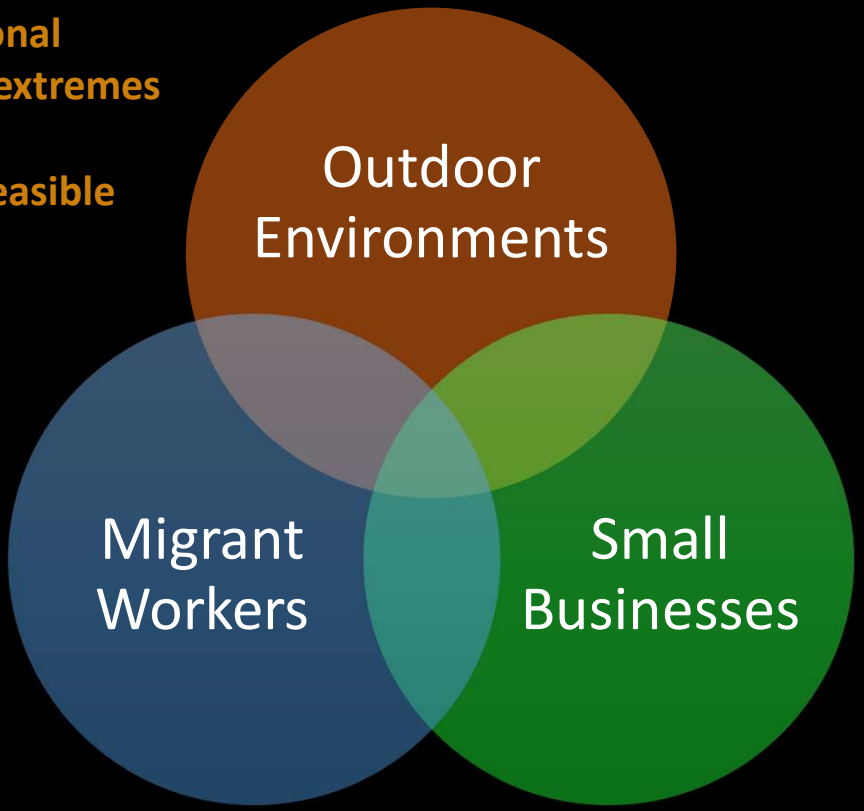
Mental Health Effects of Climate-Related Occupational Hazards

- Post-Traumatic Stress Disorder
- Depression
- Combined psychological effects
  - With other hazards (e.g., heat)
  - With personal loss

Occupational Health Equity

Millions exposed to seasonal temperature & humidity extremes

Controls are not always feasible



Increased susceptibility:

- Lack of knowledge
- Lack of training
- Poverty
- Seasonality
- Language barriers
- Cultural differences

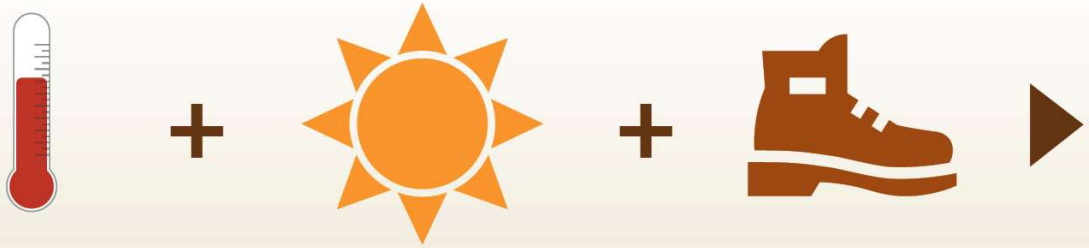
Higher injury & fatality rates:

- OSH not a priority
- Lack of resources
- Greater manager time demands
- Lack of management commitment to safety
- Fewer employees to engage in activities

Heat Stress

What is Occupational Heat Stress?

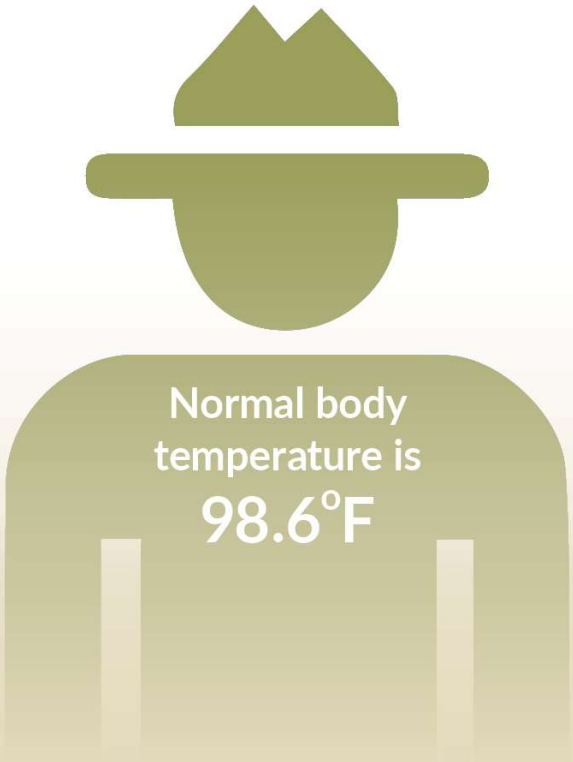
Heat Stress is the combination of:



Metabolic Heat + Environmental Factors + Clothing / PPE

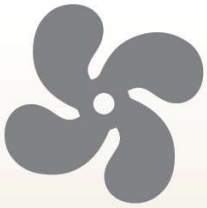
which results in increased heat storage within the body.

