Heat exposure, injury risk, and productivity in agricultural workers

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Potential heat effects

- Heat-related illness (HRI)
- Heat-related traumatic injuries
- Decreased productivity
- Kidney injury

Ganio 2011; Armstrong 2012; Zemkova 2014

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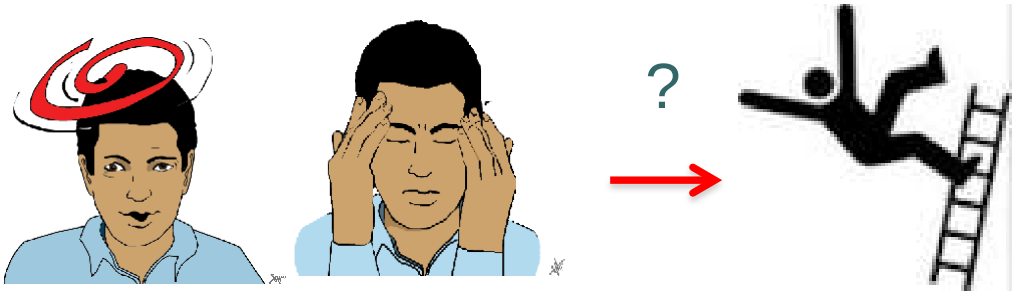
- Heat-related traumatic injuries



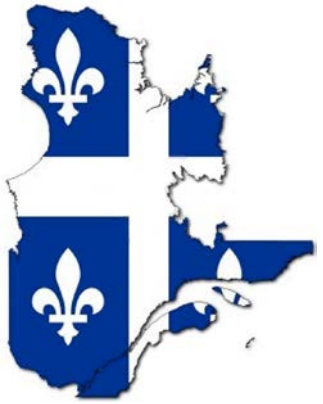
- Decreased productivity
- Kidney injury

Ganio 2011; Armstrong 2012; Zemkova 2014

What do we know? – Injury risk

Morabito et al 2006

Xiang et al 2014



Adam Poupart et al 2015

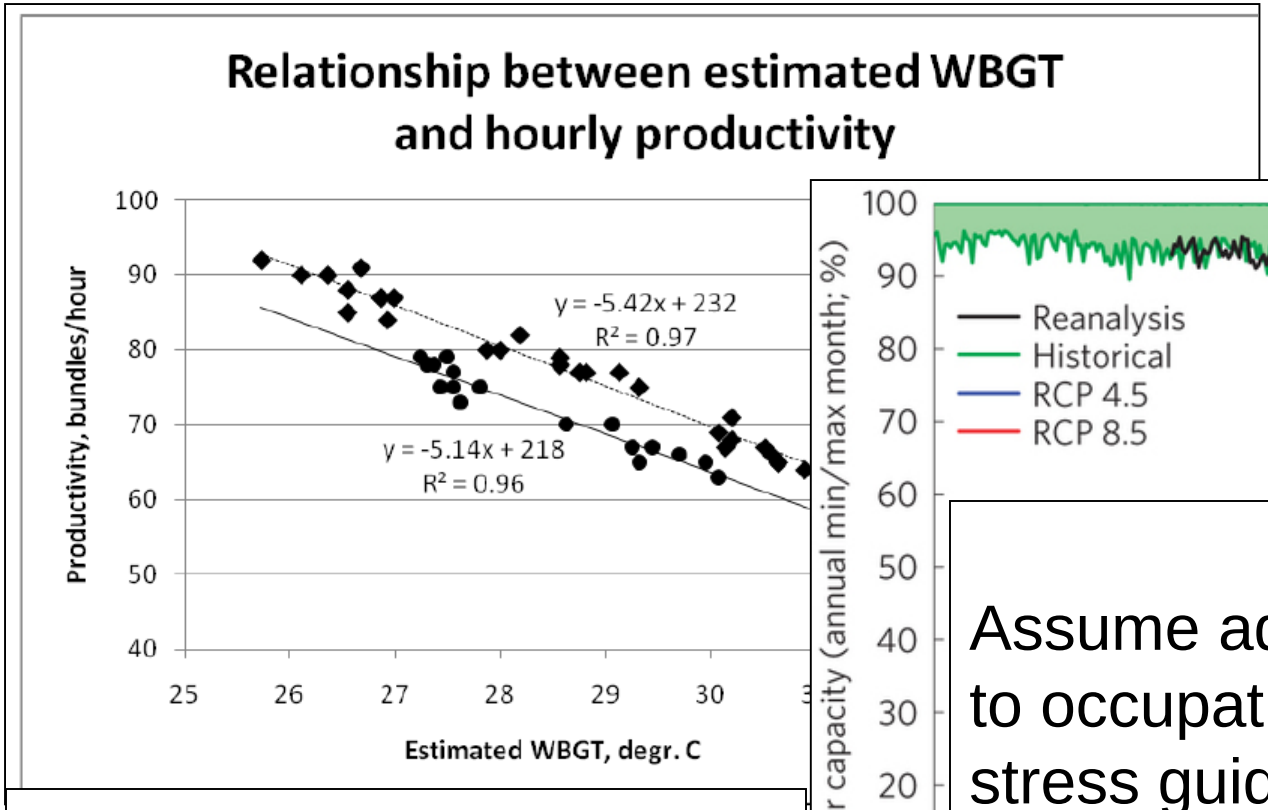
↑ mean daytime apparent temp, max daily temp

