The application of wearable technologies used for heat stress assessment.

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Today's 5 minutes…

- Wearable devices used in heat stress study of WLFFs
- Risks and Benefits of Physiological Monitoring
- Developing and evaluating guardrails

Preventing Heat Illness

Is adherence to current standards enough to prevent heat illness?

Temperature (°F)	Light Work Minutes Work/Rest	Moderate Work Minutes Work/Rest	Heavy Work Minutes Work/Rest
90	Normal	Normal	Normal
91	Normal	Normal	Normal
92	Normal	Normal	Normal
93	Normal	Normal	Normal
94	Normal	Normal	Normal
95	Normal	Normal	45/15
96	Normal	Normal	45/15
97	Normal	Normal	40/20
98	Normal	Normal	35/25
99	Normal	Normal	35/25
100	Normal	45/15	30/30
101	Normal	40/20	30/30
102	Normal	35/25	25/35
103	Normal	30/30	20/40
104	**Normal**	**30/30**	**20/40**
105	Normal	25/35	15/45
106	45/15	20/40	Caution
107	40/20	15/45	Caution
108	**35/25**	**Caution**	**Caution**
109	30/30	Caution	Caution
110	15/45	Caution	Caution
111	Caution	Caution	Caution
112	Caution	Caution	Caution

From NIOSH Criteria for a Recommended Standard

Assumptions:

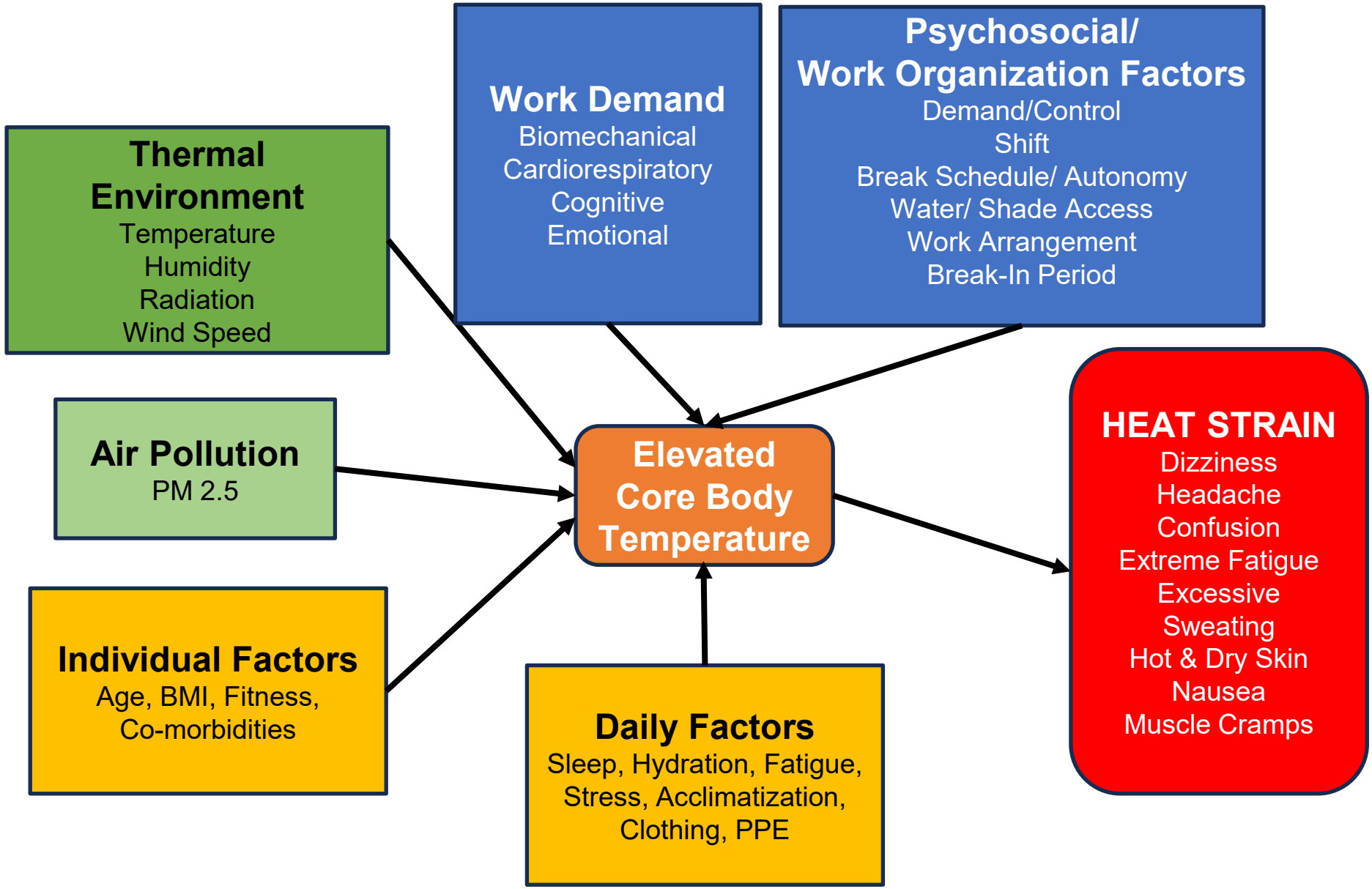
- workers are physically fit,
- well-rested,
- fully hydrated,
- under age 40,
- environment has 30% humidity
- perceptible air movement

Example

A worker performing heavy work in 104 °F temperatures should work for 20 minutes and rest for 40 minutes.

