Descriptive analysis of heat-related illness treated in Florida hospitals and emergency departments

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Introduction

Heat-related illness (HRI) has become a growing concern in the United States (US); especially as global climate change models continue to predict an increase in extreme heat events.[1] In order to be better prepared for such events a clear understanding of the burden of disease and the ability to identify susceptible populations is essential. Studies have indicated that HRI deaths in the southern US may not be as severe a problem as in the northern US.[2] However, the majority of these studies only examined extreme heat events.[3,4] Due to the warm climate in Florida a different pattern of HRI may present including different risk factors than those seen in northern states. The majority of studies in the literature specifically examined heat related deaths, and while understanding mortality related to heat is important, prevention of morbidity related to heat will also prevent deaths.

The objective of this study was to describe HRI treated in Florida hospitals and emergency departments.

HRI is comprised of a continuum of disorders that occur when the body loses the ability to regulate body temperature due to loss of fluids and electrolyte imbalance. The disorders include: heat edema, heat cramps, heat syncope, heat exhaustion and heat stroke. Death or multiple organ dysfunctions can occur from severe heat stroke which happens when the body's core temperature exceeds 103°F. HRI most often, but not always, occurs after exposure to extreme heat. Factors that contribute to an individual's increased susceptibility to HRI include increasing age, the presence of underlying medical condition(s), use of certain medications, dehydration, overall general wellness (e.g. obesity or an infection such as a cold) and lack of acclimatization. Environmental factors such as ambient temperature, humidity, wind, and sun exposure may alter the risk of HRI. An individual's physical activity level, hydration level, and amount or type of clothing may also increase the risk of HRI. [5-9]

Methods

Data on heat related hospitalizations and ED visits were obtained from the Florida Agency for Health Care Administration (AHCA) for the years 2005-2009. HRI was defined using the following International Classification of Diseases ninth revision Clinical Modification (ICD-9-CM) codes: 992.0-992.9, E900.0, E900.1, and E900.9. Cases were identified if at least one of the HRI codes was found in the primary diagnosis field or in one of the secondary diagnosis fields. Cases were restricted to Florida residents. For this analysis, cases were excluded if they were identified as work-related. Occupational HRI is discussed in a companion document (http://www.myfloridaeh.com/newsroom/index.html). Work-related cases were identified through principal

payer (workers' compensation) or a work-related ICD-9-CM Ecode*. Population data for Florida residents were obtained from the Florida Legislature's Office of Economic and Demographic Research.[10] Age-adjusted rates and their corresponding 95% confidence intervals (CI) were calculated for the years 2005-2009. Age-adjusted rates were standardized to the 2000 US standard million population for comparability. County-specific crude rates of HRI were calculated using the case's county of residence. Case fatality rates (CFR) were calculated as the number of heat-related deaths divided by the sum of heat-related deaths and cases of HRI multiplied by 1000.

Results

Between 2005 and 2009, 18,572 Floridians were treated for non-occupational HRI in the ED or hospital (age-adjusted rate = 20.2/100,000 Floridians; 95% CI = 17.3, 23.2). Among the cases of HRI identified, 53 deaths occurred (CFR = 2.8/1,000 HRI cases). The majority of HRI cases were treated in the ED (N = 15,576; 83.9%). For individuals admitted to the hospital the length of stay was a mean of 3.1 days (median = 2 days). The rate of HRI varied by county with highest rates found in the counties of Bay, Desoto, Jackson, Suwannee, Santa Rosa, and Washington (Figure 1).

Selected demographic information can be found in Table 1. As expected, the majority of HRI occurred in the summer months, July-September. The rate of HRI varies by year with 2005 having the highest rate of HRI (22.3/100,000 Floridians). The greater proportion of HRI is found among males (73.3%). Among the racial groups, non-whites had a higher rate of HRI (~24/100,000 non-white Floridians) than whites (18.8/100,000 white Floridians). However, the rate of HRI for Hispanics was half that of non-Hispanics (10.5/100,000 Hispanics vs. 22.3/100,000 non-Hispanics). The rate of HRI was also higher among residents residing in rural counties (29.0/100,000 Floridians) than among residents residing in urban counties (19.4/100,000 Floridians).