Heat Exchange Between the Body and Environment



Exchange of heat can occur through:

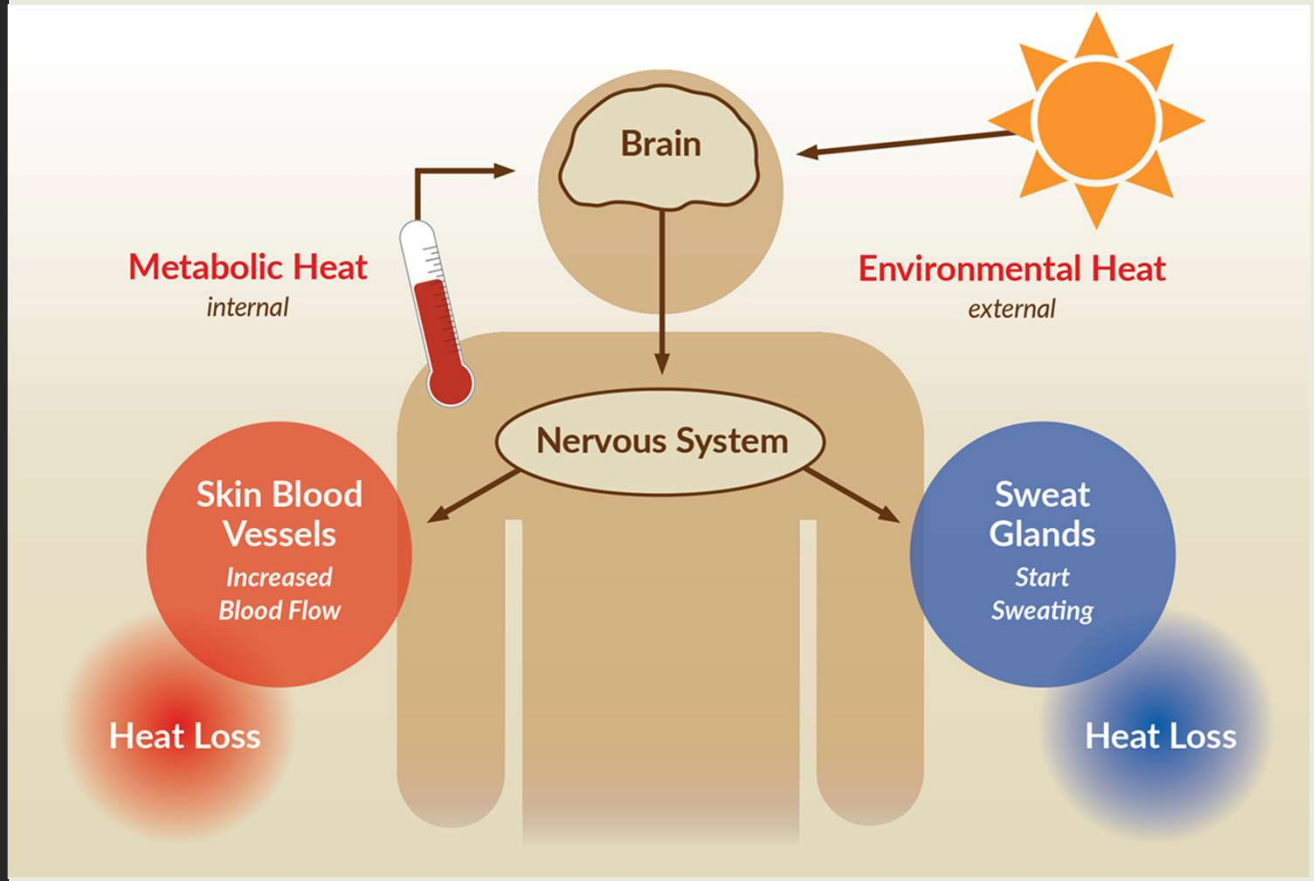
Radiation
sunny days
can feel hotter

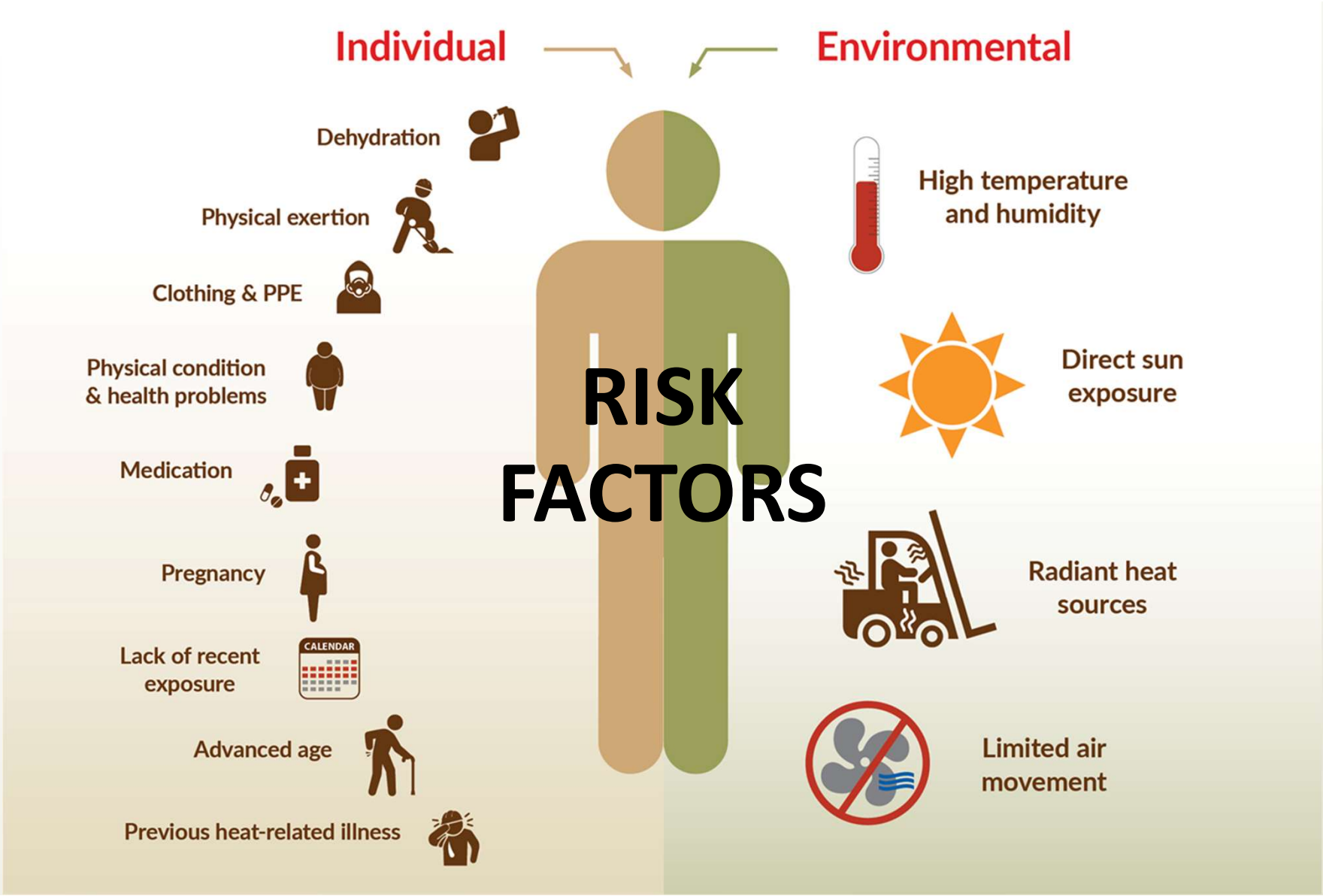


Convection
a breeze
or fan

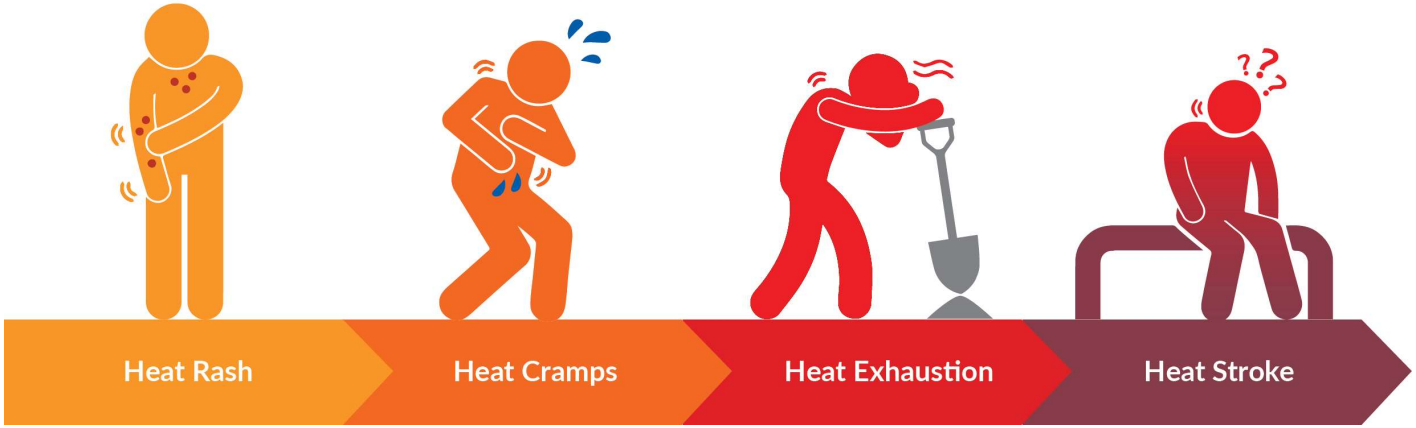
Evaporation
evaporating
sweat

Body Response to Heat




Individual
Environmental
Dehydration
Physical exertion
Clothing & PPE
Physical condition & health problems
Medication
Pregnancy
Lack of recent exposure
CALENDAR
Advanced age
Previous heat-related illness
High temperature and humidity
Direct sun exposure
Radiant heat sources
Limited air movement
RISK FACTORS

Heat-related Illnesses and Injuries



- Sweaty palms or wet drips on floors