Example

A worker performing moderate work at 108 °F should use extreme caution! The risk for heat injury is high in this situation.


Thermal Environment
Temperature
Humidity
Radiation
Wind Speed
Work Demand
Biomechanical
Cardiorespiratory
Cognitive
Emotional
Psychosocial/ Work Organization Factors
Demand/Control
Shift
Break Schedule/ Autonomy
Water/ Shade Access
Work Arrangement
Break-In Period
Air Pollution
PM 2.5
Elevated Core Body Temperature
HEAT STRAIN
Dizziness
Headache
Confusion
Extreme Fatigue
Excessive Sweating
Hot & Dry Skin
Nausea
Muscle Cramps
Individual Factors
Age, BMI, Fitness, Co-morbidities
Daily Factors
Sleep, Hydration, Fatigue, Stress, Acclimatization, Clothing, PPE

Assessing the Impact of Environmental Conditions and Work-Recovery Strategies on Physiological Responses, Heat Stress Symptoms, Perceived Exertion and Productivity among Wildland Firefighters in Chile

Jaiver Freire, PhD Student

Self-Reported Symptoms

Symptoms (N=95)	N	%
Headache	13	32.5
Confusion or difficulty concentrating	1	2.5
Excessive sweating	13	32.5
Extreme fatigue	3	7.5
Dizziness or nausea	1	2.5
Muscle Cramps	2	5
Hot and dry skin	7	17.5
Total	**40**	**100**

17 (18%) Individuals reported at least one symptoms

- 5 reported two symptoms
- 1 reported more than two symptoms

Physiological Monitoring

Slate Safety (Band V2)

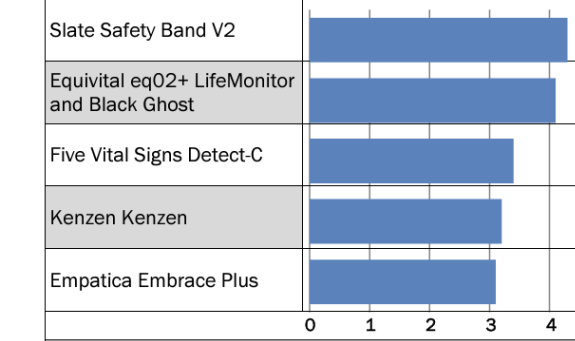
Heart rate, Heart rate variability, energy consumption, and core body temperature

Physiological Monitoring Systems for Emergency Responders

SAVER Assessment Report

NUSTL
NATIONAL URBAN SECURITY TECHNOLOGY LABORATORY

Product	Overall Score	Overall	Capability	Usability	Deployability	Maintainability	Affordability
Slate Safety Band V2		4.3	4.3	4.3	4.3	4.3	NA
Equivital eq02+ LifeMonitor and Black Ghost		4.1	4.2	3.9	4.4	4.0	NA
Five Vital Signs Detect-C		3.4	3.4	3.1	3.5	3.8	NA
Kenzen Kenzen		3.2	2.7	3.5	3.0	3.8	NA
Empatica Embrace Plus		3.1	2.5	3.1	3.6	3.9	NA

