Heat-related Illness & Death in Construction

CPWR Webinar, June 29th, 2021
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Presenters:
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Chris Le, MPH, Program Manager, Construction Solutions Database chrisle@cpwr.com
Rosa Greenberg, MPH, Research Assistant, Research to Practice (r2p) rgreenberg@cpwr.com

Image: Iron worker using a thermic lance and a supplied air respirator. Courtesy: Mount Sinai/CHEP.
According to the National Weather Service, what is the leading cause of weather-related deaths?

The answer is HEAT.
Heat has always been an occupational hazard but data show that global temperatures are rising.

[Graph showing temperature anomaly from 1880 to 2020 with a common baseline of 1951-1980.]

Credits: NASA GISS/Gavin Schmidt
Nineteen of the warmest years on record have occurred since 2000.

2020 tied with 2016 for the warmest on record.

Source: NASA/GISS
https://climate.nasa.gov/vital-signs/global-temperature/
Rising temps threaten worker health and productivity

The most recent National Climate Assessment predicts $160 billion in lost wages annually in the USA this century.
Construction can involve serious hazards, and heat exposure is one of them.

Symptoms of heat-related illnesses include:
- Dizziness
- Light-headedness
- Fainting
- Altered mental state
- Confusion
- Muscle cramps
- Seizures
CPWR researchers and colleagues published a study on heat-related deaths in construction.

Heat-related deaths among construction workers

Heat-related deaths among construction workers in the United States


Source: Fatal injury data were generated by the CPWR Data Center with restricted access to BLS CFOI micro data. The views expressed here do not necessarily reflect the views of the BLS. Employment data were from the Current Population Survey. Calculations by the authors.
Construction workers had a disproportionate risk of heat-related death (HRD)

% of US workforce

% of HRD (1992-2016)
Over 80 US construction workers suffered heat-related deaths from 2011-2016

<table>
<thead>
<tr>
<th>Industry</th>
<th>Number of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>82</td>
</tr>
<tr>
<td>Professional Services</td>
<td>41</td>
</tr>
<tr>
<td>Agriculture</td>
<td>25</td>
</tr>
<tr>
<td>Public Admin.</td>
<td>23</td>
</tr>
<tr>
<td>Transportation</td>
<td>11</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>11</td>
</tr>
<tr>
<td>Leisure &amp; Hospitality</td>
<td>8</td>
</tr>
<tr>
<td>Mining</td>
<td>5</td>
</tr>
<tr>
<td>Wholesale &amp; Retail</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
</tbody>
</table>
Most of the deaths in that time period occurred during the **warmest months** of the year, as expected.
And in the afternoon, especially 2 to 4 p.m.
The deaths occurred in **multiple subsectors**

- **Roofing Contractors**: 12 deaths
- **Residential Building**: 10 deaths
- **Nonresidential Building**: 9 deaths
- **Plumbing, Heating, and Air-Conditioning**: 7 deaths
- **Utility System**: 5 deaths
- **Masonry Contractors**: 5 deaths
- **Highway, Street, and Bridge**: 5 deaths
- **Electrical Contractors**: 5 deaths
- **All Other Specialty Trade**: 5 deaths
- **Poured Concrete Foundation and Structure**: 4 deaths
We’ve looked at frequencies, but rates tell us more about risk

The following 3 tables show:

• Rates per 100,000 full-time construction workers
• A risk index using the average risk of heat-related deaths from 2011-2016 as the reference category (risk = 1)
• Significantly elevated risks (p < 0.05) denoted by *
Foreign born workers and races/ethnicities other than white, non-Hispanic were higher risk groups for HRD

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Number of heat-related deaths</th>
<th>Incidence rate of heat-related deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011-2016 total</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>26</td>
<td>31.7%</td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>46</td>
<td>56.1%</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>6</td>
<td>7.3%</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>4.9%</td>
</tr>
<tr>
<td>Birth place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-US born</td>
<td>26</td>
<td>31.7%</td>
</tr>
<tr>
<td>US born</td>
<td>56</td>
<td>68.3%</td>
</tr>
</tbody>
</table>
Construction workers in the south also had a higher risk

