Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_________________________________ ____________________

Sandeep Shelly Date

Does home heat index predict hydration level of agricultural workers in Florida?

By

Sandeep Shelly
Master of Public Health

Environmental Health

P. Barry Ryan, PhD, MS
Committee Chair

Paige Tolbert, PhD
Committee Member

Does home heat index predict hydration level of agricultural workers in Florida?

By

Sandeep Shelly

B.D.S
B.J.S Dental College
2014

Thesis Committee Chair: P. Barry Ryan, PhD, MS

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Environmental Health
2018

Does home Heat Index predict the hydration level of agricultural workers in Florida?

Abstract

Background: Agricultural workers frequently labor in hot and humid conditions, increasing their risk of heat-related illness (HRI). Various HRIs are related to previous episodes of hypohydration. Previous findings from the Girasoles study indicate that over 50% of agricultural workers begin their work shift hypo hydrated. To our knowledge, the impact of housing characteristics and home temperature on dehydration level in agricultural workers has not yet been investigated. The objective of this study was to examine the association of indoor heat index during the post-workday recovery period, on next day hydration status of agricultural workers.

Methods: The Girasoles study is a prospective cohort study aimed to evaluate heat stress and HRI in agricultural workers recruited from three different Florida communities. A total of 198 workers were recruited for a baseline assessment and were monitored for three workdays. Ambient temperature and relative humidity at home was measured with EL-USB -2 Lacar Humidity and Temperature USB that workers brought home and placed in their bedrooms. Indoor heat index (primary exposure) was computed from temperature and relative humidity. Pre-work shift urine samples were collected to measure urine specific gravity (USG). USG ≥ 1.020 was used to define significant hypohydration. Multivariable logistic regression was used to examine the association between indoor heat index and pre-workday dehydration. The model was adjusted for sex, house type and presence of air conditioning in the house.

Results: No association was found between indoor heat index and significant hypohydration (OR =0.97; CI: 0.93-1.02) controlling for sex, house type and presence of air conditioning in the house.

Conclusion: There was no relationship between indoor heat index and hydration status of the agricultural workers.

Does home heat index predict hydration level of agricultural workers in Florida?

By

Sandeep Shelly

B.D.S
B.J.S Dental College
2014

Thesis Committee Chair: P. Barry Ryan, PhD, MS

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Environmental Health
2018

Acknowledgments

A deep gratitude to agricultural workers who participated in this study, the Farmworker Association of Florida, the Girasoles Study team. Many thanks to Dr. P. Barry Ryan and Dr. Paige Tolbert for their continuous guidance, suggestions and support. Special thanks to Jacqueline M. Mix and Lisa Elon for continuous editing and support. I would also like to thank Dr. Vicki Hertzberg for her expert advice and encouragement during the project. A sincere acknowledgement to Dean McCauley for providing me the opportunity to work on this project.

INTRODUCTION

Climate change is raising numerous health concerns worldwide (Luber & McGeehin, 2008). According to United States Centers for Disease Control and Prevention, the earth is warming due to the continuous release of greenhouse gases including carbon dioxide into the atmosphere (NCEH, 2011). In the United States, the average air temperature has risen more than 2.0°F in last 50 years and is projected to increase in the future (NCEH, 2011). Climate model simulations projects that for the first half of the 21st century, the year-round temperature across North America will warm approximately by 2.0°- 5.0° F (Luber & McGeehin, 2008). The leading cause of this change is urbanization, causing an increase in engineered infrastructures, blacktop roads, emissions from a large number of vehicles, contributing to increase in heat production in urbanized communities. (Luber & McGeehin, 2008).

One of the consequences of temperature rise across the globe is extreme heat events (NCEH, 2011) that negatively affects the human health (Luber & McGeehin, 2008). Extreme heat events are defined by U.S. Environmental Protection Agency as "periods of summertime weather that are substantially hotter and/or more humid than typical for a given location at that time of year (NCEH, 2011) ." Increase in global surface temperature also changes the frequency, severity, and longevity of these events (NCEH, 2011). These projected changes in heat events would further exacerbate the health outcomes (Hanna & Tait, 2015) owing to excessive heat stress.