The greatest proportion of cases presented on Saturday (Figure 2). The mean and median age for HRI was 39.6 and 37 years, respectively. The age-specific rates for HRI can be found in Figure 3. The highest rates of HRI are found for teenagers (age 15-19) and the lowest rates are found among children less than 9 years of age. The majority of HRI cases (59.4%) were due to hot weather conditions (Table 2).

* Work-related Ecodes: E000.0-E000.1, E800-E807 (4^{th} digit = 0), E830-E838 (4^{th} digit = 2 or 6) , E840-E845 (4^{th} digit = 2 or 8), E846, E849.1-E849.3[11]

Conclusion - General

A descriptive analysis of the Florida hospitalization and ED data were performed examining non-occupational heat related illness (HRI). The source of the data are hospitals and EDs, HRI is also treated in outpatient settings such as a physician's office or a clinic. HRI treated in these settings are not captured in the analysis and the estimates presented here are an underestimate of the total burden of HRI in the state of Florida.

Men typically have a higher rate of HRI than women. This has been seen in prior literature and may be due to life-style choices, such as men engaging in outdoor activities more frequently than women in hot weather.[9,12,13] The racial disparity seen in the analysis (non-whites have a higher rate of HRI than whites), may be a reflection of socio-economic status.[4, 14] Individuals of lower socio-economic status are also more likely to have an underlying medical condition that may put them at higher risk of HRI including having higher rates of obesity.[9] Furthermore, air conditioning has been shown to be an effective preventative measure against HRI.[4] Individuals of low socio-economic status may not have the ability to adequately cool their homes due to the cost of electricity, the equipment (e.g. air conditioning) or both.

Underlying factors associated with the much lower rate of HRI among Hispanics versus non-Hispanics are not clear. Little exists in the literature related to ethnicity differences although a few articles suggest behavioral, cultural and socio-economic differences as an explanation. Further research is required in order to determine how these factors are associated within the Florida population.[15-17] The differences seen in race and ethnicity may also play a role in the distribution of HRI by county across the state. South Florida, with its large Hispanic population, has lower rates of HRI than the northern part of the state. Additionally, the differences seen by county may also be related to access to health care, which is a large problem in rural counties[18]. Four of the six counties with the highest rate of HRI are rural, and in general, Florida rural counties have a higher rate of HRI than urban counties. If individuals are not able to obtain timely treatment in a clinic or doctor's office, a disproportionate number of rural residents would end up in the ED or, if severe enough, the hospital. Additionally, a smaller proportion of rural residents may have access to air conditioning than urban residents[†].

Teens and young adults were identified as having the highest rate of non-occupational HRI. These findings are in contrast to the mortality literature which indicates the elderly and children have the highest risk of HRI.[4,12,19]

[†] Data on air conditioning usage is not available below the national level outside of major metropolitan areas. At this time this statement is a hypothesis that requires further investigation.

However, Florida is a state that is accustomed to high temperatures for long periods with little night time cooling and as such the majority of homes and businesses are equipped with central air conditioning. Wide-spread use of air conditioning reduces the number of HRI related to general overheating due to increased outdoor temperatures (classic HRI).[4] Classic HRI develops over days and is seen most often during extreme heat (and humidity) events.[8] Children, the elderly and individuals with underlying medical conditions are at the highest risk of classical HRI.[8] Exertional HRI, on the other hand, typically occurs in healthy individuals who are poorly acclimatized to their environment.[8] Exertional HRI is usually brought on by strenuous physical activity such as outdoor sports related to periods of extreme heat or prolonged outdoor activity.[8] This type of HRI is often seen in teens and young adults but the elderly and children are also at risk when they are active outdoors.[13,15] It has been suggested that the continual use of air conditioning may prevent an individual from becoming acclimatized to activity outdoors[4] thereby potentially increasing the risk of exertional HRI. For Florida, it is important to keep in mind that the use of central air conditioning may not be evenly dispersed across the state, with urban areas having a larger proportion of central air conditioning than rural areas[‡] possibly leading to a difference in the type of HRI affecting rural and urban areas. Unfortunately, ED and hospitalization records are not coded in such a way to allow differentiation of these two types (exertional and classic HRI).