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of heat-related deaths</th>
<th>Incidence rate of heat-related deaths</th>
<th>95% Confidence Interval</th>
<th>Risk index $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011-2016 total</td>
<td>%</td>
<td>2011-2016 average rate $^a$</td>
<td>Lower</td>
</tr>
<tr>
<td>Northeast</td>
<td>9</td>
<td>11.0%</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>Midwest</td>
<td>13</td>
<td>15.9%</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>South</td>
<td>51</td>
<td>62.2%</td>
<td>0.22</td>
<td>0.21</td>
</tr>
<tr>
<td>West</td>
<td>9</td>
<td>11.0%</td>
<td>0.07</td>
<td>0.07</td>
</tr>
</tbody>
</table>
The biggest differences in risk were related to occupation

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number of heat-related deaths</th>
<th>Incidence rate of heat-related deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011-2016 total</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laborer</td>
<td>24</td>
<td>29.3%</td>
</tr>
<tr>
<td>Roofer</td>
<td>11</td>
<td>13.4%</td>
</tr>
<tr>
<td>Carpenter</td>
<td>8</td>
<td>9.8%</td>
</tr>
<tr>
<td>Cement mason</td>
<td>5</td>
<td>6.1%</td>
</tr>
<tr>
<td>Brick mason</td>
<td>4</td>
<td>4.9%</td>
</tr>
<tr>
<td>Electrician</td>
<td>4</td>
<td>4.9%</td>
</tr>
<tr>
<td>Plumber</td>
<td>4</td>
<td>4.9%</td>
</tr>
<tr>
<td>Foreman</td>
<td>4</td>
<td>4.9%</td>
</tr>
<tr>
<td>Heating A/C mech</td>
<td>3</td>
<td>3.7%</td>
</tr>
<tr>
<td>Helper</td>
<td>3</td>
<td>3.7%</td>
</tr>
<tr>
<td>All construction</td>
<td>82</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Any guesses why?
The answer is **we really don’t know, but we can make educated guesses**

- Study wasn’t designed to tell us why risks exist
- Could risks be interrelated?
- Are foreign born workers more likely to:
  - work in hotter southern states,
  - perform physically demanding jobs,
  - work for smaller firms with fewer H&S resources,
  - and be unaware of basic rights?
- The large differences by occupation suggest something about the work itself
Heavy workloads can increase core temps and cause electrolyte imbalance and dehydration through sweat loss.
Machinery and power tools can generate radiant heat

Image by: Mount Sinai/CHEP
Many jobs involve exposure to direct sunlight.
Heavy PPE can interfere with the body’s ability to cool itself

Image by: Mount Sinai/CHEP
Access to water, shade, and cooled spaces varies by jobsite.
Temporary employment in construction can complicate training and prevention efforts.
Going back to our study, relationships between increasing temps and HRD were statistically significant.

“Over the entire duration of the study period, increasing summer temperatures in the contiguous United States correlated positively with the annual number of heat-related deaths in construction (r=0.609; 95% CI: 0.282, 0.810) and with the rate of heat-related death (r=0.414; 95% CI: 0.022, 0.695).”
This chart shows rising temperatures and heat-related construction deaths over time.

Number of deaths vs. Calendar year:
- Linear (Number of deaths):
  \[ Y = -511.18 + 0.26X \]
  \[ R^2 = 0.270 \]

Avg. temp. (F), June – Aug. vs. Calendar year:
- Linear (Avg. temp. (F), June – Aug.):
  \[ Y = -91.03 + 0.08X \]
  \[ R^2 = 0.303 \]
Increases in average summer temps within a narrow range were associated with higher rates of HRD

\[ Y = -2.01 + 0.029 \times X \]

\[ R^2 = 0.422 \]
Some takeaways from the CPWR study

• Heat is a **serious hazard** for construction workers
• The threat it poses appears to be **getting worse**
• **Cement masons** were 10 times more likely to die from heat than the average construction worker
• **Roofers and helpers** were 7 times more likely
• **Interventions are needed** to protect the health and productivity of all construction workers, especially those in the highest risk groups
• **Further research is warranted** (e.g. non-fatal illness)
Heat Stress can be like a volcano - explosive and deadly.
“The incidence of occupational heat-related disorders in the US is not known although millions of workers have some level of exposure to hot environments.”