- Fogged-up safety glasses/goggles

- Hot equipment could cause burns

- Dizziness and other heat illness symptoms can cause workers to forget or neglect safety protocols, resulting in injuries to self or others.

Heat Stroke: Classical vs. Exertional

Characteristic	Classical Heat Stroke	Exertional Heat Stroke
Age	Young children or elderly	15-45 years
Health	Chronic illness common	Usually healthy
Activity	Sedentary	Strenuous exercise
Sweating	Usually absent	Often present
Weather	Prolonged heat waves	Variable

Rhabdomyolysis

Associated with heat stress and prolonged physical exertion, resulting in the rapid breakdown, rupture, and death of muscle. Rhabdomyolysis can result in death of muscle tissue, irregular heart rhythms, seizures, and kidney damage.

Symptoms

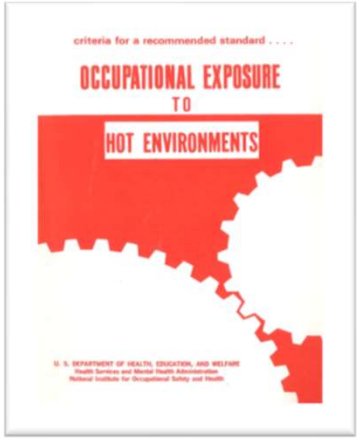
- Muscle cramps/pain
- Exercise intolerance
- Weakness
- Abnormally dark urine (tea or cola colored)
- Asymptomatic

First Aid

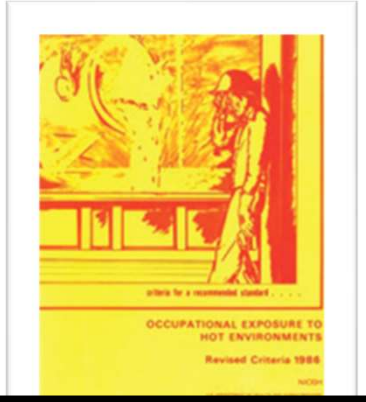
- Stop activity
- Increase oral hydration (water preferred)
- Seek immediate care at nearest medical facility
- Ask to be checked for rhabdomyolysis (i.e., blood sample analyzed for creatine kinase)

NIOSH Criteria for a Recommended Standard: Occupational Exposure to Heat and Hot Environments

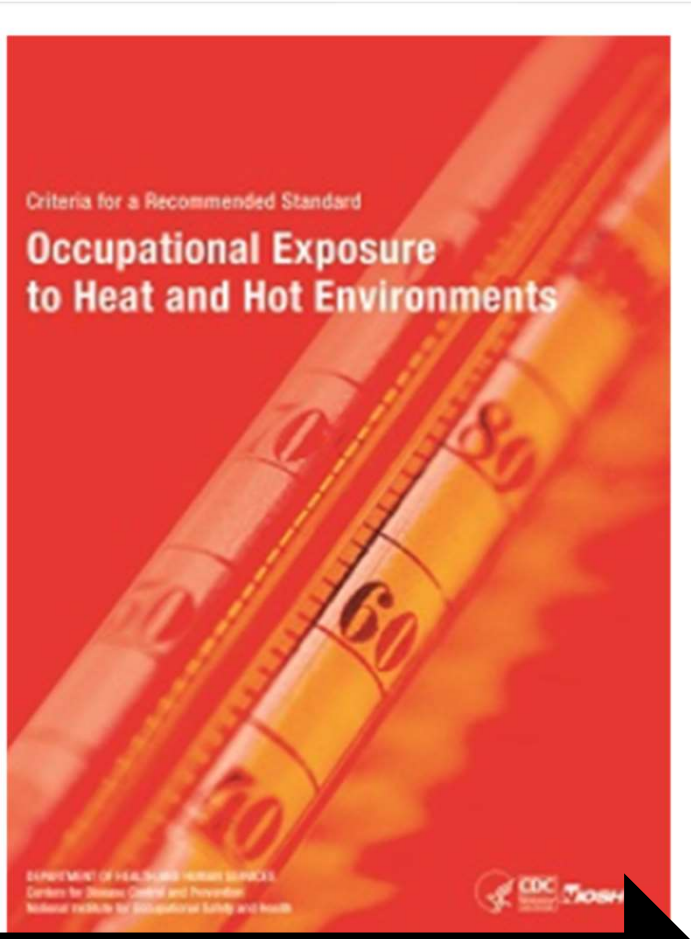
1972



1986



2016



Literature Review (2010) → Internal Review → Public Comment → External Peer Review → Clearance → Publication (2016)