In this study, only heat related illness (ICD-9-CM 992) was evaluated. If other conditions associated with heat-related illness (e.g. electrolyte imbalance or acute renal failure)[§] had also been included, age-specific rates may indicate a different pattern. In addition, if only periods of heat waves (extreme heat events, heat advisories, etc) were examined, the distribution of age-specific rates might also indicate a different pattern.

Future work will be conducted examining the relationship between HRI and temperature/humidity, including the impact of environmental disasters (e.g. hurricanes) on the rate of HRI. For instance, widespread power outages (including loss of air conditioning) occurred in Florida in 2005 in the aftermath of three hurricanes. Such devastation was not seen in more recent years potentially accounting for the highest rate of HRI seen in year

[‡] Data on air conditioning usage is not available below the national level outside of major metropolitan areas. At this time this statement is a hypothesis that requires further investigation.

[§] Exposure to high temperatures and an elevation of the body temperature induces a number of changes within the body adversely affecting many organs leading to the onset of disease such as acute renal failure or a cardiovascular event. It is difficult from the available data to determine which diseases are related to a heat event or to some other non-heat related condition (e.g. electrolyte imbalance may be due to dehydration from excessive heat or diabetes). As such only individuals with a specific heat diagnostic code were included in the analysis.

2005. Analysis will also be done on a finer geographical level and further examination of subgroups (e.g. race, gender, age) will be done. The literature has suggested that urban heat islands, where the temperature is higher in the city than outside the city, may contribute to higher rates of HRI.[9,14] This effect can only be assessed at a finer geographical scale.

With awareness and a few simple steps HRI can be prevented. Information on prevention of HRI can be found at http://www.bt.cdc.gov/disasters/extremeheat/heat_guide.asp

References

1. Intergovernmental Panel on Climate Change (IPCC) 2007. Climate change 2007: impacts, adaptation and vulnerability. Working group II contribution to the fourth assessment report of the intergovernmental panel on climate change. Cambridge and New York: Cambridge University Press, 2007.
2. Anderson BG, Bell ML. Weather-related mortality: how heat, cold, and heat waves affect mortality in the United States. Epidemiology. 2009 Mar;20(2):205-13.
3. Kovats RS, Kristie LE. Heatwaves and public health in Europe. Eur J Public Health. 2006 Dec;16(6):592-9. Epub 2006 Apr 27.
4. Hajat S, O'Connor M, Kosatsky T. Health effects of hot weather: from awareness of risk factors to effective health protection. Lancet. 2010 Mar 6;375(9717):856-63. Epub 2010 Feb 12.
5. Cent. Dis. Control (CDC). 1995. Heat-related Illness and deaths—United States, 1994–1995. MMWR 44:465–468.
6. Barrow MW, Clark KA. Heat-related Illness. Am Fam Physician 1998; 58(3):749-756,759.
7. Patz JA, McGeehin MA, Bernard SM, Ebi KL, Epstein PR, et al. The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the U.S. National Assessment. Environ Health Perspect. 2000 Apr;108(4):367-76.
8. Lugo-Amador NM, Rothenhaus T, Moyer P. Heat-related illness. Emerg Med Clin North Am. 2004 May;22(2):315-27, viii.
9. Kovats RS, Hajat S. Heat stress and public health: a critical review. Annu Rev Public Health. 2008;29:41-55.
10. The Florida Legislature, Office of Economic and Demographic Research. Population estimates accessed through Florida Community Health Assessment Resource Tool Set (CHARTS) population query. Available at: http://www.floridacharts.com/FLQuery/Population/PopulationRpt.aspx Accessed June 2011.
11. Alamgir H, Koehoorn M, Ostry A, Tompa E, Demers P. An evaluation of hospital discharge records as a tool for serious work related injury surveillance. Occup Environ Med. 2006 Apr;63(4):290-6.
12. Cent. Dis. Control (CDC). 2006. Heat-related deaths—United States, 1999–2003. MMWR 55:769–9.
13. Cent. Dis. Control (CDC). 2006. Nonfatal Sports and Recreation Heat Illness Treated in Hospital Emergency Departments --- United States, 2001--2009. MMWR 60(29);977-80.
14. McGeehin MA, Mirabelli M. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. Environ Health Perspect. 2001 May;109 Suppl 2:185-9.