One of the essential outcomes of the heat stress on human health via these heat events is Heat Related Illness (HRI) (Hanna & Tait, 2015). HRI is defined as a physiologic insult to the body when the body is unable to maintain homeostasis under extreme heat exposure (Atha, 2013). Various studies using emergency dispatch data showed a strong association between morbidity and increase in temperature (Mathes, Ito, Lane, & Matte, 2017). The United States Department of Labor included several conditions under heat-related illness according to increasing severity: heat rash, heat cramps, heat exhaustion and heat stroke (OSHA). These illnesses occur along a continuum from heat exhaustion to heat stroke with latter involving multiorgan failure (Atha, 2013).

Continued exposure to high temperature induces heat strain or thermal stress that causes increased sweating with loss of plasma volume and electrolytes leading to heat exhaustion, characterized by mild symptoms like malaise, headache, and nausea (Jackson & Rosenberg, 2010). As described above, untreated heat exhaustion leads to heat stroke which is a serious illness associated with central nervous system dysfunction manifested by delirium and coma (Glazer, 2005). Excessive loss of body fluid and electrolytes lead to dehydration that exposes the population to adverse outcomes related to HRI (Jackson & Rosenberg, 2010). Furthermore, the studies on athletes showed that hypohydration before work also exacerbates the rate of increase in heart rate and core temperature (Logan-Sprenger & Spriet, 2013). This leads to premature fatigue in individuals during workout (Logan-Sprenger & Spriet, 2013).Thus, adequate hydration and fluid balance is required to prevent dangerous health outcomes.The National Athletic Trainer's Association (NATA) classified hydration status into 4 types, namely; well hydrated (urine specific gravity < 1.010), minimal hypohydration (urine specific gravity 1.010–1.020), significant hypohydration (urine specific gravity >= 1.020), and serious hypohydration (urine specific gravity > 1.030) (Logan-Sprenger & Spriet, 2013).

Outdoor workers are one of the groups that encounter the climate-sensitive health outcome like HRI (Bethel & Harger, 2014) owing to direct sunlight exposure (Hancock & Vasmatzidis, 2003). Heat stress due to sun exposure also leads to physiological discomfort, loss of concentration, coordination, and judgment resulting in deteriorating cognitive and physical performance (Hancock & Vasmatzidis, 2003). Laborers such as agricultural workers are one of the vulnerable populations experiencing these health consequences due to their long working hours in hot and humid conditions under direct sunlight (Mac & McCauley, 2017). According Centers for Disease Control and Prevention report, between 1992 to 2006, 423 workers died from exposure to environmental heat (0.02 deaths per 100,000 workers) among all workers, including 68 workers employed in crop production (0.39 deaths per 100,000 workers (MMWR, 2008).

Studies on military personnel, athletic and laborers identified several strategies to combat HRI. These include hydration, appropriate rest periods, acclimatization, worker, and employer education (Bethel & Harger, 2014). Other studies have also shown that daily recovery from heat stress helps in reducing the adverse health outcomes (Quandt & Wiggins, 2013). One of the most important recovery methods is sound sleep (Fullagar et al., 2015). However, the quality of sleep depends upon indoor temperature (Libert et al., 1988) and the housing conditions such as the presence of air condition and fans (Quandt, 2015; Quandt & Wiggins, 2013). It has been reported that 83% of heat-related illnesses are related to prior periods of sleep deprivation (Relf et al., 2017).Thus, lack of sufficient rest allows inadequate recovery that leads to deteriorating health and worsening of HRI symptoms during work (Quandt, 2015; Quandt & Wiggins, 2013). Morbidity and Mortality Weekly Report also showed that there is a high prevalence of short sleep duration in production workers (42.9%) (Wheaton, 2013 -2014). According to Libert et al., high temperatures hinder the quality and quantity of good sleep by affecting the initial sleep cycle and enhancing wakefulness (Libert et al., 1988). Additionally, researches have also shown a relation between the type of housing and temperature-related mortality (Scovronick & Armstrong, 2012).

Hence, all the above assertions suggest that heat stress experienced by the agricultural workers during the day can be exaggerated depending upon household environment. If the indoor temperature and humidity is high, it would add to the daytime heat stress and would also increase the frequency of sleep deprivation episodes. High humidity also leads to evaporative heat loss through sweating resulting in loss of body fluid (Nerbass et al., 2017). Excessive fluid loss causes tiredness (Logan-Sprenger & Spriet, 2013) before going to the fields and also lead deleterious outcomes like heat exhaustion (Jackson & Rosenberg, 2010). Thus, there is a need to examine the impact of home temperature and humidity on hydration status of agricultural workers. The objective of this study was to evaluate the association of indoor heat index on hydration level of workers where heat index includes both indoor temperature and humidity to predict better the effect of heat on individuals. This study also described the association of housing characteristics such as presence of fan, windows, air conditioning, and presence of number of people on indoor heat index during worker’s recovery period.