Inside the NIOSH Criteria Document

Recommendations for an Occupational Standard

Workplace Limits & Surveillance Medical Monitoring
Sentinel Events
Posting of Hazardous Areas
PPE & Clothing
Training
Controls
Recordkeeping

Heat Balance & Heat Exchange

Heat Balance Equation
Modes of Heat Exchange
Effects of Clothing

Biological Effects of Heat

Physiological Responses
Acute & Chronic Disorders

Measurement of Heat Stress

Environmental Factors
Meteorological Factors
Metabolic Heat

Control of Heat Stress

Engineering
Administrative
PPE

Medical Monitoring

Medical Evaluations
Medical Surveillance
Employer Actions

Basis for the Recommended Standard

Occupational Exposure Limits (RELs & RALs)
Physiological Monitoring
Other Agencies & Organizations

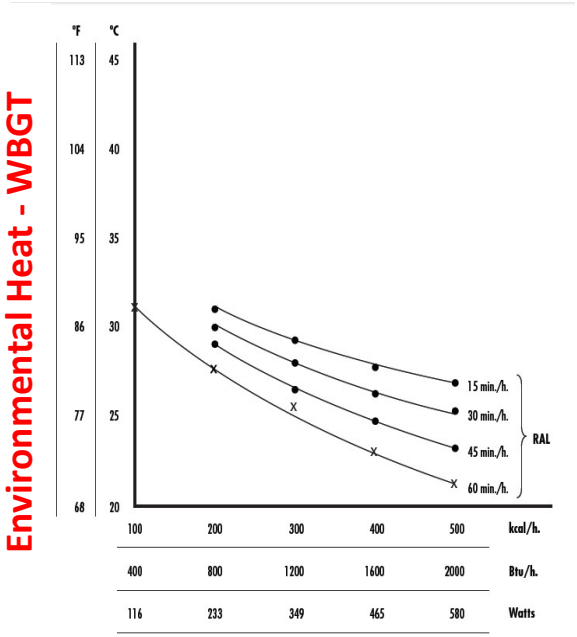
Indices for Assessing Heat Stress and Strain

Direct, Rational, & Empirical Indices
Physiological Monitoring

Research Needs

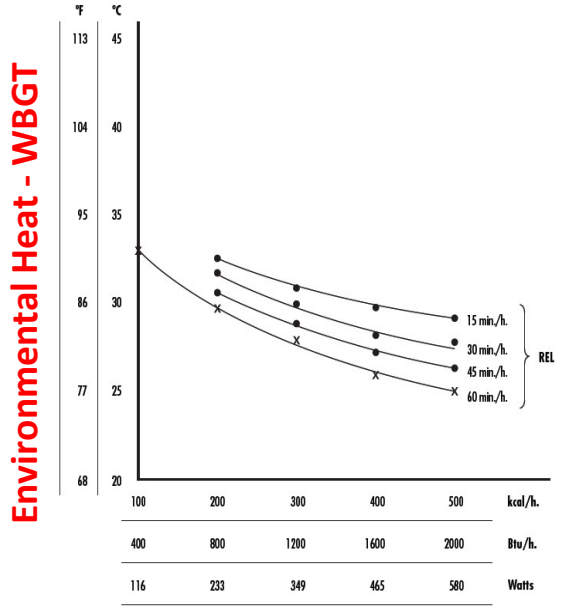
Chronic Exposures
Shift Work
Climate
Toxicology

NIOSH Recommended Limits



Recommended Alert Limit (RAL)