15. Carter R 3rd, Cheuvront SN, Williams JO, Kolka MA, Stephenson LA, et al. Epidemiology of hospitalizations and deaths from heat illness in soldiers. Med Sci Sports Exerc. 2005 Aug;37(8):1338-44.
16. Basu R, Ostro BD. A multicounty analysis identifying the populations vulnerable to mortality associated with high ambient temperature in California. Am J Epidemiol. 2008 Sep 15;168(6):632-7. Epub 2008 Jul 28.
17. Klinenberg, E. Heat Wave: A Social Autopsy of Disaster in Chicago. Chicago,IL: University of Chicago Press; 2002:79-128.
18. Florida Department of Health Office of Rural Health. Current rural Health issues in Florida. Retrieved 6 August 2011 from http://www.doh.state.fl.us/workforce/ruralhealth/ruralhlthissues.htm
19. Semenza JC, McCullough JE, Flanders WD, McGeehin MA, Lumpkin JR. Excess hospital admissions during the July 1995 heat wave in Chicago. Am J Prev Med. 1999 May;16(4):269-77.

Table 1. Selected characteristics of Florida residents diagnosed in a Florida hospital or ED with heat-related illness (HRI) and characteristics of the Florida population, 2005-2009 (N=18,572)

Characteristic	HRI Frequency	HRI Percent	Florida Residents* Frequency	Florida Residents* Percent	Rate/100,000 residents	Rate Ratio (p-value)
Gender						
Male	13,621	73.3	45,458,854	49.0	30.0	Reference
Female	4,951	26.7	47,362,785	51.0	10.5	0.35 (<0.0001)
Race†						
White	14,110	76.5	74,938,292	80.7	18.8	Reference
Black	3,712	20.1	15,287,253	16.5	24.3	1.29 (<0.0001)
Other	614	3.3	2,596,094	2.8	23.7	1.26 (<0.0001)
Ethnicity†						
Non-Hispanic	16,428	89.1	73,717,937	79.4	22.3	Reference
Hispanic	2,008	10.9	19,103,702	20.6	10.5	0.47 (<0.0001)
Rural/Urban‡						
Urban	16,873	90.6	86,963,676	93.7	19.4	Reference
Rural	1,700	9.2	5,857,963	6.3	29.0	1.50 (<0.0001)
Quarter§						
January-March	805	4.3	92,821,639	---	0.9	0.07 (<0.0001)
April-June	5230	28.2	92,821,639	---	5.6	0.48 (<0.0001)
July-September	11,006	59.3	92,821,639	---	11.9	Reference
October-December	1531	8.2	92,821,639	---	1.6	0.14 (<0.0001)
Year						
2005	4023	21.7	18,018,497	19.4	22.3	1.08 (0.0003)
2006	3539	19.1	18,440,700	19.9	19.2	0.93 (0.002)
2007	3858	20.8	18,731,287	20.2	20.6	Reference
2008	3059	16.5	18,812,155	20.3	16.3	0.79 (<0.0001)
2009	4093	22.0	18,819,000	20.3	21.7	1.06 (0.02)

*Population data from the Florida Legislature's Office of Economic and Demographic Research.
†Note 136 individuals did not report their race/ethnicity.
‡Rural and Urban counties were defined according to the Florida Department of Health Office of Rural Health.
§The total population for all years was used as population data were not available by quarter.

