

Heat & Cold Related Injuries

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**SCHOOL OF
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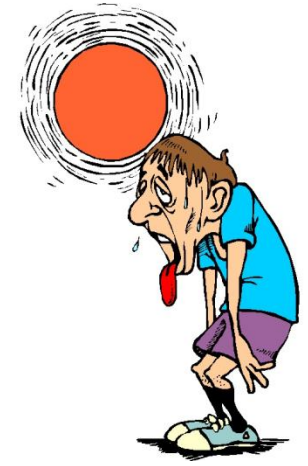
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Research Question

- Is greater emphasis on heat related injuries warranted?
- Heat vs. cold related injuries - Which is a greater public health concern?
- Hypothesis: Heat related injuries occur more frequently & are associated with greater mortality and medical costs relative to cold related injuries.
 - Also, temperature related injuries will correlate with average daily ambient temperature.
- Goal: Determine appropriate allocation of public health resources as related to temperature related injuries.



Literature Review



Heat

- Climate change, heat waves
- Rash, edema, syncope, exhaustion, stroke
- Associated mortality is short lived
- Core temp >40 Celsius life threatening
- Highest risk: extremes of age, outdoor labor, low SES, chronic dz, live alone
- Kills more people than hurricanes, lightning, tornadoes, floods, earthquakes combined
- U.S. 1999-2003: annual mean deaths 688, 66% male, 35% hyperthermia
- Sinusoidal pattern over previous decade overall injuries



Literature Review



Cold

- Cold spells & mortality
- Core temp <35 Celsius (Fauci, 2008)
- Hypothermia, frostbite, BP, blood clots, bronchoconstriction
- Highest risk: extremes of age, female, chronic CV & respiratory dz
- 107 U.S. cities over 14-yrs: deaths delayed up to 25 days
- U.S. & Australia: hypothermia among long distance open water swimmers



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Methods

- Illinois Hospital Discharge Database (2011–2013)
 - Cold related diagnoses (N991.0-991.9)
 - Heat related diagnoses (N992.0 -992.9)
 - Excluded patients categorized >95yo
- 2010 Illinois population from U.S. Census
- National Oceanic and Atmospheric Administration database - daily and monthly temp & precipitation as measured at Chicago O'Hare
- SAS Enterprise software

	COLD RELATED INJURIES		HEAT RELATED INJURIES	
	Inpatient (N=3303)	Outpatient (N=3426)	Inpatient (N=1324)	Outpatient (N=10250)
MEAN AGE (SD)	59.4 (23.17)	42.7 (22.38)	58.0 (20.5)	23.0 (39.1)
0 to 4 yrs	120 (3.6%)	187 (5.5%)	7 (0.5%)	156 (1.5%)
5 to 9yrs	15 (0.5%)	67 (2.0%)	3 (0.2%)	246 (2.4%)
10 to 14yrs	24 (0.7%)	110 (3.2%)	6 (0.5%)	534 (5.2%)
15 to 24yrs	158 (4.8%)	502 (14.7%)	83 (6.3%)	1981 (19.3%)
25 to 34yrs	177 (5.4%)	399 (11.6%)	103 (7.8%)	1810 (17.7%)
35 to 44yrs	224 (6.8%)	414 (12.1%)	132 (10.0%)	1564 (15.3%)
45 to 54yrs	541 (16.4%)	724 (21.1%)	213 (16.1%)	1546 (15.1%)
55 to 64yrs	573 (17.3%)	502 (14.7%)	238 (18.0%)	1176 (11.5%)
65 to 74yrs	461 (14.0%)	207 (6.0%)	194 (14.7%)	624 (6.1%)
75 to 84yrs	497 (15.0%)	176 (5.1%)	218 (16.5%)	424 (4.1%)
85yrs to 95yrs	513 (15.5%)	138 (4.0%)	127 (9.6%)	189 (1.8%)
GENDER				
Male	1437 (43.5%)	1173 (34.2%)	393 (29.7%)	3671 (35.8%)
Female	1865 (56.5%)	2253 (65.8%)	931 (70.3%)	6579 (64.2%)
Unspecified	1 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
ETHNICITY				
White Non-Hispanic	1906 (57.7%)	1865 (54.4%)	850 (64.2%)	6988 (68.2%)
American Indian/Alaska Native	8 (0.2%)	7 (0.2%)	2 (0.2%)	13 (0.1%)
Asian	32 (1.0%)	25 (0.7%)	12 (0.9%)	84 (0.8%)
Black or African American	943 (28.5%)	1019 (29.7%)	287 (21.7%)	1713 (16.7%)
Hispanic/Latino	253 (7.7%)	330 (9.6%)	93 (7.0%)	872 (8.5%)
Pacific Islander	6 (0.2%)	9 (0.3%)	2 (0.2%)	7 (0.1%)
Other Race	144 (4.4%)	160 (4.7%)	59 (4.5%)	538 (5.2%)
missing	11 (0.3%)	11 (0.3%)	19 (1.4%)	35 (0.3%)