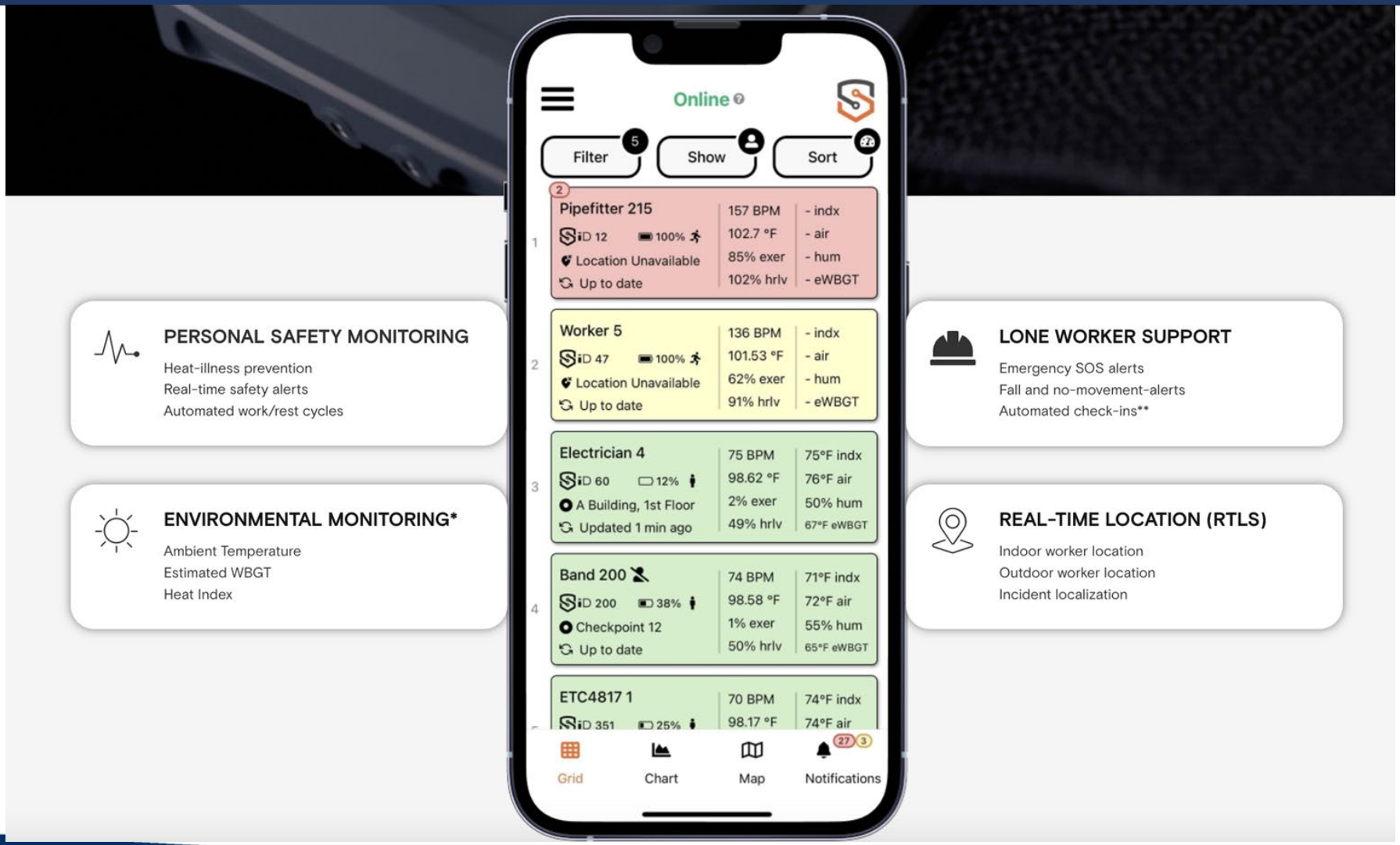


Key: 1 (least favorable) to 5 (most favorable)