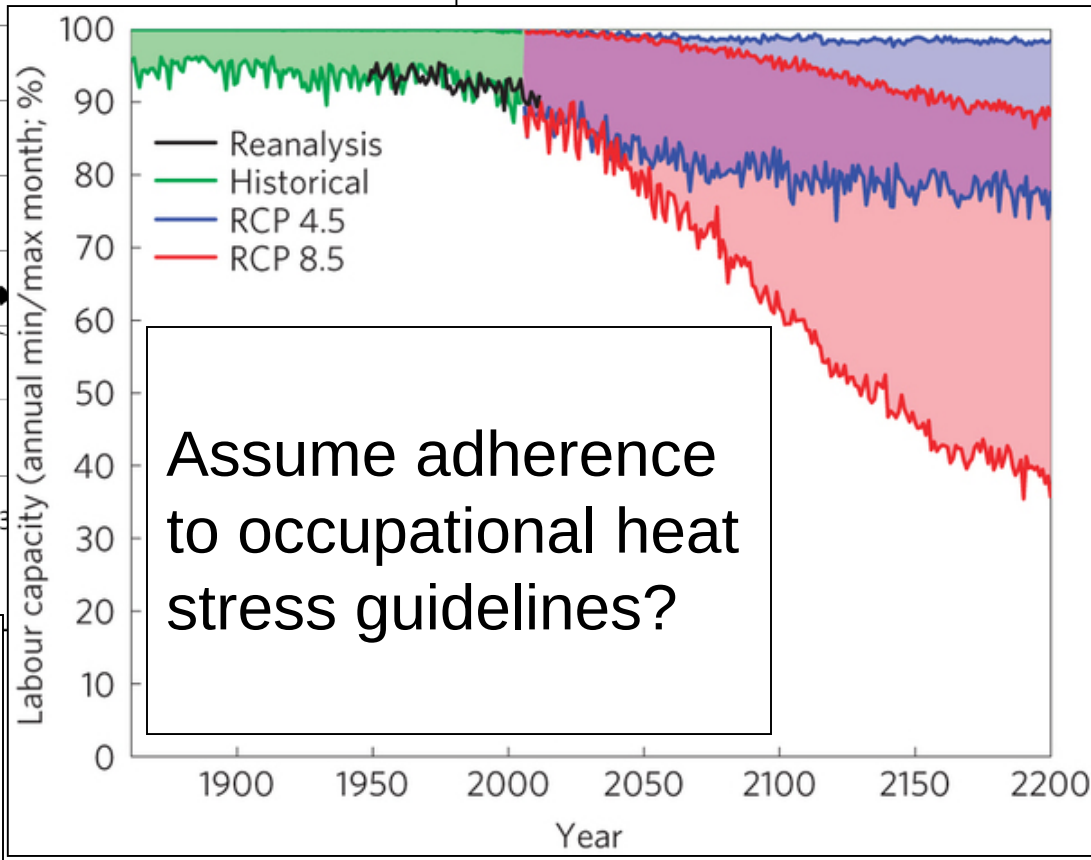
↓ ↓ ↓

↑ occupational injuries

What do we know? – Productivity

Sahu et al, Ind Health 2013





Assume adherence to occupational heat stress guidelines?

But what about economic incentives that counter natural response to slow down in heat?

Dunne et al. Nat Clim Change 2013

Questions we aimed to address:

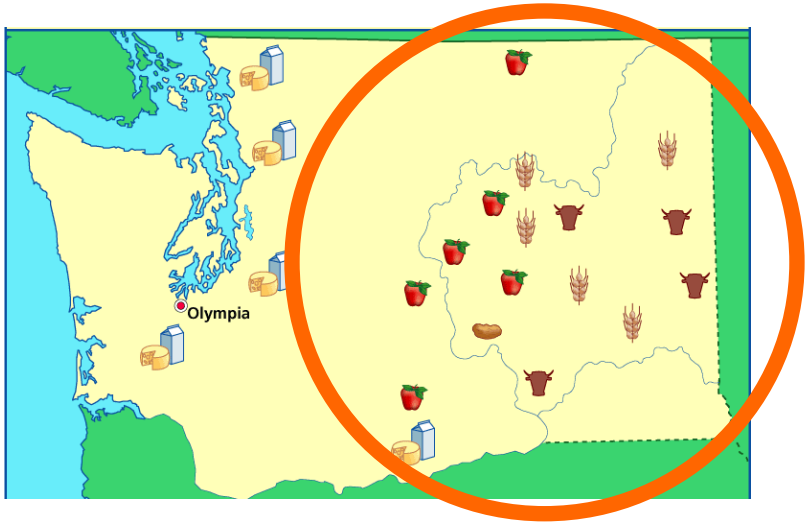
Is there decreased productivity and an increased risk of occupational traumatic injury in outdoor agricultural