Table 2. Summary of ICD-9-CM Ecodes identifying the source of the heat-related illness (HRI) among Florida residents (2005-2009)

ID-9-CM	Definition	Cases of HRI
E900.0	Excessive heat due to weather conditions	11,028 (59.4%)
E900.1	Excessive heat of man-made origin*	148 (0.8%)
E900.9	Excessive heat of unspecified origin	4,122(22.2%)
	Unknown (ecode not present)	3,274 (17.6%)
	Total	18,572 (100%)

* May include heat in a boiler room, drying room, factory, furnace room, kitchen or generated in transport vehicle.

Figure 1. Quintiled rates of heat-related illness (HRI) treated in Florida hospitals and EDs, 2005-2009 (N=18,572)

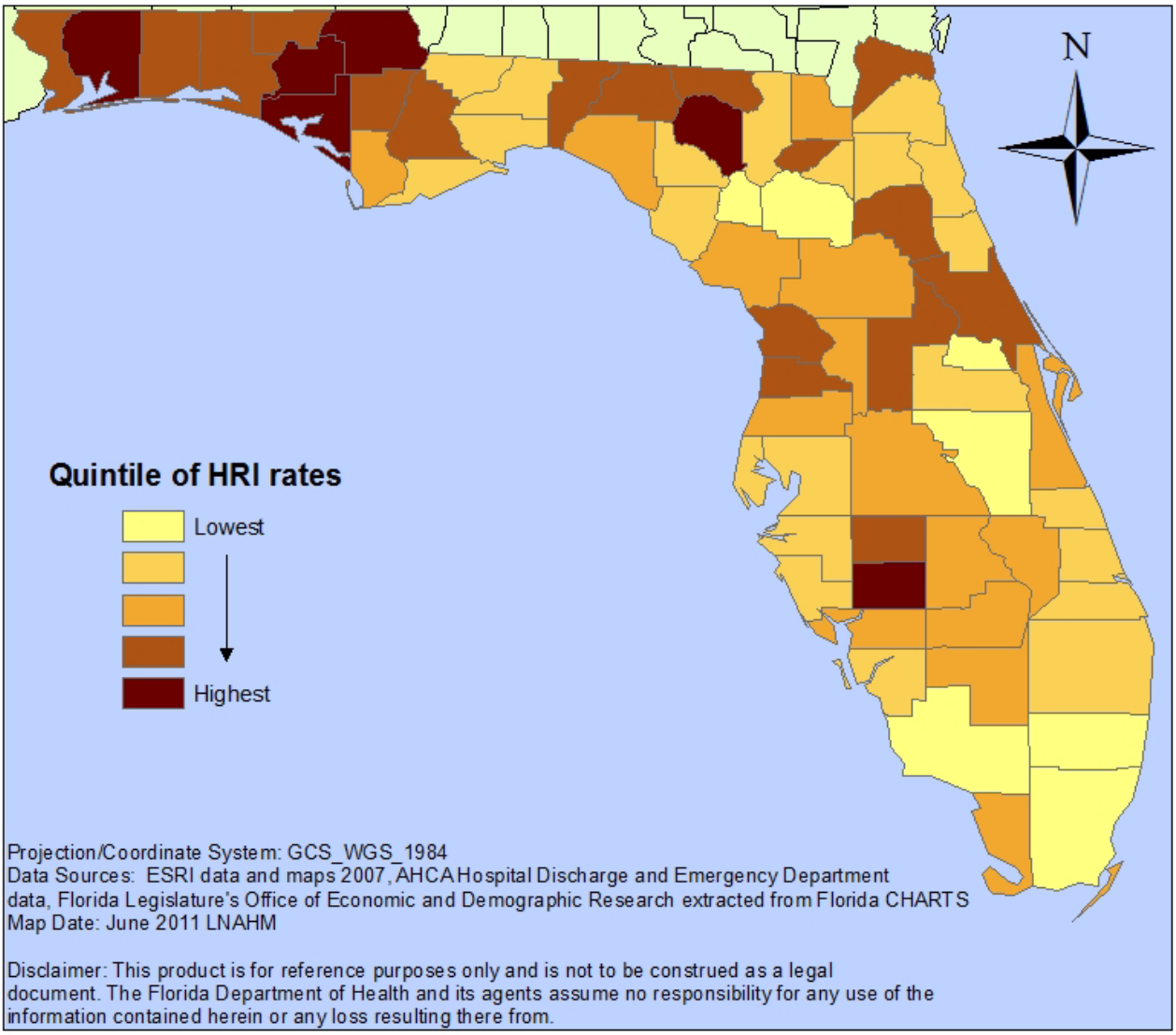
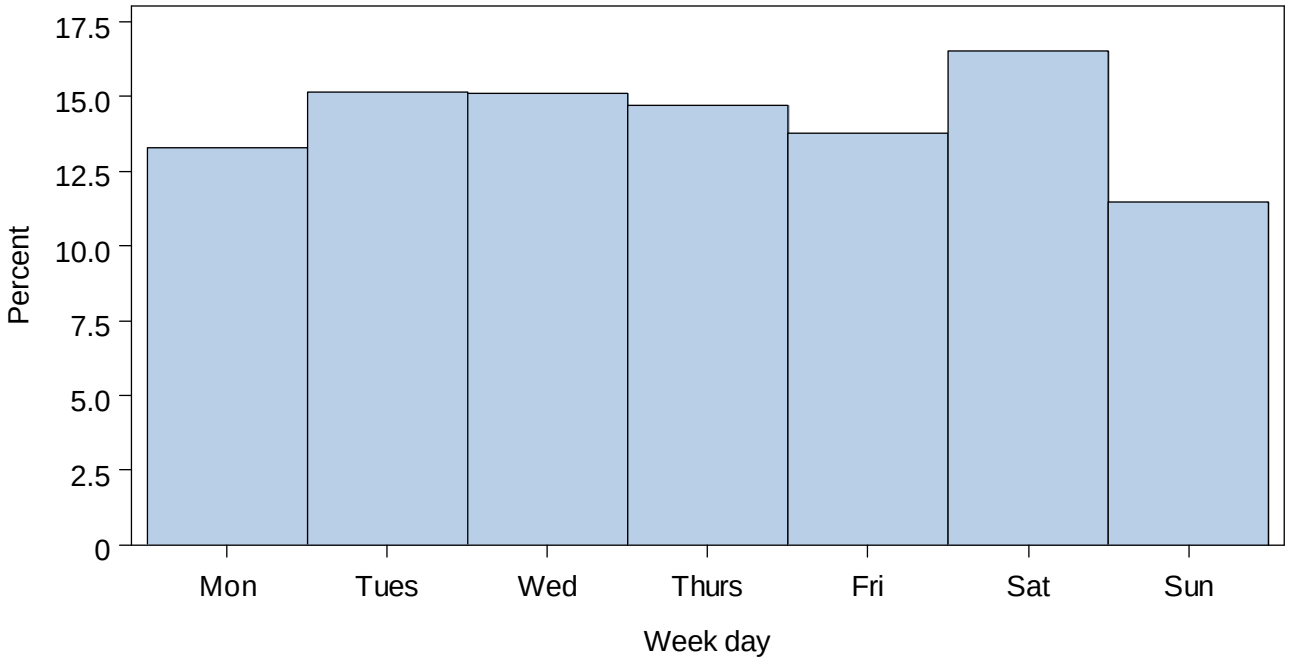


Figure 2. Distribution of admission/visit day of week for heat-related hospitalizations and ED visits among Florida residents, 2005-2009 (N = 18,572)*



*Summary statistics: Mean = 3.0, Median = 3, Minimum = 0, Maximum = 6, Standard deviation = 1.9, Skewness = 0, Kurtosis = -1.2

Figure 3. Distribution of age group by rates of heat-related hospitalizations and ED visits among Florida residents, 2005-2009 (N=18,572)