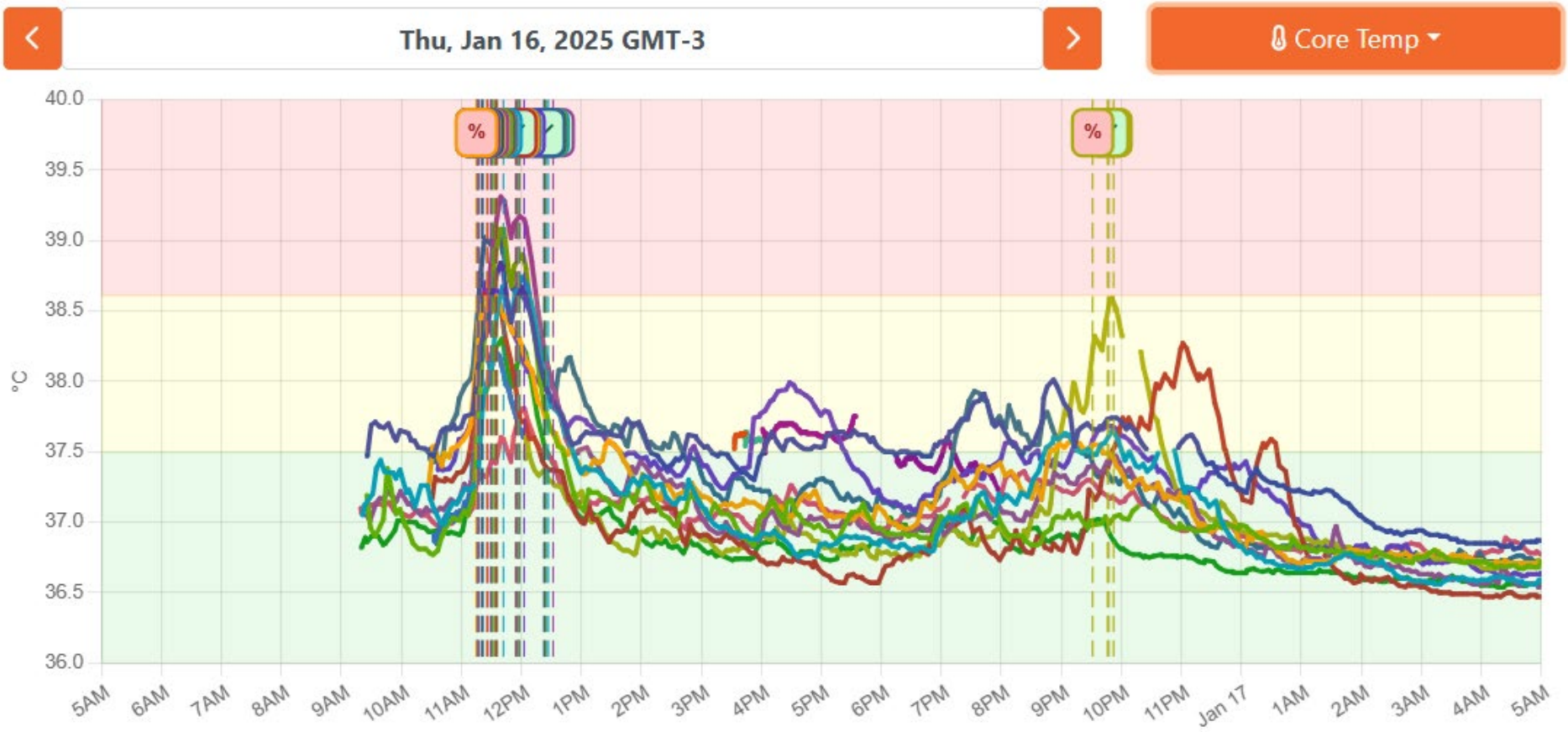
Physiological Monitoring

Core Temp (°C)	N (WLFFs)	%
<38°C	48	34.8
>=38°C	90	65.2
Total	**138**	**100.0**

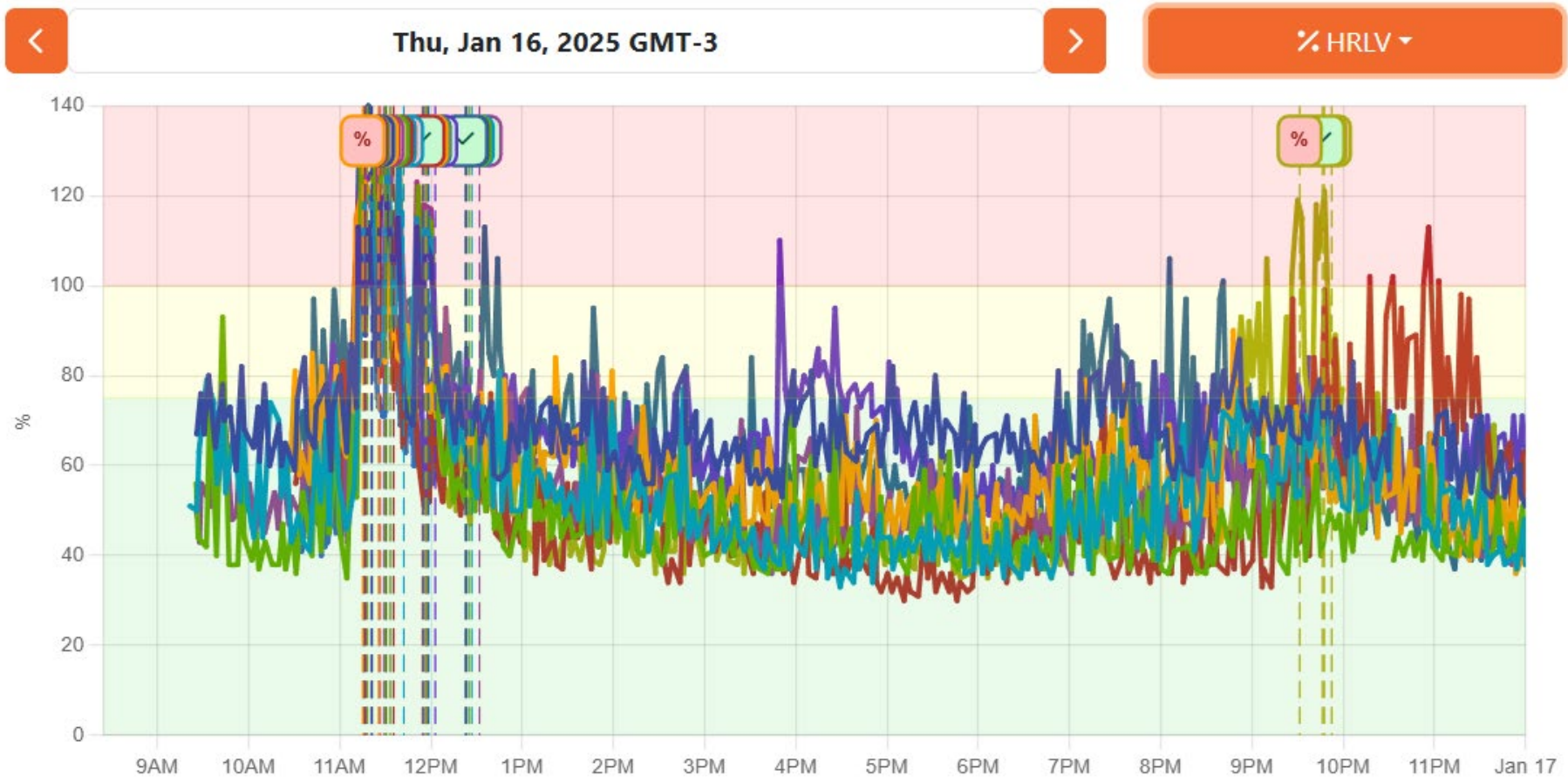
Physiological Monitoring



Physiological Monitoring



Physiological Monitoring



Implementation of Wearables

"I felt the band was very comfortable on my arm, I even forgot I was wearing it."

"I had to adjust the band because it was loose, but overall it was very comfortable."

"I'm concerned about whether the information from the band could harm us in some way."

"I liked using the band, but I felt it vibrated too much during the wildfires and exercise."

Implementation of Wearables

Risks

- Increase workplace stress
- Promote worker alienation
- Lower job satisfaction
- Used to push productivity beyond safe levels

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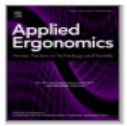