workers in warmer weather, and what is the mechanism for this increased injury risk?

Epidemiologic study

Field study

What we did: Epidemiologic study

- Case crossover, time-stratified referent selection
- Injury cases: 2000-2012 accepted new adult (age 18 or older) WA State Fund outdoor agriculture workers' compensation (WC) traumatic injury claims, E. of Cascade mountains



Spector et al. PLOS ONE 2016

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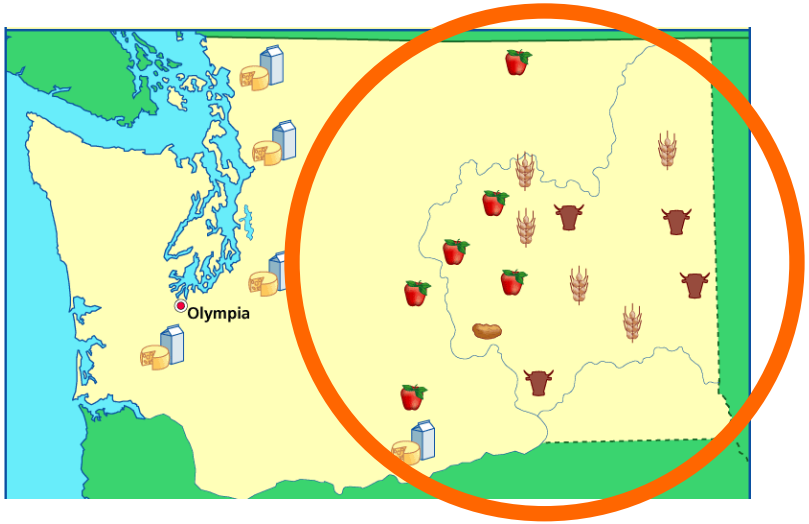