METHODS

Study Design

Data for this study were utilized from Girasoles ("Sunflower") study, a prospective cohort study done in collaboration between Emory University and the Farmworker Association of Florida (FWAF) during the year 2015-2017. FWAF is a membership organization of farmworkers that aims to empower the agricultural community by addressing social, political, economic, workplace, health, and environmental justice issues. FWAF collaboration supported the project by providing access to the agricultural population and training community health workers *(promotoras)* for data collection. The population of interest for the study were agricultural workers employed in various types of agricultural operations such as fernery, field crop, and nursery in the state of Florida.

The overall objective of the Girasoles study was to determine the impact of environmental heat on physiological responses of the agricultural population. The physiological response was determined by obtaining data on HRI symptoms and calculating Physiological Strain Index (PSI). Five sites in Florida were selected for the main study, depending upon Florida Automated Weather Network (FAWN) reports showing the hottest regions. FAWN are the monitoring centers that collects natural wet bulb globe temperature, globe thermometer temperature, dry bulb temperature, relative humidity, and environmental information after every 15 minutes. There was a FAWN monitoring station in all the five regions used in this study. Approval for the study was obtained from Emory University's Institutional Review Board (IRB).

Study Population

Data from the Girasoles study was used for this project and included three sites (Apopka, Immokalee, and Pierson, see Figure 1). Inclusion criteria for the for the study participants were: male and female agricultural workers between the age of 18 – 54 years, currently working in a nursery, fernery or crop field and worked there for at least one month. The exclusion criteria were: weight less than 80 pounds; any history of disease or surgery of esophagus, stomach or intestine, swallowing difficulties, presence of a pacemaker, pregnant women and individuals with Type 1 diabetes. Data from the study population were collected by trained community health workers (*promotoras)* and were hired by FWAF. The agricultural workers were contacted by *promotoras* via phone, through home visits and community outreach. Oral consents were obtained from all the study participants to promote anonymity/confidentiality.

Figure1. Pierson, Apopka and Immokalee regions (Florida)

https://commons.wikimedia.org/wiki/File:USA_Florida_location_map.svg
By Eric Gaba [Sting - fr:Sting] [CC BY 3.0 (https://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

The study protocol included baseline assessment and three monitored workdays. Clinical and survey data were collected at the baseline visit that included demographic, physiological, work and household characteristics. Biological data included pre-shift urine samples and were collected over three consecutive days. Participants reported to the testing station (FWAF office) in the morning before traveling to their worksite to provide the urine samples. Data on overnight home temperature and humidity were also collected over three monitored workdays using EL-USB -2 Lacar Humidity and Temperature USB Logger. Participants were asked to take temperature monitoring device home every night during the study period. The instructions were given to keep the USB logger in their bedrooms and return the next morning at the pre-workday visit.

Survey data

The survey administered at baseline included questions about the participants' age, gender, number of years in agriculture, years of education, country of birth and type of work. Information was also collected on household characteristics and fluid intake preferences at home. Housing characteristics included the type of house; presence of air conditioning, electric fans, and windows, number of people sleeping in the house. Data were also collected on the number of people living in the same household.

Clinical Assessment

The clinical examinations consisted of measurements of height, weight, systolic and diastolic blood pressure obtained by trained research staff during the baseline visit. Body mass index was measured following standardized formula (WHO, 2000) using height and weight.

Biological samples

To assess urine specific gravity, we collected pre-shift urine samples at the FWAF office. USG was measured onsite (FWAF office) by the trained research staff. Urine specific gravity is used to access the concentration/density of urine to provide a fair estimate of hydration status of the individual (Chadha, Garg, & Alon, 2001). USG is related to hydration status as follows: well hydrated (urine specific gravity < 1.010), minimal hypo hydration (urine specific gravity 1.010–1.020), significant hypo hydration (urine specific gravity >= 1.020), and serious hypo hydration (urine specific gravity > 1.030) (Logan-Sprenger & Spriet, 2013). Urine specific gravity (USG) of more than 1.02 (Significant hypohydration) was defined as the primary outcome of interest.