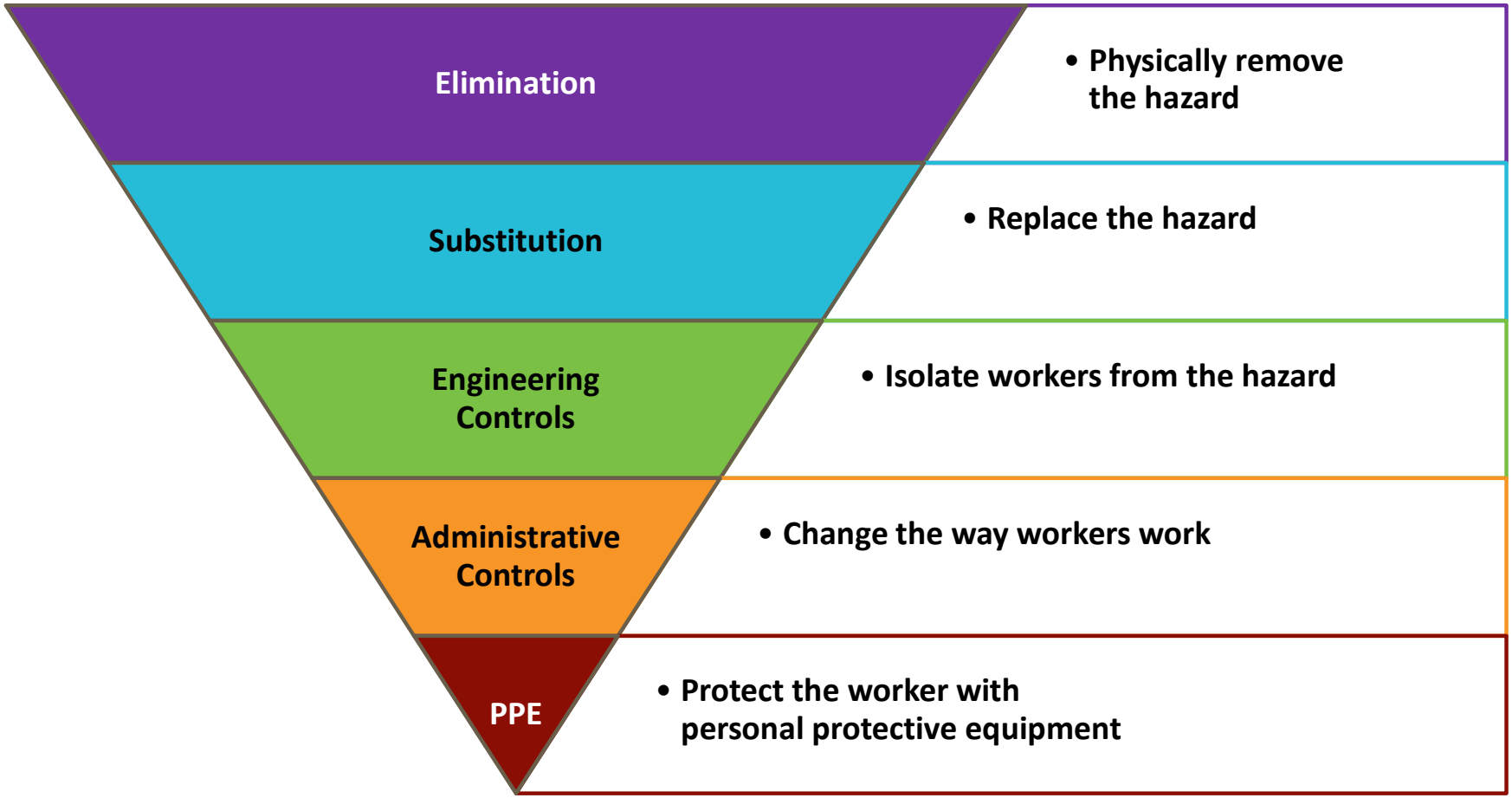
For Unacclimatized Workers



Recommended Exposure Limit (REL)

For Acclimatized Workers

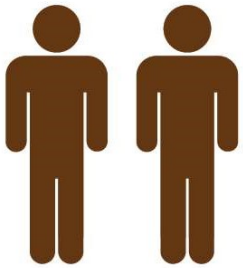
Hierarchy of Controls



Engineering Controls

- Increase air velocity. Example: Fans
- Use reflective or heat-absorbing shielding or barriers
  Example: Shaded area or canopy

Administrative Controls



- Implement a buddy system and routinely check workers to ensure
  - they make use of available water and shade
  - they don't have heat-related symptoms
- Monitor the weather.
- Limit time in heat and/or increase rest time in a cool environment.
- Increase the number of workers per task.
- Require workers to conduct self-monitoring.
- Implement a heat alert program when a heat wave is likely.

Training

Workers and supervisors:

- Recognize symptoms of HRI
- First Aid
- HRI risk factors
- Importance of acclimatization
- Importance of reporting HRI symptoms

Personal protective equipment may increase the risk of heat stress.

In addition, supervisors should be trained on:

- How to implement an acclimatization plan.
- Procedures for when a worker has symptoms of a HRI.
- How to monitor weather reports and respond to advisories.
- How to monitor and encourage adequate fluid intake and rest breaks.

Acclimatization Plan

Acclimatization occurs after daily repeated exposure.

Benefits:

- increased sweating efficiency
- stabilization of the circulation
- the work is performed with lower core temperature & heart rate

TIPS

Gradually increase time spent in hot conditions over 7-14 days

New worker heat exposure schedule:
Exposures to heat should be less than 20% on Day 1,
and increase max 20% per day after

Experienced worker heat exposure schedule:
Day 1 – 50%; Day 2 – 60%; Day 3 – 80%; Day 4 – 100%

Hydration

Employers should provide appropriate hydration:

- Water should be cool and near the work area.
- Individual drinking cups should be provided.
- Encourage workers to hydrate themselves.