The Asuncion Valdivia Heat Illness and Fatality Prevention Act was introduced by congress this year

- The bill notes that:
- “Between 1992 and 2017, 815 United States workers died from heat and almost 70,000 were seriously injured.”
- “These numbers are generally understood to be gross undercounts because many heat-related illnesses and deaths are blamed on natural causes.”
Heat-Related Solutions

Chris Le, MPH
Program Manager, Construction Solutions Database
Construction Solutions Overview
Background

• Three states with standards for heat exposure:

  • Federal OSHA does not have a specific heat standard
    • They launched a OSHA’s Heat Illness Prevention Campaign in 2011

State Heat Plans  VS  OSHA Guidance

California
- “... when the outdoor temperature in the work area exceeds 80 degrees Fahrenheit, the employer shall...”

Minnesota
- Uses WBGT for measuring climate which also measures effect of humidity... but it is indoor only

Washington
- “apply to outdoor work environments ... at or above an applicable temperature...”

| TABLE 1. Two-hour time-weighted average permissible heat exposure limits. |
|-------------------------|------------------|
| WORK ACTIVITY          | WBGT, °F         |
| Heavy work             | 77               |
| Moderate work          | 80               |
| Light work             | 86               |

**Minnesota’s Work Activity Factor Table**

<table>
<thead>
<tr>
<th>TABLE 1. Outdoor Temperature Action Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of clothing</td>
</tr>
<tr>
<td>Nonbreathing clothing, including vapor barrier clothing or PPE such as chemical-resistant suits</td>
</tr>
<tr>
<td>Double-layer woven clothing including coveralls, jackets, and sweatshirts</td>
</tr>
<tr>
<td>All other clothing</td>
</tr>
</tbody>
</table>

**Washington’s Clothing Factor Table**

State Heat Plans VS OSHA Guidance

OSHA Guidance

- **Heat Index** combines both air temperature and relative humidity (moisture in air) into a single value.

  - **Heat Index Table (photo credit: OSHA)**

<table>
<thead>
<tr>
<th>Heat Index</th>
<th>Risk Level</th>
<th>Protective Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 91°F</td>
<td>Lower (Caution)</td>
<td>Basic heat safety and planning</td>
</tr>
<tr>
<td>91°F to 103°F</td>
<td>Moderate</td>
<td>Implement precautions and heightened awareness</td>
</tr>
<tr>
<td>103°F to 115°F</td>
<td>High</td>
<td>Additional precautions to protect workers</td>
</tr>
<tr>
<td>Greater than 115°F</td>
<td>Very High to Extreme</td>
<td>Triggers even more aggressive protective measures</td>
</tr>
</tbody>
</table>

  - **Heat Index Table (photo credit: OSHA)**

  - [https://www.osha.gov/heat/heat-index/protective-measures](https://www.osha.gov/heat/heat-index/protective-measures)

Heat Stress Program

Solution: Heat Stress Program

Description:
Working in high temperatures and high humidity for an extended period can result in heat-related illnesses. Implementing a comprehensive heat stress program can have a positive impact on safety and productivity. Ensuring adequate hydration, rest and cooling are part of a heat stress program and help to lower risks for heat stress and other heat-related issues.

Specific actions:
- Check the extended weather forecast. Call or visit the National Weather Service at http://www.weather.gov/ to plan for upcoming work and prior to the start of each workday to ensure that adequate plans are in place to protect workers. You can also receive weather alerts on your cell phone or computer through http://weather.weatherbug.com/Alerts/ or the National Weather Service at http://www.nws.noaa.gov/owd/WEA/wxalerts_emergency.php.php.
- Conduct worker and supervisor training on how to prevent and identify heat-related illnesses, and provide regular reminders.
- If possible, schedule work activities during cooler times of the day and shade the work area.
- Acclimate workers to working in a hot work environment. With no recent exposure to heat stress, acclimatization may require up to two weeks of gradually increasing heat stress exposure.
- Make sure all workers know where to go for water and shade. Locate water and shaded areas or air-conditioned areas for breaks as close as possible to where the work is being performed.
- Identify the quantity of drinking water and ice, and the number of disposable cups that will be needed for the shift. Remind workers to drink water and the amount they should drink – OSHA recommends drinking small amounts of water before workers become thirsty or at least one pint of water per hour in moderately hot conditions, aounce or a manned glass for every 15 minutes. Keep water containers in sanitary conditions.
- Increase the frequency of rest and water breaks to prevent dehydration and over-heating during heat waves.