Results

- **6,729 cold injuries**
- **11,574 heat injuries**
- **Crude rates**
 - Heat 30 per 100k
 - Cold 17.5 per 100k
- **In-pt crude rates**
 - Heat 3.4 per 100K
 - Cold 8.6 per 100k
- **Females 63%**
- **Heat injuries 63.3% overall**
- **Mean age**
 - Heat 41yo (SD 21)
 - Cold 51yo (SD 24)

**Table 2:
Total Charges, Severity and Discharge Characteristics for Heat or Cold
Related Injury, Illinois: 2011 -2013**

	COLD RELATED		HEAT RELATED	
	Inpatient (N=3303)	Outpatient (N=3426)	Inpatient (N=1324)	Outpatient (N=10250)
TOTAL CHARGES				
50th percentile	33201.8	1462.8	15467.8	2375.0
mean	60309.7	3482.5	26600.2	3261.1
standard deviation	★ 119109.7	5434.7	39585.6★	3246.9
Hospital Treatment				
Mean Days in Hospital	6.7850439		3.4	
Put on Ventilator	913 (28%)	24 (1%)	102 (8%)	2 (0%)
Severity of Injury				
In-Hospital Fatalities	467 (14%)★	66 (2%)	31 (2%)	11 (0%)
In-Hospital Fatalities & Hospice	584 (18%)	71 (2%)	40 (3%)	11 (0%)
Outcome - Discharge				
Discharge to other institution for continued care	488 (15%)	383 (11%)	54 (4%)	124 (1%)
Left against medical advice	21 (1%)	64 (2%)	2 (0%)	132 (1%)
Routine discharge (home or self care)	273 (8%)	2860 (83%)	83 (6%)	9959 (97%)
Still in patient or expected to return for outpatient	0 (0%)	3 (0%)	0 (0%)	3 (0%)
unknown	1937 (59%)	17 (0%)	1145 (86%)	4 (0%)★

**Table 2:
Total Charges, Severity and Discharge Characteristics for Heat or Cold
Related Injury, Illinois: 2011 -2013**

	COLD RELATED		HEAT RELATED	
	Inpatient (N=3293)	Outpatient (N=3426)	Inpatient (N=1324)	Outpatient (N=10250)
TOTAL CHARGES	Heat		Cold	
50th percentile	33201.8	1462.8	15467.8	2375.0
mean	60309.7	3482.5	26600.2	3261.1
standard deviation	49109.7	5434.7	39585.9	3246.9
Hospital Treatment				
Mean Days in Hospital				
Put on Ventilator				2 (0%)
Severity of Injury				
In-Hospital Fatalities				11 (0%)
In-Hospital Fatalities & Hospice	304 (10%)	71 (2%)		11 (0%)
Outcome - Discharge				
Discharge to other institution for continued care				24 (1%)
Left against medical advice				32 (1%)
Routine discharge (home or self care)				59 (97%)
Still in patient or expected to return for outpatient	0 (0%)	3 (0%)	0 (0%)	3 (0%)
unknown	1937 (59%)	17 (0%)	1145 (86%)	4 (0%)