May-Sept 2000-2012 mean (range) max daily air temp: 82 (46-107)° F

- Exposures (Humidex): UW Climate Impacts Group modeled meteorological data (~ 7 x 4.5 km resolution), linked to injury data by location and injury/control dates

Spector et al. PLOS ONE 2016

What we found: Epidemiologic study

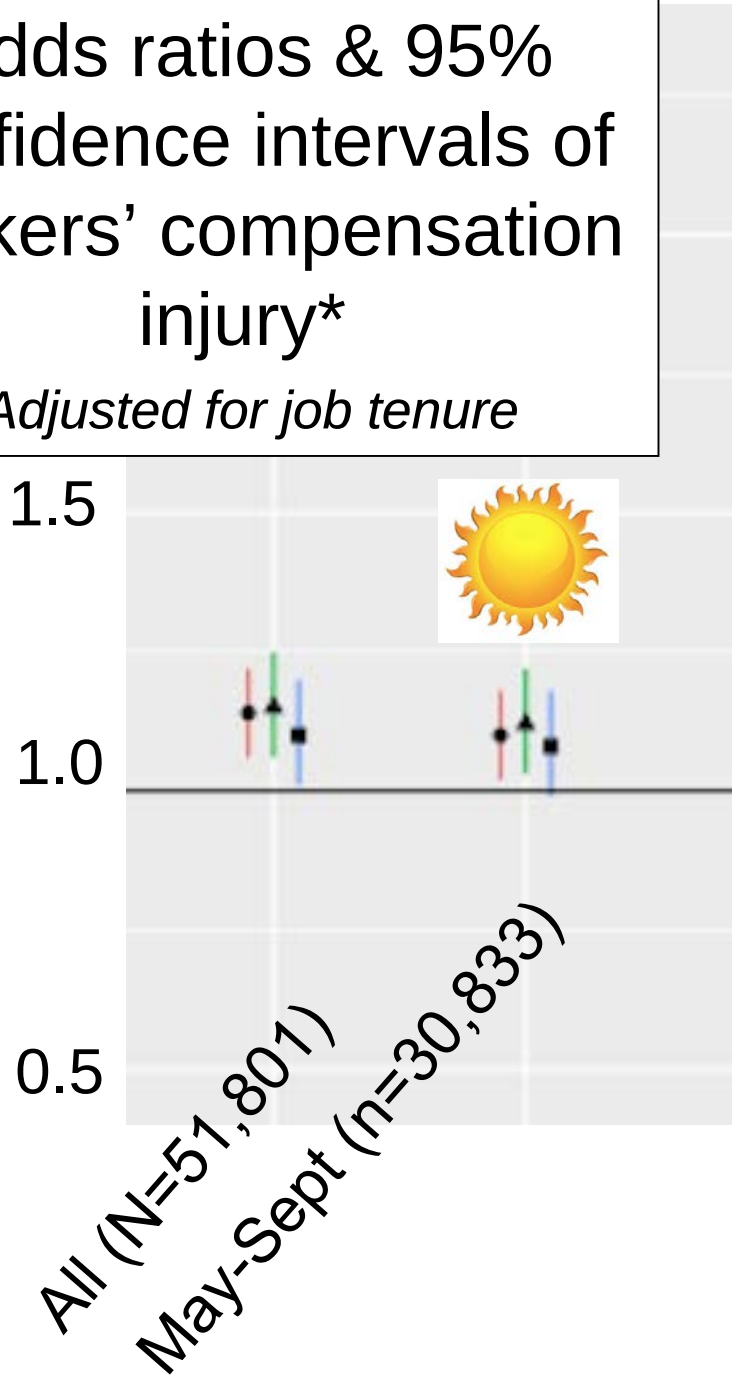
Selected injury claim characteristics (N=12,213)