Availability:
- To obtain information, visit Oppenheimer 4th Floor, 415-441, 1800 4th St. or contact 1-800-752-8472.
- Enviroguard Safetemp Sensor
To obtain information, visit Safetemp or contact 1-800-345-5972 or orders@enviroguard.com.
- OSGB Heat Safety Tool Application
This app allows users to calculate the heat index for their worksite, and, based on the heat index, displays a risk level to outdoor workers. [https://www.osha.gov/pls/oshaweb/owadisp.show昂n.jsp?ag=net/heatindex/he_ا@_app.html](https://www.osha.gov/pls/oshaweb/owadisp.show昂n.jsp?ag=net/heatindex/he_ا@_app.html)
- NIOSH Workplace Solutions Shell
The National Institute of Safety and Health (NIOSH) has published a series of "Workplace Solutions" which are easy-to-understand recommendations from NIOSH research results. Related to this construction solution, please find more information on: Preventing Heat-Related Illness or Death of Outdoor Workers and Criteria for a Recommended Standard Occupational Exposure to Heat and Hot Environments.
- State Plans
To obtain information, visit California §3255, Heat Illness Prevention in Outdoor Races of Employment and Minnesota §225.0110 INDOOR VENTILATION AND TEMPERATURE IN PLACES OF EMPLOYMENT and Washington §220.010 INDOOR VENTILATION AND TEMPERATURE IN PLACES OF EMPLOYMENT.
- OSHA
This guide offers recommended practices to prevent against the spread of COVID-19 and the risk of heat-related illness. COVID-19 Guidance on the Use of Face Coverings while Working Outdoors in Hot, Humid Conditions.

Related Safety Solutions:
- Administrative control

Some Key Points to Consider

- Identifying responsible individual for ensuring program is in place.

- Training for workers and supervisors on how to identify, prevent, and respond to heat-related illnesses

- Track the worksite heat conditions daily

- Evaluate work activities and implement plan when conditions trigger

- Steps for aiding workers suffering from a heat-related illness including emergency preparations for possible heat stroke cases

COVID-19 Impact: Face Coverings in Hot Conditions

- Face coverings (FC) can be uncomfortable during strenuous construction activities.
- Some recommended practices can include:
  - Acclimatize while wearing FC.
  - Allow workers to remove cloth FC when safe.
  - Evaluate face coverings for each worker and consider alternatives.
  - Increase frequency of water and rest breaks.
  - Use moisture-wicking, materials or light colors FC when working in direct sunlight.

How it works

- Per manufacturer, most effective when users’ forearms and hands are fully submerged in ice water.

- Lowers
  - Core temperature
  - Heart rate
  - Blood pressure

<table>
<thead>
<tr>
<th>TEMPERATURE (°F)</th>
<th>IMMERSION TIME (MINUTES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35° - 44°</td>
<td>2 - 5</td>
</tr>
<tr>
<td>45° - 54°</td>
<td>5 - 8</td>
</tr>
<tr>
<td>55° - 70°</td>
<td>8 - 12</td>
</tr>
<tr>
<td>71° - 80°</td>
<td>12 - 15</td>
</tr>
<tr>
<td>80° +</td>
<td>Add Ice</td>
</tr>
</tbody>
</table>

*Immersion Cooling Equipment (ICE) (photo credit: First Line Technologies)*

https://www.cpwrconstructionsolutions.org/solution/989/arm-immersion-cooling-system.html
Efficacy and Potential Application


Workers working in hot asphalt conditions (photo credit: ELCOSH)

https://www.cpwrconstructionsolutions.org/solution/989/arm-immersion-cooling-system.html
Real-time Monitoring Through A Connected Jobsite Platform

- Spot-R is a mesh network system for monitoring worker location, equipment utilization and safety incidents
- Proprietary technology for better location accuracy
- Provides real-time data that can improve safety through preliminary risk identification.