\$68 million

\$211 million

3 year total

Results

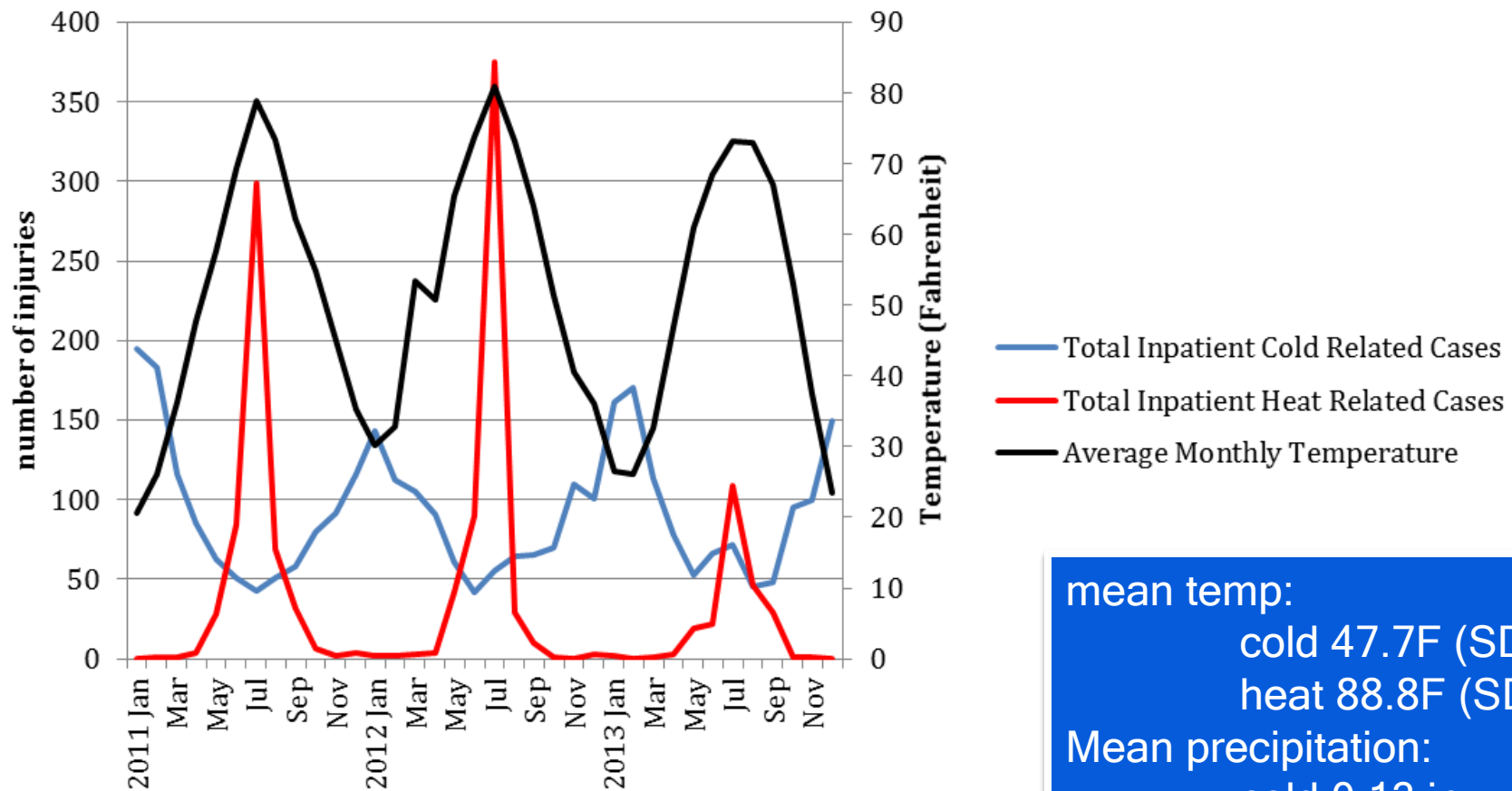
Table 3:

Mortality by Diagnosis for Heat and Cold Related Injuries, Illinois: 2011 - 2013

	Inpatient N (%) [*]	Outpatient N (%) [*]
COLD RELATED INJURIES		
HYPOTHERMIA	570 (21.0)	51 (4.3)
FROSTBITE	18 (2.5)	22 (1.0)
OTHER HEALTH EFFECTS RELATED TO COLD	2 (5.7)	2 (0.4)
HEAT RELATED INJURIES		
HEAT STROKE	29 (4.1)	5 (0.1)
HEAT SYNCOPE	0 (0.0)	1 (0.6)
HEAT FATIGUE	12 (2.0)	3 (0.1)
MILD HEAT INJURY (INC. EDEMA/CRAMPS)	1 (1.2)	2 (0.2)

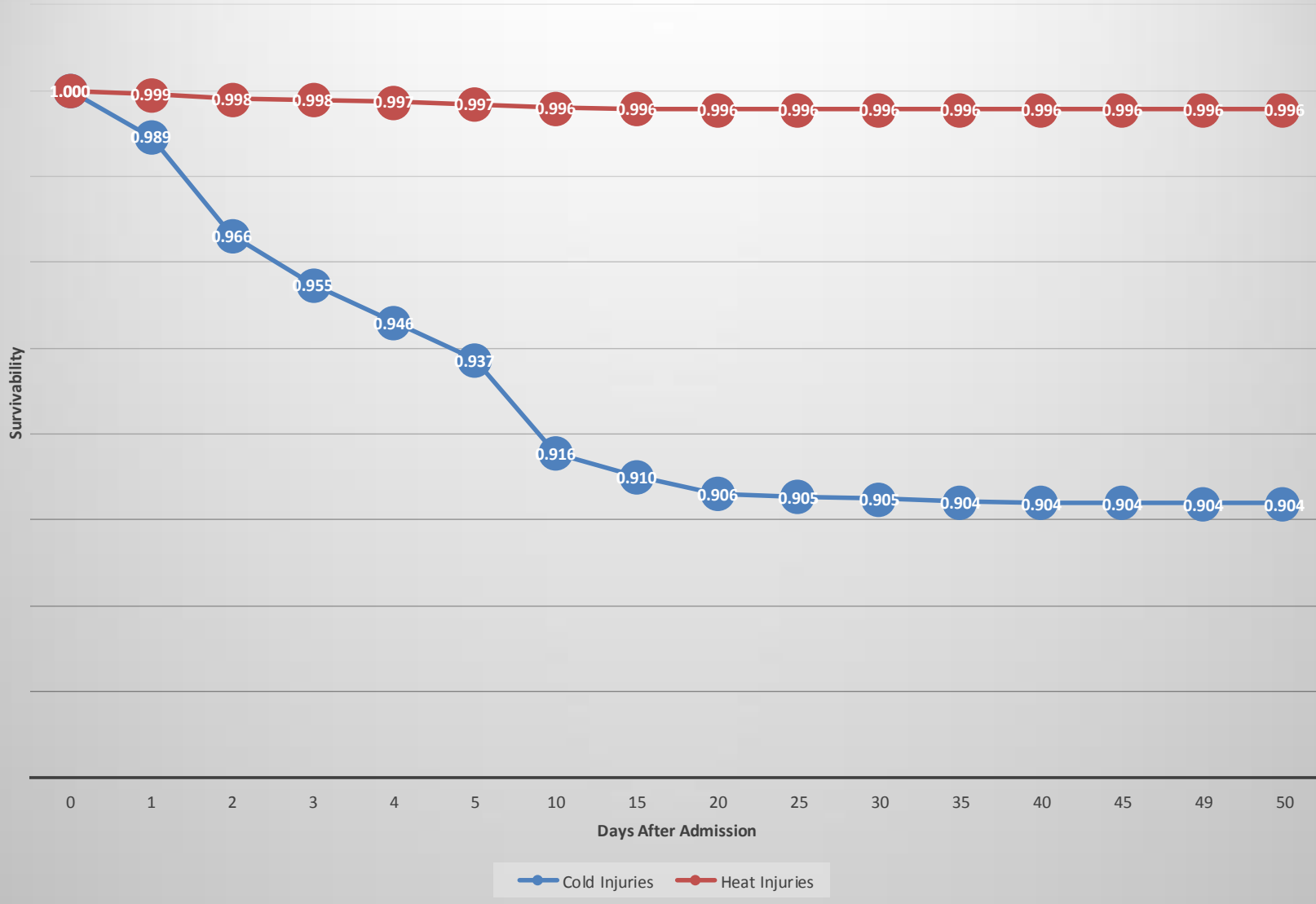
^{*}Percent represents the fatality rate based on persons who died during the course of hospitalization and those discharged to hospice care