Characteristic		n(%), median (IQR)
Age (years):	18-34	6,929 (57%)
	35-44	2,762 (23%)
	45-54	1,638 (13%)
Male gender		9,468 (78%)
Length of employment (days)		61 (7, 760)
Body part:	Upper extremity	4,717 (39%)
	Lower extremity	2,709 (22%)
Event/exposure:	Falls	5,893 (48%)
	Bodily reaction/exertion	3,947 (32%)

Spector et al. PLOS ONE 2016

Odds ratios & 95% confidence intervals of workers' compensation injury*

**Adjusted for job tenure*



Max daily Humidex (< 25)

25-29

30-33

≥ 34

Spector et al. PLOS ONE 2016

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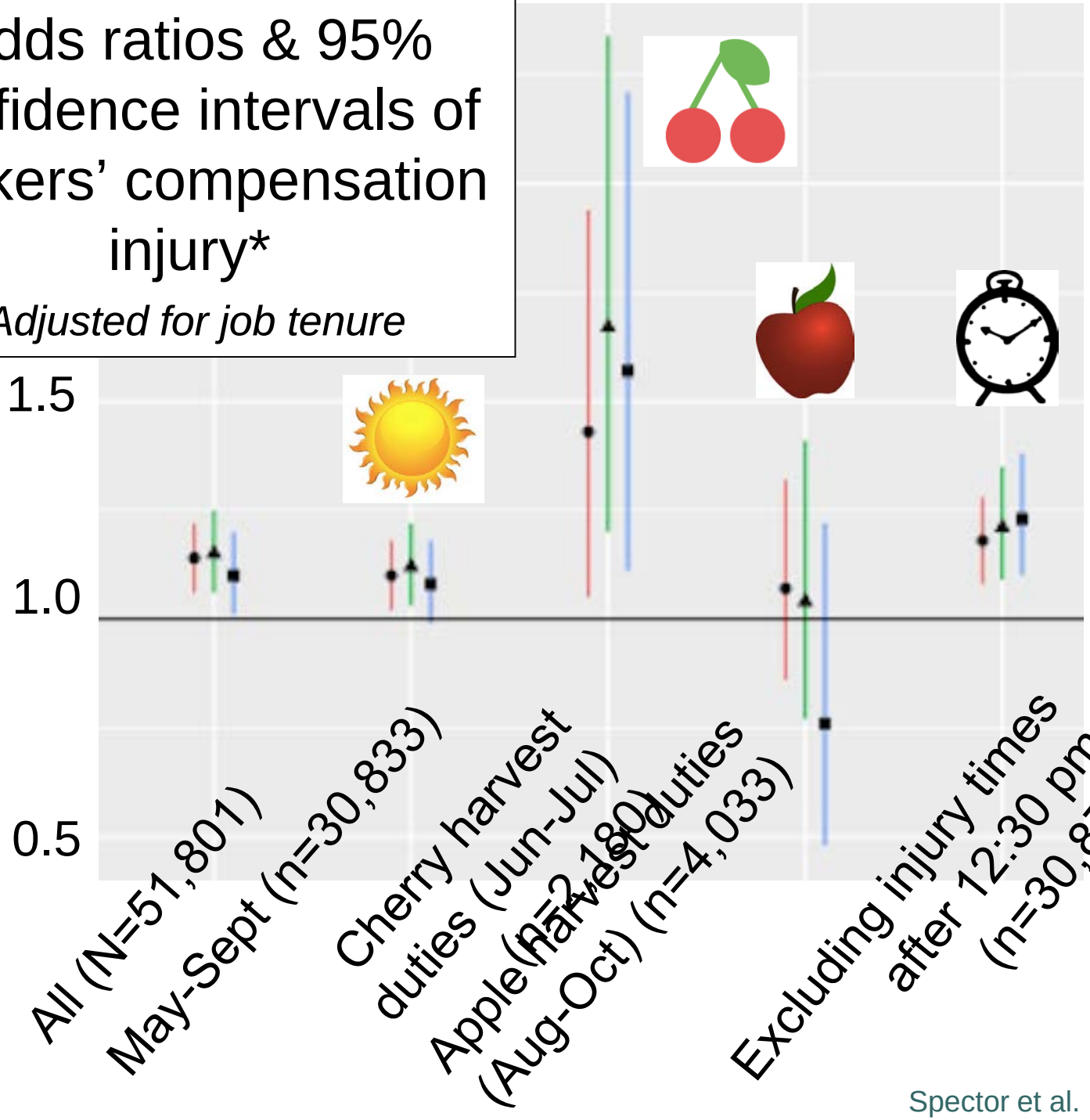