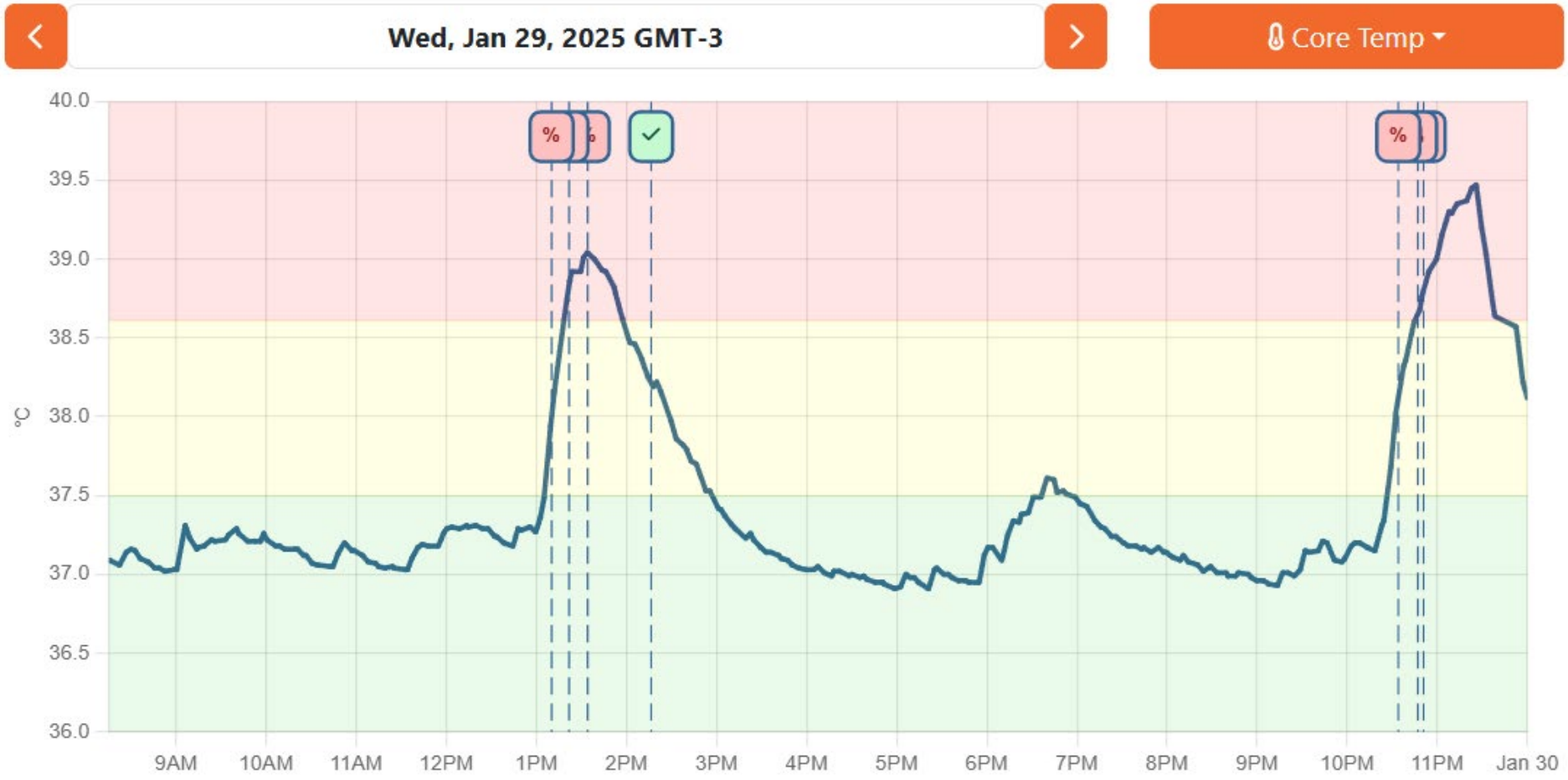
Employee acceptance of wearable technology in the workplace

Jesse V. Jacobs [a, b], Lawrence J. Hettinger [a], Yueng-Hsiang Huang [a, c], Susan Jeffries [a], Mary F. Lesch [a], Lucinda A. Simmons [a], Santosh K. Verma [a], Joanna L. Willetts [a]

