A Case-Crossover Study of Heat Exposure and Injury Risk in Outdoor Agricultural Workers

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What’s the problem?

↑Heat-related illness fatality rate, 20x higher in crop production and support than all industries

1992-2006; US CDC/MMWR 2008
What’s the problem?

Heat-related illness fatality rate, 20x higher in crop production and support than all industries.

Injury rate, WA State Fund workers’ comp claims for fruit/tree nut farming falls from elevation: 91/100,000 FTE.

1992-2006; US CDC/MMWR 2008

2002-2010; Anderson et al 2013
What do we know?

\[\uparrow \text{mean daytime apparent temp, max daily temp} \]

\[\downarrow \]

\[\uparrow \text{occupational injuries} \]
Potential mechanisms

Exercise-related ↓hydration, ↑core body temp

↓Vigilance, concentration, balance

? Falls

Ganio 2011; Armstrong 2012; Zemkova 2014
Relevance in Washington State

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

http://wak.infobaselearning.com/media/10635/Washingtonstate-agri-e.gif
Gaps we aimed to address

- Outdoor agricultural work
  - Tree fruit harvest

- Potential exposure misclassification
  - Modeled exposure data
What we did

- Study design: Case-crossover

- Study population: WA State Fund adult outdoor agriculture workers’ comp new traumatic injuries, 2000-2012
Modeled/gridded UW Climate Impacts Group meteorological data: 
~4 x 7.5 km resolution

Maurer 2002; https://github.com/geocommons/geocoder/
http://wak.infobaselearning.com/media/10635/Washingtonstate-agri-e.gif
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~4 x 7.5 km resolution

Where & how we did it

Injury lat/long assigned

Joined to nearest daily max Humidex (~ air temperature, dew point) using Euclidean nearest neighbor approach

H_max

What we compared

\[ H_{\text{max}} \]

Injury day (Tu)

Referent days (Tu)

Referent window (calendar mo)

Start of employment

Conditional logistic regression

\( A \text{ priori, max daily Humidex (} H_{\text{max}}) \)

\(< 25\)

25-29

30-33

\( \geq 34 \)

Janes 2005; Occ Health Clinics for Ontario Workers 2012
What we found

Selected injury claim characteristics (N=12,213)

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<tr>
<th>Characteristic</th>
<th>n(%) or median (IQR)</th>
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<td><strong>Body part:</strong></td>
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<td>Upper extremity</td>
<td>4,717 (39%)</td>
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<td>Lower extremity</td>
<td>2,709 (22%)</td>
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<td><strong>Event/exposure:</strong></td>
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<tr>
<td>Falls</td>
<td>5,893 (48%)</td>
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<td>Bodily reaction/exertion</td>
<td>3,947 (32%)</td>
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Odds ratios & 95% confidence intervals of workers’ compensation injury*

*Adjusted for job tenure

Max daily Humidex

(< 25)

25-29

30-33

≥ 34

All (N=51,801)

May-Sept (n=30,833)
Odds ratios & 95% confidence intervals of workers’ compensation injury*

*Adjusted for job tenure

Max daily Humidex

- (< 25)
- 25-29
- 30-33
- ≥ 34
What does it mean?

- ↑ risk WA agriculture workers’ compensation injuries in warm conditions, particularly when Humidex 30-33 (compared to <25)
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- Particularly ↑ risk during cherry harvest duties, Jun-Jul
  - Early in season, warm
  - Workers more vulnerable?
“Reverse U-shaped” dose-response relationship

- Consistent with other studies
  - Better acclimatization when exposures higher?
  - Misclassification of exposures at higher exposures (work shifts end earlier)?

Xiang 2014. PNASH

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What are the implications?

- High risk populations may benefit from combined injury and heat-related illness prevention efforts.

- 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.
Climate change context: Risk of heat health effects may increase!

- Increased frequency & severity of extreme heat events, increased temperatures
- High risk industries include agriculture & construction