Spector et al. PLOS ONE 2016

What we did: Field study

- Cross sectional, 46 piece rate WA apple & pear harvesters, Aug-Sept 2015

- Exposures: Max shift wet bulb globe temperature (WBGT), measured near each worker every 1-3 hours

Spector et al. In revision 2017

What we did: Field study

- Cross sectional, 46 piece rate WA apple & pear harvesters, Aug-Sept 2015

- Outcomes:

Psychomotor vigilance

Balance

Productivity

- Exposures: Max shift wet bulb globe temperature (WBGT), measured near each worker every 1-3 hours

Spector et al. In revision 2017

What we found: Field study

Selected participant characteristics (N=46)

Characteristic	% or mean (SD)
Age (years)	39.1 (14.1)
Male	85
Latino/a	98
Epworth sleepiness scale* score 10-15 (may be excessively sleepy)	24
Urine specific gravity**:	
Pre-shift	1.025 (0.007)
Post-shift	1.025 (0.007)

**Spanish adaptation; **preliminary data: n=45*

Spector et al. In revision 2017

What we found: Field study

	August pear harvest (n=34)	September apple harvest (n=12)
Mean (SD) max daily WBGT	28 (4)	21 (2)
n (%) exceeding ACGIH TLV (WBGT 28)	15 (44%)	0 (0%)
n (% exceeding ACGIH Action Limit) exhibiting heat strain §	13 (54%)	0 (0%)

§ Heat strain: HR > 180-age for several minutes or core body temp >38.5˚ C

Spector et al. In revision 2017; ACGIH American Conference of Governmental Industrial Hygienists Heat Stress & Strain Threshold Limit Value (TLV)®; WBGT Wet Bulb Globe Temp

What we found: Field study

Main heat/balance/vigilance findings:

- No statistically significant associations between max shift WBGT and post-shift vigilance (reaction time) or balance (total path length), adjusted for potential confounders

- Selected limitations:
  - Time lag before outcomes assessment
  - Circadian effect on outcomes

Spector et al. In revision 2017

What we found: Field study

Main heat/productivity findings:

- Trend of decreasing productivity with increasing max shift WBGT, although not statistically significant

- Productivity likely impacted by other factors such as years of work experience, amount paid per bin, and shift duration

Quiller et al. Arch Environ Occup Health 2017

What does it mean?

- ↑ risk WA agriculture workers' compensation injuries in warm conditions, particularly when Humidex 30-33 (compared to <25)
- Workers may not be adequately hydrated at the start of the work shift
- Sleep was not optimal in a relatively large proportion of workers, which can increase injury risk

What are the implications?

- The potential benefits of heat prevention interventions, including policies, should take into account reductions in morbidity, mortality, and costs associated with heat-related injuries in addition to other heat-related outcomes

- Efforts to ensure adequate hydration by the start of the work shift are needed

What are other implications?

- Further studies are needed to inform recommendations for optimizing both sleep and work-shift timing in order to reduce the risk of both occupational injuries and HRI in outdoor agricultural workers

- Not considering individual, work, and economic factors that affect rest and recovery in projections of the impacts of climate change could result in inaccurate estimates of reductions in future productivity and underestimate risk of heat illness

Contributors

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