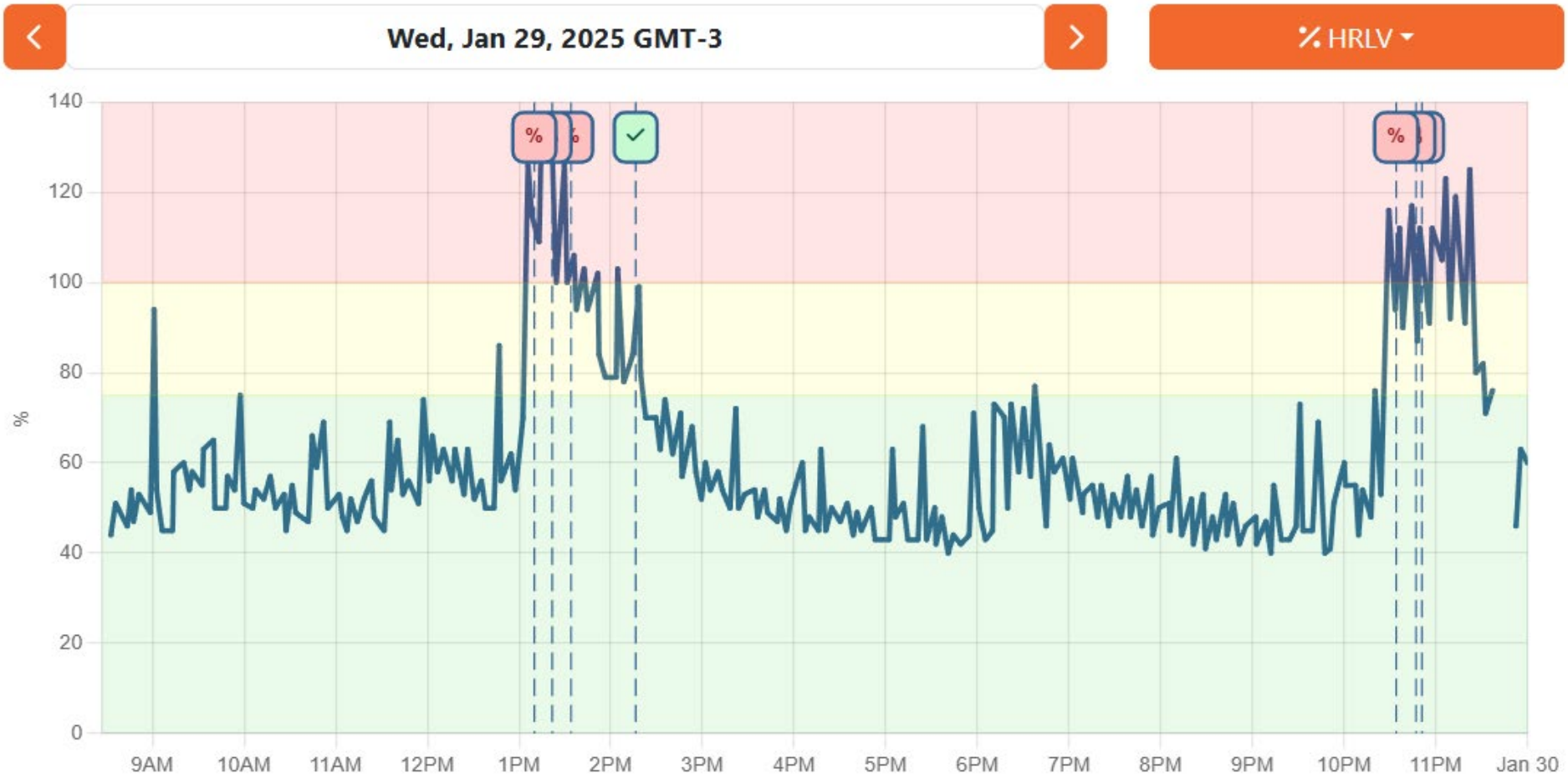
Benefits

- Improve workplace safety
- Advance a positive safety climate
- Ensure sufficient evidence that the wearable will meet its objective
- Involve and inform employees in the process

Physiological Monitoring



Physiological Monitoring



Possible Pitfalls

- Will monitoring result in action or discrimination?
- Will workers feel comfortable requesting rest, water, and shade when alerted?
- Will wearables be required or optional?
  - GPS Locator
  - Mistrust of how data is being used

Possible Guardrails

- Individual data access by 3rd party only
- GPS locator is only on for remote/solo workers
- Alerts trigger worker protections against firing (what about rehiring?)
- Alerts first go to the worker, then the supervisor, then EHS, or even Emergency Personnel

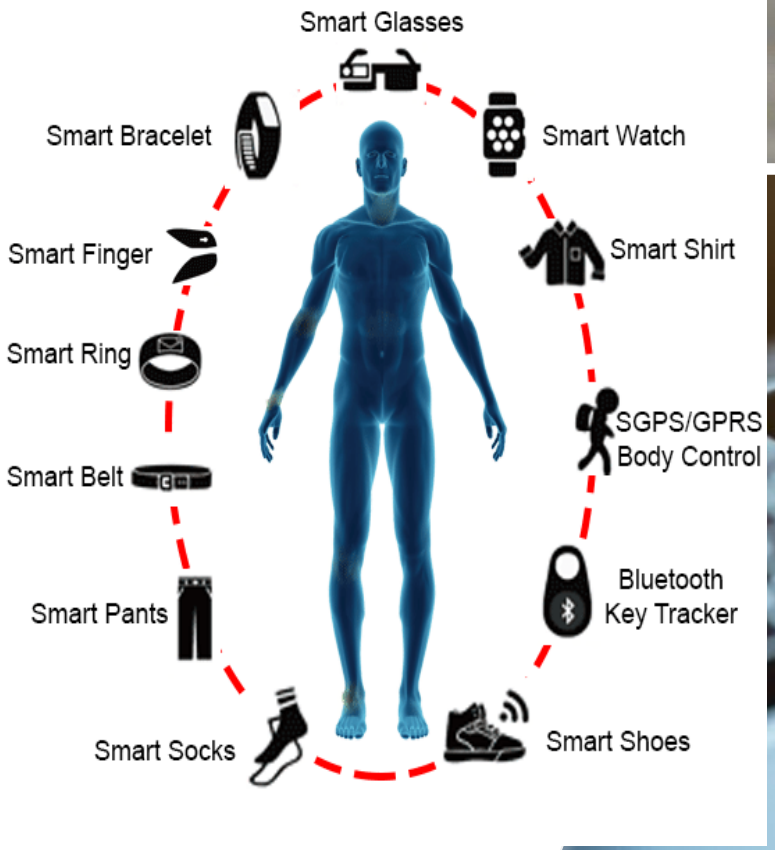
Possible Benefits

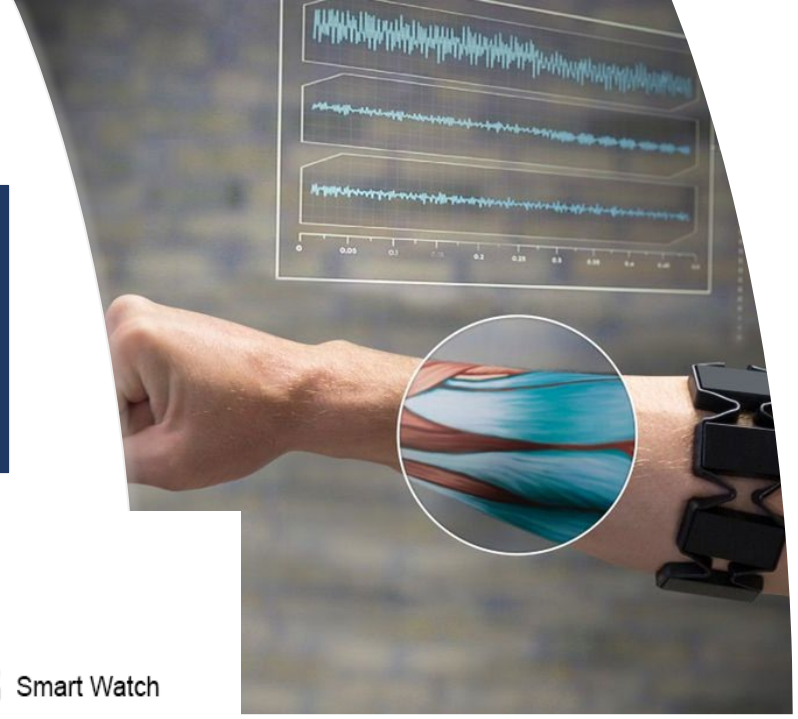
- Primary benefit – Identify and intervene when core temp >38C (100.4F)
- Threshold—Info—Action can be customized
- Provide individualized feedback on when it is safe to return to work/activity
- Could be used to evaluate workload by task to support work organization strategies on hot days