Figure 1: Heat and Cold Related Injury Rates and Average Temperature by Month



mean temp:
 cold 47.7F (SD 21)
 heat 88.8F (SD 11)
 Mean precipitation:
 cold 0.13 in
 heat 0.23 in

Survivability Curve for Heat and Cold Related Injuries



Results

- Multivariable Regression
 - Odds ratio of dying among patients admitted for cold vs heat injury 11.6 (95% CI 8.6 – 15.6; c-statistic = 0.9)
 - *controlling for age, NISS16, length of stay and comorbidities
- Additional mechanism of injury
 - Adverse drug effect (6% cold injury, 2% heat injury)
 - Falls (6% cold injury, 3% heat injury)
 - Associated trauma
 - cold (fracture, open wounds and medication poisoning -each 3%)
 - heat (open wounds, trauma complication and sprain/strain - each 1%)
- Medical care complications (p<0.0001)
 - Cold 13%
 - Heat 1%

Results

Payer source

Medicaid/Medicare

cold 54%

heat 36%

Worker's Comp

cold 0.6%

heat 5%

Private insurance

cold 17.6%

heat 36%

Comorbidities

Fluid and electrolyte disorders, depression, **drug abuse**, **alcohol abuse**, **weight loss**, congestive heart failure, cardiac arrhythmia, hypertension, chronic pulmonary disease, neurologic conditions other than paralysis, diabetes, hypothyroidism, renal failure, and **obesity**

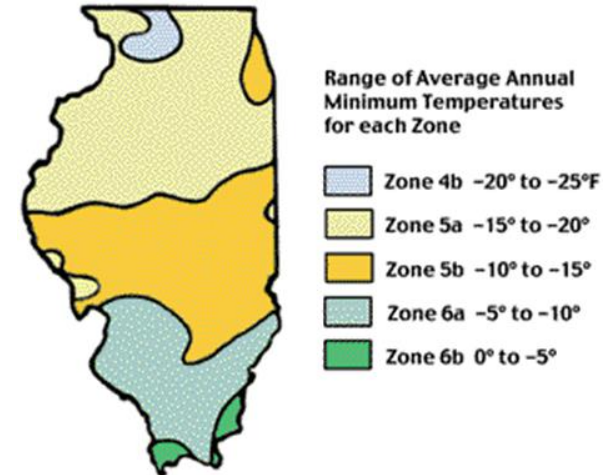
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Discussion

- Cold injury less frequent in Illinois, but is associated with:
 - Higher mortality
 - Longer length of stay
 - Need for long term care
 - Higher total hospital charges (3x)
 - Increased risk of medical complications
- Cold injury related deaths can be delayed up 1mo +
- High baseline of cold-injuries during warm months
- Indigent and elderly are particularly susceptible

Limitations & Future Work

- Limitations
 - No income to assess for poverty as confounder
 - No data from urgent care, FQHC, Occ Med or primary care clinics
 - Underreporting from immigrants?
 - Deaths prior to hospital arrival
 - O'Hare weather station used for climatology data
- Future work & questions
 - Recommend more resources allocated for preventing and treating cold injuries
 - Medical record review to investigate cause of summertime cold injury
 - Cold injury education campaign
 - Data from other out-pt settings