TIPS

Avoid alcohol and drinks with high caffeine or sugar.

Generally, fluid intake should not exceed 6 cups per hour.

Workers should drink an appropriate amount to stay hydrated:

If you are...	Drink...
In the heat < 2 hours and involved in moderate work activities	1 cup (8 oz.) of water every 15–20 minutes
Experiencing prolonged sweating lasting several hours	Sports drinks containing balanced electrolytes

Rest Breaks

Ensure and encourage rest and hydration breaks:

- Permit breaks when a worker feels discomfort.
- Assign new workers lighter work and longer, more frequent breaks.
- Shorten work and increase rest periods:
  - As temperature, humidity, and sunshine increase.
  - When there is no air movement.
  - If protective clothing or PPE is worn.
  - For heavier work.

Personal Protective Equipment

- Wearable PPE that protects against heat exposures are called **auxiliary cooling systems** or **personal cooling systems**.
- Examples: water-cooled or air-cooled garments, cooling vests, and wetted overgarments.
- Range in simplicity, cost, and maintenance.
- Can be worn during rest breaks.
- Understand limitations.

NIOSH Research & Resources

NIOSH Climate and Heat Activities

Update Climate Framework Article

CDC Climate & Health Task Force

Interagency and External Workgroups

Physiology/PPE studies

Heat product & communication evaluations

Surveillance Tools & Work-related Data Collection

Search: niosh heat

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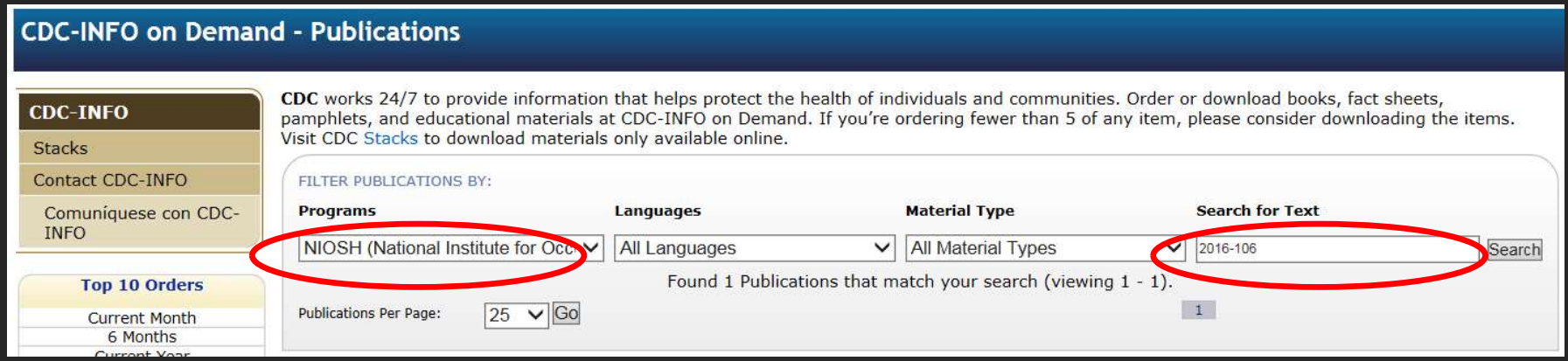

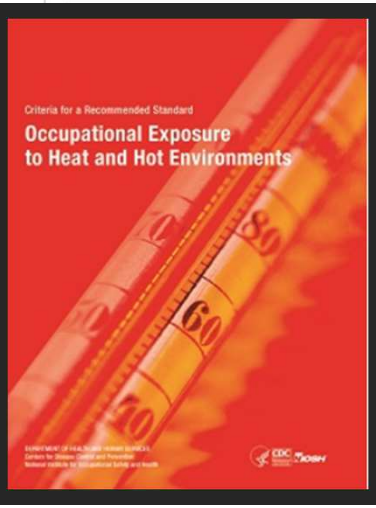

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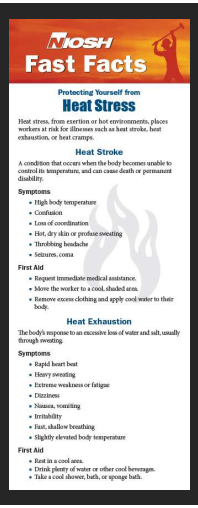