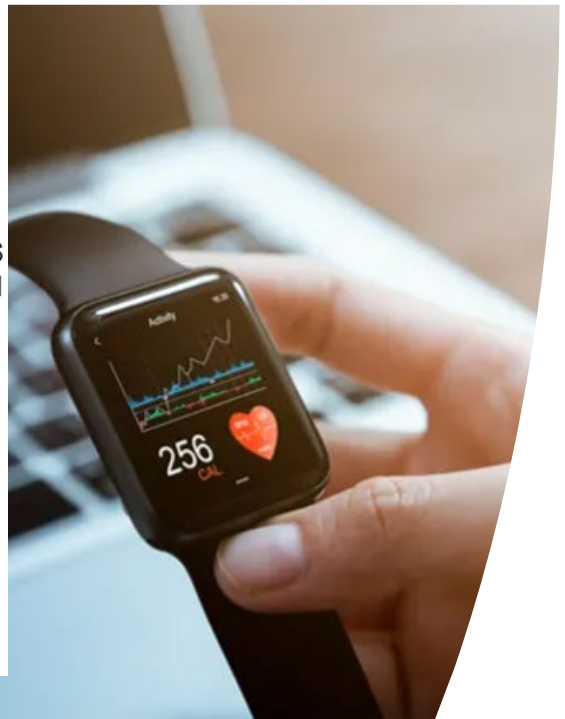
Pilot Testing/Research is Needed

- Engage stakeholders in developing guardrails
  - Workers, Labor Orgs, Employers, Researchers, Government
- Evaluate in a represented worker population
  - Construction?
- Prioritize implementation and intervention research

Wearable Technology







Resources

National Urban Security Technology Report

- NUSTL

OSHA

- https://www.osha.gov/heat-exposure/standards
- https://www.osha.gov/heat-exposure/resources
- https://www.osha.gov/heat

International Labor Organization

- https://www.ilo.org/publications/heat-work-implications-safety-and-health
- https://www.ilo.org/resource/news/ai-and-digitalization-are-transforming-safety-and-health-work

ACGIH

- https://www.acgih.org/heat-stress-and-strain-2/
- https://publications.aiha.org/202304-wearable-sensors-heat