Home temperature and relative humidity

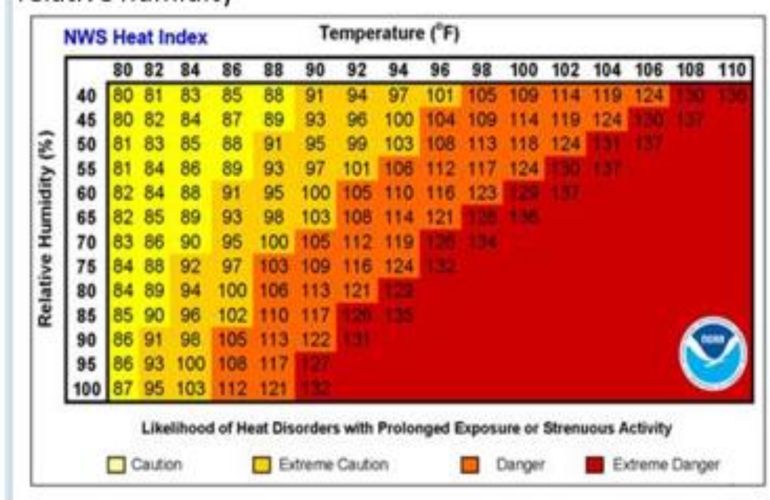
The home temperature and humidity data were collected by EL-USB -2 Lacar Humidity and Temperature USB. It is a temperature monitoring device in combination with USB. When the data collection mode was turned on, it collected real-time home temperature and relative humidity after every 15 minutes in degree Fahrenheit. In total 21 measurements were taken per day by the device from 10 pm to 3 am. The rationale behind using this specific time range was to predict better the exposure of sample population to heat when they are at home. Most of the workers were leaving for work early in the morning and returning late in the evening. We assumed that most of the participants would be home between 10pm to 3am.

The device was given to the participants every evening before they left the worksite, with instructions to keep the monitor in the bedroom, by or under the bed. The device was retrieved from the participants the next morning at the pre-workday visit. The data were downloaded and saved as CSV files in the computer by referring the participants' location, ID number and day of data collection. The monitoring device is shown in Figure 2. The temperature and humidity measurements were used to calculate Heat Index (HI). HI indicates the degree of perception of heat when relative humidity is factored with the air temperature (NOAA). The heat index was calculated using Steadman apparent temperature formula and, the methodology is described elsewhere (Anderson, Bell, & Peng, 2013). The relation between heat index, relative humidity and temperature can be seen in Figure 3.

Figure 2. Device used to measure the temperature and humidity of homes (*EL-USB -2 Lacar Humidity and Temperature USB)*

Primary outcome and exposure variables

Figure 3. Relation between Heat index, temperature and relative humidity



(NOAA), http://www.nws.noaa.gov/om/heat/heat_index.shtml

The primary independent exposure of interest was the overnight heat index of the house. The primary outcome of interest for this study was significant hypohydration, that is represented by morning urine specific gravity; measured the day following the heat index measurement.

Potential confounders/covariates

We included age and sex to control for potential confounding based on a priori hypotheses. Other variables considered as covariates/ potential confounders are type of house and presence of air conditioning in the house.

Data processing

Home temperature data was explored for unexpected values in low 40's (<45 º F) due to occasional malfunctioning of the monitoring device or if the participant mistakenly kept the device near the air conditioner. None of the values were found to be below the cutoff (<45 º F). To assess home temperature and humidity per person, the mean of the 21 temperature and humidity measurements from 10 pm to 3 am was computed. The process was followed by calculating the mean of the values for three individual monitored days obtained from previous steps. Thus, a single temperature and humidity measurement value was obtained by summarizing the values of three consecutive days exposure. Heat Index was calculated from the summarized temperature and humidity values.

The means of USG measures were also obtained from the values obtained across three days of the study. Finally, merging of overnight heat index data, baseline demographic data, and next day urine specific gravity data was done. Urine specific gravity was dichotomized as: Significant hypohydration (USG >= 1.02) and no significant hypohydration (USG < 1.02). A newer variable (household ID) was made to describe the people living in the same household. However, this variable was not included in the analysis for this project.