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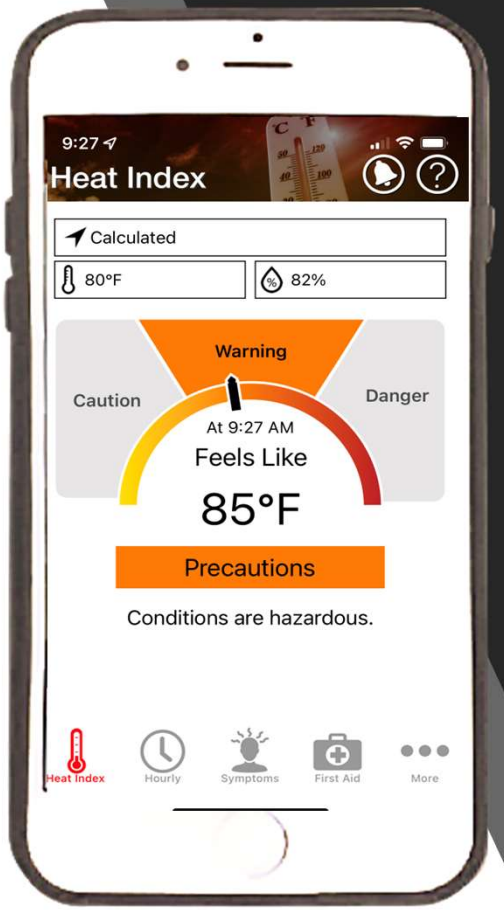
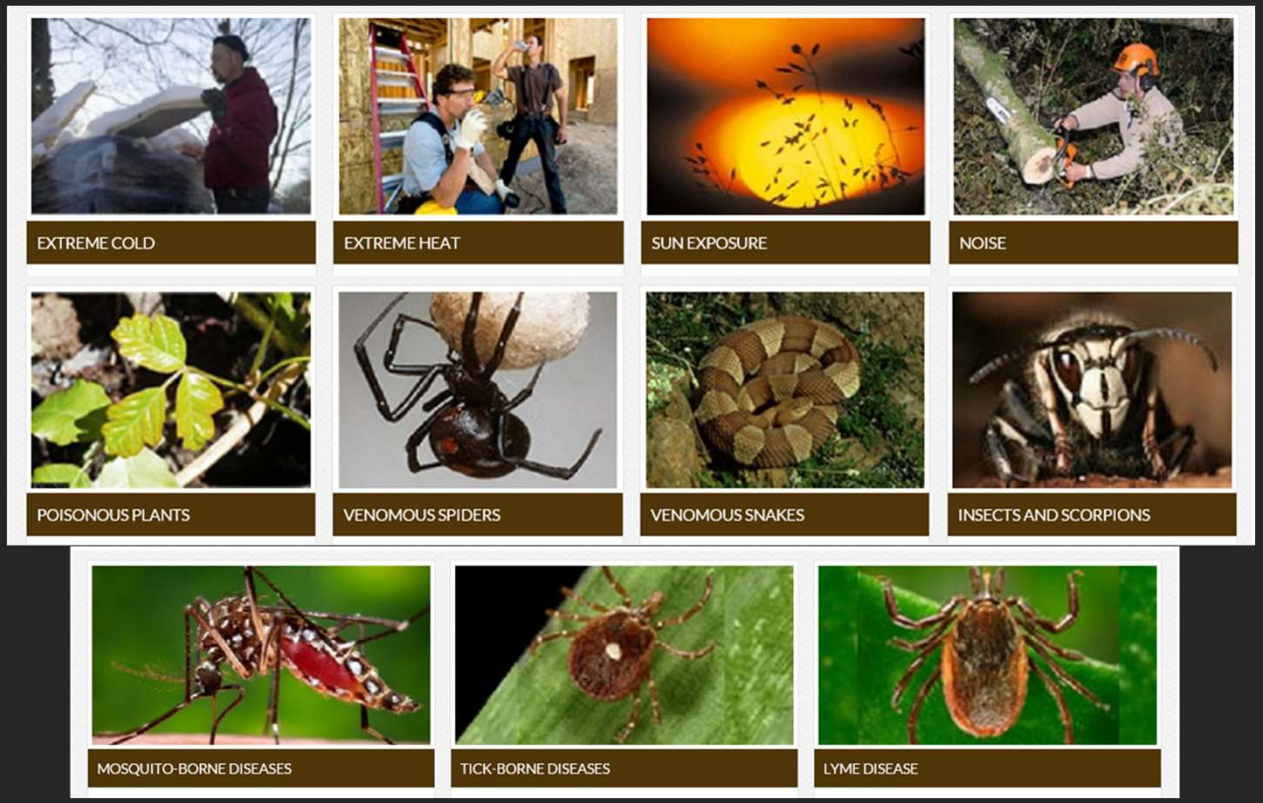
English & Spanish



OSHA-NIOSH Heat Safety Tool App

- Real-time heat index and hourly forecasts at your outdoor location
- Precautions based on heat index level
- Symptoms & First Aid
- Risk factors
- Training recommendations

App Store Search: niosh heat



NIOSH Hazards to Outdoor Workers

Search: niosh outdoors

Questions?

For additional information on occupational heat stress

SEARCH: **NIOSH heat**

CONTACT: **Brenda Jacklitsch**
GWE6@CDC.GOV