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UCSF

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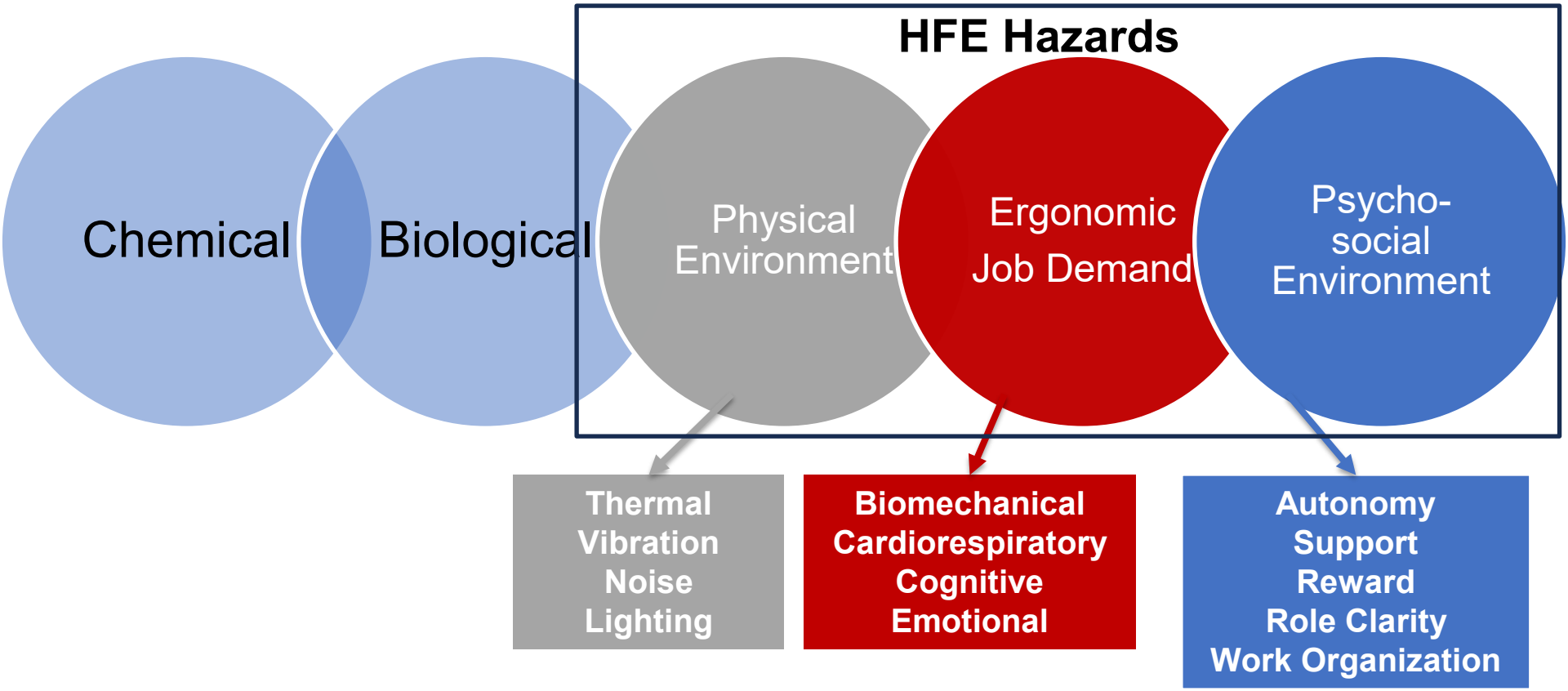
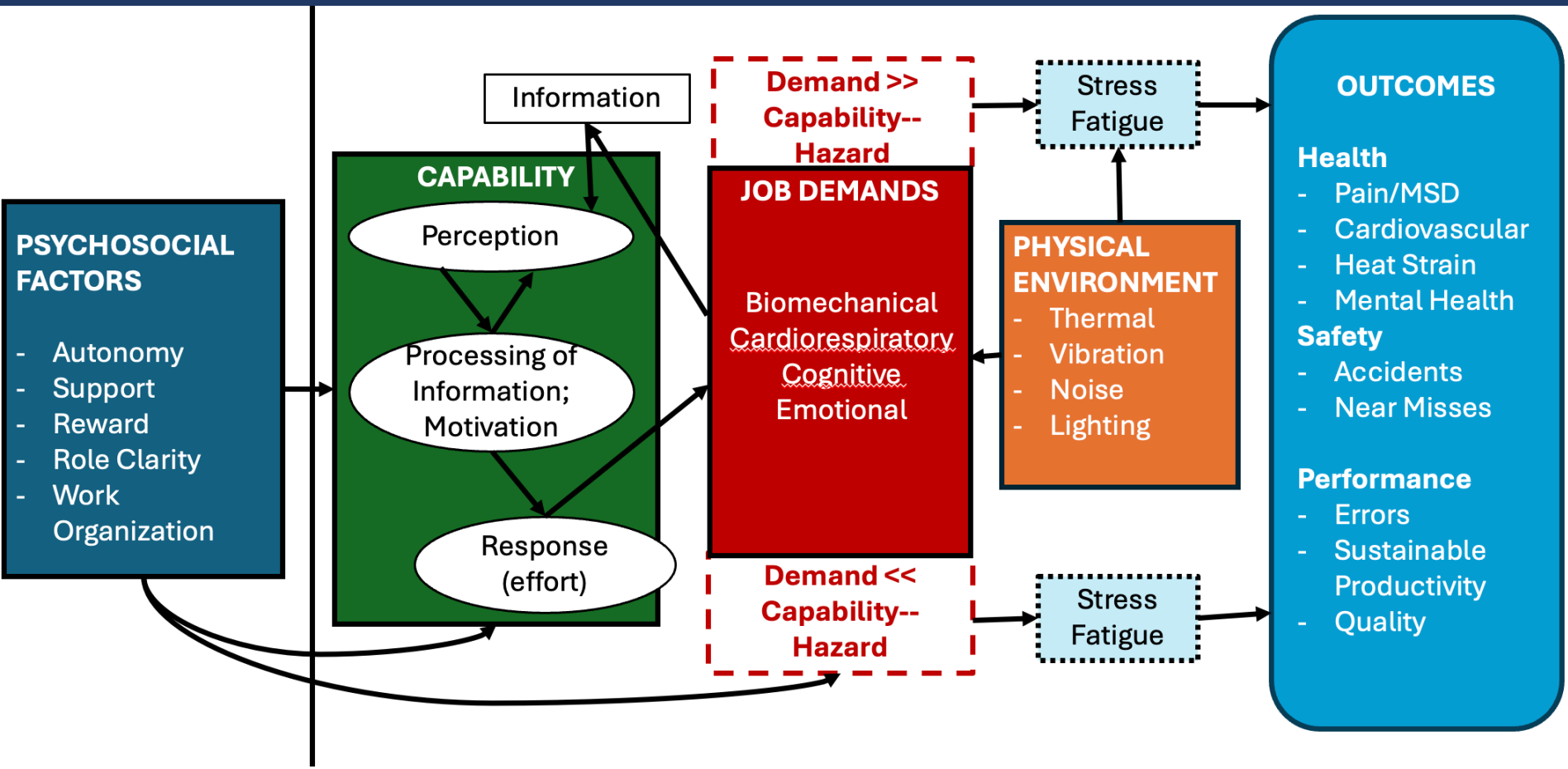
Hazards


HFE Hazards
Chemical
Biological
Physical Environment
Ergonomic Job Demand
Psycho-social Environment
Thermal
Vibration
Noise
Lighting
Biomechanical
Cardiorespiratory
Cognitive
Emotional
Autonomy
Support
Reward
Role Clarity
Work Organization

Hazards-Outcome



Wildland Firefighters Task Assessment

Tasks

Building Fire lines
Equipment Maintenance
Hose Operations
Cleaning of dormitories
Training and Drills
Rescue Operations
Carrying equipment