STATISTICAL ANALYSIS

To ascertain the normality of the continuous variables (age, heat index, urine specific gravity, number of years in agriculture), univariate analysis was performed. All continuous variables were found to be normally distributed. Descriptive statistics were summarized for both categorical (Country of birth, gender, type of work) and continuous (age, weight, BMI, number of years in agriculture and number of days and hours worked) variables. Also, descriptive statistics were also determined for type of beverages used at home and characteristics of the house. The Pearson correlation coefficient was used to evaluate the relationship between urine specific gravity, heat index, age and, BMI. The Student's two sample t-test was used to evaluate the mean difference in heat index with the presence of air conditioning, electric fan and windows. The Student's two sample t-test was also used to assess differences in USG with fluid preferences of workers at home. The One-Way Analysis of Variance (ANOVA) test was performed to identify the differences in means of heat index and USG across different house types and number of people in the house. The Chi-Square test was used to examine the relationship between categorical variables (household characteristics and fluid preferences at home).

The Student's two sample t-test showed statistically significant differences in heat index according to presence and absence of air condition, and number of people in the house. The two variables were used in a multivariable linear regression model to assess the variability (in heat index) accounted by the presence of air conditioning and number of people in the house.

We considered variables for inclusion in logistic multivariable models, based upon *a priori* (age and sex) and bivariate analysis that showed statistically significant associations (presence of air conditioning and house type). The model fit statistics used to keep the variables in the model was -2 log likelihood ratios. The relation between heat index and hydration status was also assessed for other confounders by using 10% change criteria of confounding (Budtz-Jorgensen, Keiding, Grandjean, & Weihe, 2007). Multivariable logistic regression was used to identify the association between heat index and hydration status of the agricultural workers. All analyses were completed in SAS, version 9.4 (SAS Institute, Cary, NC).

RESULTS

A total of 198 participants were included in this study. The sociodemographic, work and physiological characteristics of workers are reported in table 1. Most of the participants were crop (35.4%), fernery (33.8%) and nursery (30.8%) workers; females (60.6%) and of Mexican (66. 7%) descent. The mean age of participants was 38 years (SD 8.2). The workers have been engaged in agricultural work from last 12 (SD 7.8) years on an average, with seventh standard as the highest grade completed. Significant hypo hydration was seen in 44.8% of the study population with mean urine specific gravity of 1.02 (SD 0.005).

The common beverages consumed at home are reported in Table 2. Water was seen to be the main source of hydration at home (77.3%). Juice was found to be the second common drink consumed (45.5%) by the workers followed by soda or coke (34.4%) and sports drink (27.8%). Energy drinks were the least preferred fluid at home (8.4%). Household characteristics of the sample population are reported in Table 3. Most of the families had air conditioning (95%), windows (94.4%) and fans (60.6%) in households with 4 to 6 people living together (59.7%). The sample population living in single-family houses is 38.4% as compared to mobile trailers and apartments that consisted 33.8% and 27.8% respectively. The mean heat index of the houses was 77.5ºF.

The Student's two sample t-test showed that heat index varied according to the presence and absence of air conditioning and windows. The heat index was 10-degree

Fahrenheit and 4-degree Fahrenheit higher in houses with no air conditions (87 ^{o} F, 77 ^{o} F) and windows (81.1 ^{o} F, 77.2 ^{o} F) respectively. Multivariable linear regression between the home index and household characteristics showed statistically significant negative association between the presence of air condition and number of people in the house. The variables explained 17% of the variability in heat index [Table 6].

ANOVA analysis showed that the heat index decreased with increase in the number of people living in a house but remained same across different types of houses [Table 4, Figure 3]. However, statistically significant difference in means of urine specific gravities were seen according to the type of house (F-value = 3.44, p-value = 0.03). High urine specific gravities were found in people living in apartments. The difference in means can be seen in Figure 4.

Pearson correlation showed that age has significant correlation with heat index (r = 0.14 , p-value = 0.057) and urine specific gravity (r = -0.14, p-value = 0.05) [Table 5]. USG was dichotomized as a new variable representing, significant and non - significant hypohydration. Multivariable logistic regression was used to access the relationship between hydration level and heat index in the study population. Figure 5. shows scatter plot between heat index and urine specific gravity.