References

1. AE Kunst, C. L. (1993). Outdoor air temperature and mortality in the Netherlands: a time series analysis. *American Journal of Epidemiology*, 137:331-341.
2. AJ McMichael, A. H. (1996). *Climate change and human health*. Geneva: WHO/WMO/UNEP.
3. Analitis, A. K. (2008). Effects of Cold Weather on Mortality: Results From 15 European Cities Within the PHEWE Project . *American Journal of Epidemiology*, 168:1397-1408.
4. Armed Forces Health Surveillance Center. (2014). Update: cold weather injuries, active and reserve components, U.S. Armed Forces, July 2009-June 2014. *Medical Surveillance Monthly Report*, 21(10):14-20.
5. B Anderson, M. B. (2009). How heat, cold, and heat waves affect mortality in the United States. *Epidemiology*, 20:205-213.
6. Brandstrom, H. J. (2014). Accidental cold-related injury leading to hospitalization in northern Sweden: an eight-year retrospective analysis. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, (22)1-6.
8. Brannigan, D. R. (2009). Hypothermia Is a Significant Medical Risk of Mass Participation Long-Distance Open Water Swimming. *Wilderness & Environmental Medicine*, (20)1:14-18.
9. Carter, R. C. (2005). Epidemiology of Hospitalizations and Deaths from Heat Illness in Soldiers. *Medicine & Science in Sports & Exercise*, 1338-1344.
10. Centers for Disease Control and Prevention. (2006). *Heat-related deaths—United States, 1999–2003. Morbidity and Mortality Weekly Report*. doi:[PubMed: 16874294
11. Centers for Disease Control and Prevention. (2009). *Extreme heat: A prevention guide to promote your personal health and safety*. Retrieved from http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp
12. G Anderson, M. B. (2011). Heat waves in the United States: Mortality risk during heat waves and effect modification by heat wave characteristics in 43 U.S. communities. *Environmental Health Perspectives*, 119:210-218.
13. Gasparri, A. A. (2012). The effect of high temperatures on cause-specific mortality in England and Wales. *Occupational and Environmental Medicine*, 69(1):56-61.

14. Hajat, S. K. (2007). Heat-related and cold-related deaths in England and Wales: who is at risk?". *Occupational Environmental Medicine*, 64(93).
15. J Kravchenko, A. A. (2013). Minimization of Heatwave Morbidity and Mortality. *American Journal of Preventive Medicine*, 44(3):274-282.
16. J Valdez-Delgado, V. F.-G. (2012). *Hypothermia: prevention, recognition, and treatment*. New York: Nova Science Publishers, Inc.
17. JC Semenza, C. R. (1996). Heat-related deaths during the July 1995 heat wave in Chicago. *New England journal of medicine*, 335(2), 84-90.
18. Johnathan Patz, H. F. (2014). Climate Change Challenges and Opportunities for Global Health. *Journal of the American Medical Association*, 312(15):1565-1580. doi:10.1001/jama.2014.13186
19. Maud Huynen, P. M. (2001). The Impact of Heat Waves and Cold Spells on Mortality Rates in the Dutch Population . *Environmental Health Perspectives*, 463-70.
20. MMWR. (2008). Heat-related deaths among crop workers--U.S., 1992-2006. 57(24):649-653.
21. National Weather Service, Office of Climate, Water and Weather Services. (2013). *Natural Hazard Statistics: Weather fatalities*. Available at <http://www.nws.noaa.gov/om/hazstats.shtml#>. Last accessed 3/19/15.
22. Nuckton, T. C. (2000). Hypothermia and after drop following open water swimming: The Alcatraz/San Francisco swim study. *The American Journal of Emergency Medicine*, (18)6:703-707.
23. Olivier Deschenes, E. M. (2009). Extreme Weather Events, Mortality, and Migration. *The Review of Economics and Statistics*, 659-681. doi:10.1162/rest.91.4.659
24. S Pattenden, B. N. (2003). Mortality and Temperature in Sofia and London. *Journal of Epidemiology and Community Health*, 57:8, 628-633.
25. SM Bernard, M. M. (2004). Municipal heat wave response plans. *American Journal of Public Health*, 94(9):1520-1522.
26. T Kjellstrom, I. H. (2009). Workplace heat stress, health and productivity—an increasing challenge for low- and middle-income countries during climate change. *Glob Health Action*, 2:1-6.
27. Ying Zhang, M. N. (2012). Risk factors for direct heat-related hospitalization during the 2009 heatwave: A case crossover study. *Science of the Total Environment*, 1-5.