Spot-R Mesh Network System (photo credit: Triax Technologies)

https://www.cpwrconstructionsolutions.org/solution/1028/real-time-monitoring-through-a-connected-jobsite-platform.html
Safety Applications for Lone Workers

• **Lone workers** are those who work by themselves without close or direct supervision

• Risks for lone workers include
  • Lack of communication with supervisors and coworkers
  • Inadequate provision of first aid arising from emergency accidents
  • Sudden illness
  • Inadequate provision of rest, hygiene, and welfare facilities

• OSHA states that employers should check on lone workers “at regular intervals”
  • Safety applications can help with check-in procedures between lone workers and supervisors

https://www.cpwrconstructionsolutions.org/solution/1009/safety-applications-for-lone-workers.html
Tents, Shades and Canopies

Solution Summary: Tents and Shade Canopies

Risks Addressed:
Thousands of outdoor workers suffer from heat-related illnesses each year and many die. In 2010 alone, 30 workers died from heat stroke. In hot environments, the body releases excess heat to maintain a stable internal temperature by circulating blood to the skin and through sweating. If the body cannot get rid of excess heat, it will begin to raise the body’s core temperature to rise and the heat rate to increase. When this happens, the person begins to lose concentration and has difficulty focusing on tasks, may become irritable or sick, and often loses the desire to drink water. If the person’s body temperature is not brought down, sweating, and even death, can occur (OSHA Fact Sheet).

Heat stress can lead to many different conditions, including, but not limited to, heat stroke, heat exhaustion, heat syncope, heat cramps, and/or heat rash. (CDC Heat Stress).

How Risks are Reduced:
The risk of heat-related illness and injury is reduced by providing a shaded area where workers can go to cool down or to perform some work activity away from direct sunlight.
Fans, Misters and Air Conditioning Units

Misting Fan (photo credit: Big Fogg)

A portable AC unit (photo credit: MovinCool)

https://www.cpwrconstructionsolutions.org/solution/841/fans-misters-and-air-conditioning-units.html
Cooling Clothing and PPE

Cooling Vest accommodating female anthropometry (photo credit: Glacier Tek)

Neck Tie and Neck Wrap (photo credit: Arctic Heat USA)

High Visibility Cooling Vest (photo credit: Glacier Tek)

https://www.cpwrconstructionsolutions.org/solution/841/fans-misters-and-air-conditioning-units.html
CPWR Research to Practice (r2p)
Resources on Working in Hot Weather

Rosa Greenberg, MPH
Research Assistant, r2p
CPWR Resources on Working in Hot Weather

• Key topics
  • Hot environments
  • Skin cancer
  • Lightning
  • Disaster preparedness

• Formats
  • Toolbox talks
  • Hazard alert cards
  • Infographics
  • Phone-based apps
  • Training materials

• Language access
  • English and Spanish

https://www.cpwr.com/research/research-to-practice-r2p/r2p-library/other-resources-for-stakeholders/working-in-hot-weather/
Toolbox Talks

https://www.cpwr.com/research/research-to-practice-r2p/r2p-library/toolbox-talks/
Hazard Alert Cards

- Available for online download (PDF format) or print-to-order
- Printed cards are folded to be pocket-sized (3.5” by 5.5”). They are water-resistant and made to last
- Order cards here: https://www.cpwr.com/research/research-to-practice-r2p/r2p-library/hazard-alert-cards/
CPWR-NIEHS Disaster Preparedness App

• Phone-based, interactive mobile application that provides tailored awareness-level resources on disasters and related topics
• Available for iOS and Android
• Download here: https://tools.niehs.nih.gov/wetp/index.cfm?id=2536
OSHA’s Heat Illness Prevention Campaign

• Goal is to educate employers and workers on the dangers of working in the heat
• Launched in 2011
• Provides training guides, outreach, informational sessions, publications, social media campaigns, media appearances
• Learn more and access resources: https://www.osha.gov/heat
OSHA-CPWR Alliance Heat Exposure Infographics

https://www.cpwr.com/research/research-to-practice-r2p/r2p-library/other-resources-for-stakeholders/working-in-hot-weather/protect-yourself-against-heat-exposure/
Thank you! Questions?