ANOVA analysis showed that urine specific gravity differed according to the type of house [Table 4] and was considered as a potential confounder. Fisher exact test showed that 147 people out of 192 had both air conditioning and more use of water at home (Fishers p-value = 0.0001, not presented in the tables). Air conditioning was also seen to be associated with low heat index [Table 4] and thus considered to be a potential confounder. Both house type and presence of air conditioning in the house were used for model building apart from gender and age (*a priori hypotheses*). Multivariable logistic regression procedure with the heat index, gender, age, presence of air conditioning and house type in the model showed that none of the variables are significant except gender. However, the odds ratio for presence of air conditioning (OR = 3.9; 95% CI: 0.68 - 22.27) and house type (OR = 1.39; 95% CI: 0.69 – 2.82 and OR = 1.96; 95% CI: 0.91 – 4.22) were high. Thus, both the variables contained in the final model [Table 8]. In the final model, there was no association between urine specific gravity and heat index adjusting for sex, presence of air condition and type of house (OR = 0.97; 95% CI: 0.93-1.02) [Table 7].

DISCUSSION

To our knowledge, this is a unique study that attempted to establish a link between heat index of the house and hydration status of agricultural workers before starting the work shift. The study showed no evidence of a relationship between heat index of the house and hydration status of the agricultural workers. However, workers living in apartments showed significant hypohydration as compared to people living in trailers/moving houses and single-family houses. Most of the participants in Girasoles study were females (60.6%) and of Mexican descent (63.1%).

A study, conducted in South Carolina, assessed the relation between heat index and use of air conditioning. More than half of the workers in this study had no air conditions in their house (Quandt, 2015) . Our study had 95% of the population with presence of air conditioners, this is an unusual finding and contrasted with Quandt. et el. On the other hand, there was no association of heat index with house type which coincides with Quandt. et el.

A Significant difference in hydration status was present across different types of houses. Differences in the availability of running water in different types of houses can be one of the explanations for this outcome. Interestingly minimal hypo hydration was found in people living in trailers or moving houses. One of the interesting findings in this analysis supporting the null association between outcome and exposure is the significant positive correlation between presence of air conditioning and high consumption of water (for drinking) at home. It shows that people with presence of air conditioning are also more hydrated. According to Table 5. people with presence of air condition in house have low heat index. Thus, there is less evaporative heat loss via sweating that maintains the optimal hydration status of the body. In addition, the low heat index maintains a good sleep quality and allows complete recovery from heat exposure occurred during the day time.

The study has several strengths. It is a unique study to assess the effect of indoor heat on agricultural workers' hydration status. It considered one of the most important populations vulnerable to climate-sensitive health outcomes. The size of the sample provided adequate power to the study. The study measured the real-time temperature and humidity in the house with innovative monitoring devices. Moreover, monitoring device also provided a relevant test-retest reliability, as the measurements taken over 15 minutes intervals were similar on an average. In addition to this, the repetitive measure design of the study provided the opportunity to collect more measurements from each participant, downsizing the measurement errors. The statistical methods also explored the potential confounders in the relation between heat index and hydration level.

The study had some limitations. We estimated the indoor heat index without considering the ambient humidity and temperature, which might be a confounder because ambient temperature, humidity can affect both indoor temperature, humidity and, hydration status of the workers. In addition to this, we did not have the data on the size of the houses that might be correlated with heat index and presence of air conditioning and windows. Regarding hydration status, we used the urine specific gravity rather than serum osmolality. Serum osmolality is the gold standard to measure the hydration status (Chadha et al., 2001). We also did not consider the group effect by the individuals living in the same household that could have moved the p-value towards non-significance. But the p-values are non-significant even without considering the group effect. Thus, we assume that would not have made much change in the results. One of the other limitations is precision of the estimate. We summarized the data taking the mean of all the values. Since we did not consider all the data points, it might have led to less precision of the result estimates.

Despite these limitations, this study provides a direction for future research. The results of this study can be consulted in amending policies and regulations related to agricultural workers' housing. The upcoming studies should use serum osmolality measures to predict better the hydration status. They should also collect information on the size of the house and the age group of the people living in the household. Furthermore, the data should be collected from different states of the United States to generalize the results to a broader agricultural community. In addition, group effect due to people living in the same household should also be considered in future research.

TABLES

Table 1. Sociodemographic, work, and physiological characteristics of Florida Agricultural Workers, Girasoles study 2015-2016

Characteristics	**n (%) or mean (sd) n = 198**
Sociodemographic	
Age (years)	38 (8.2)
Sex	
Male	78 (39.4%)
Female	120 (60.6%)
Nationality	
Mexico	125 (63.1%)
Guatemala	34 (17.7%)
Haiti	28 (14.1%)
United States	3 (1.5%)
Others	8 (4.04%)
Highest grade completed	6.5 (3.5)
Health - Related	
Body mass index	28.7(4.4)
Weight (lbs)	157.8 (28.3)
Work - Related	
Years worked in agriculture	12 (7.8)
Number of hours worked per day	7.5 (1.4)
Number of days worked per week	5.1 (0.9)
Agricultural work type	
Nursery	61 (30.8%)
Field crop	70 (35.4%)
Fernery	67 (33.8%)

Table 2. Consumption of beverages among participants at home, Girasoles study 2015-2016

Characteristics	n (%) n= 198
Type of drink used at home	
Water	153 (77.3)
Alcohol/Beer/Wine	17 (8.6)
Sports Drink	55 (27.8)
Energy Drink	8 (4.0)
Coffee/Caffeinated tea	19 (9.6)
Soda/Coke	64 (34.4)
Juice	90 (45.5)

Table3. Household characteristics of Florida Agricultural Workers, Girasoles study 2015-2016

Characteristics	n (%) (n = 198)
Type of house	
Single family house	76 (38.4)
Mobile home/Trailer	67 (33.8)
Apartment	55 (27.8)
Presence of Air conditioning	188 (95)
Presence of Windows	187 (94.4)
Presence of Fan	120 (60.6)
Number of people sleeping in house	
1 to 3	50 (26.9)
4 to 6	111 (59.7)
7 to 11	25 (13.4)
Heat index	77.5 (7.14)

Table 4. The Student's two sample T-test and ANOVA showing Indoor heat index according to various household characteristics, Girasoles study 2015-16

Household characteristics	Heat Index mean (SD) n= 198	p-value
Type of house		.715[1]
Single family house	77.8 (6.9)	
Apartment	77.6 (7.4)	
Mobile home/Trailer	76.9 (7.2)	
Presence of air conditioning		<0.001
Yes	77.0 (6.7)	
No	87.0 (8.8)	
Presence of windows		.06
Yes	77.2 (7.1)	
No	81.1 (7.3)	
Presence of fan		.59
Yes	77.2 (6.5)	
No	77.8 (8.2)	
Number of people in house		.0001[1]
1 to 3	80.9 (8.6)	
4 to 6	76.3 (6.4)	
7 to 11	75.5 (4.3)	

[1]p-value for ANOVA

Table 5. Pearson correlation between age, BMI, heat index, number of years in agriculture and USG, Girasoles study 2015-16

Variables*	Age	BMI	Number of years in agriculture	Heat index
BMI	.12 .098			
Number of years in agriculture	.46 <0.0001	.25 .0006		
Heat index	.14 .057	-.10 .200	-.03 .637	
USG	-0.14 .05	.08 .285	.01 .859	-.04 .625

*Variable values are shown as Pearson correlation
p-value

Table 6. The association of heat index with household characteristics, assessed with multivariable linear regression, Girasoles study 2015-16*

Variable	Parameter estimate	Standard error	95% Confidence Interval	
Intercept	91.19	2.77	85.72	96.65
Presence of air condition	-8.12	2.30	-12.65	-3.59
Number of people in house	-1.01	0.25	-1.50	-0.52

*r^2 (coefficient of determination) for the analysis = 0.168

F-value = 18.88, p-value = <0.001

Table 7. The association between significant hypo hydration and indoor heat index, assessed with Logistic regression, Girasoles study 2015-16

Characteristics	Model A[1] OR (CI)	Model B[2] OR (CI)
Heat index	.98 (.93 - 1.02)	.97 (.92 - 1.02)
Sex (ref – male)	.50 (.27 - .94)	.51 (.27 - .95)
Presence of air conditioning (ref -yes)	3.9 (.68 - 22.3)	4.3 (.77 - 23.7)
Type of house (single family house vs mobile home/trailer)	1.39 (.67 - 2.8)	1.4 (.68 - 2.8)
Type of house (apartment vs mobile home/trailer	1.96 (.91 - 4.2)	1.8 (.88 – 4.0)
Age	.97 (.93 – 1.0)	

[1] Model A controlled for sex, presence of air conditioning, house type and age, -2 log likelihood ratios = 15.77, p-value -0.02
[2] Model B controlled for sex, presence of air conditioning and house type. -2 likelihood ratios = 12.35, p-value - 0.03

FIGURES

Figure 3. ANOVA output of heat index across different types of houses

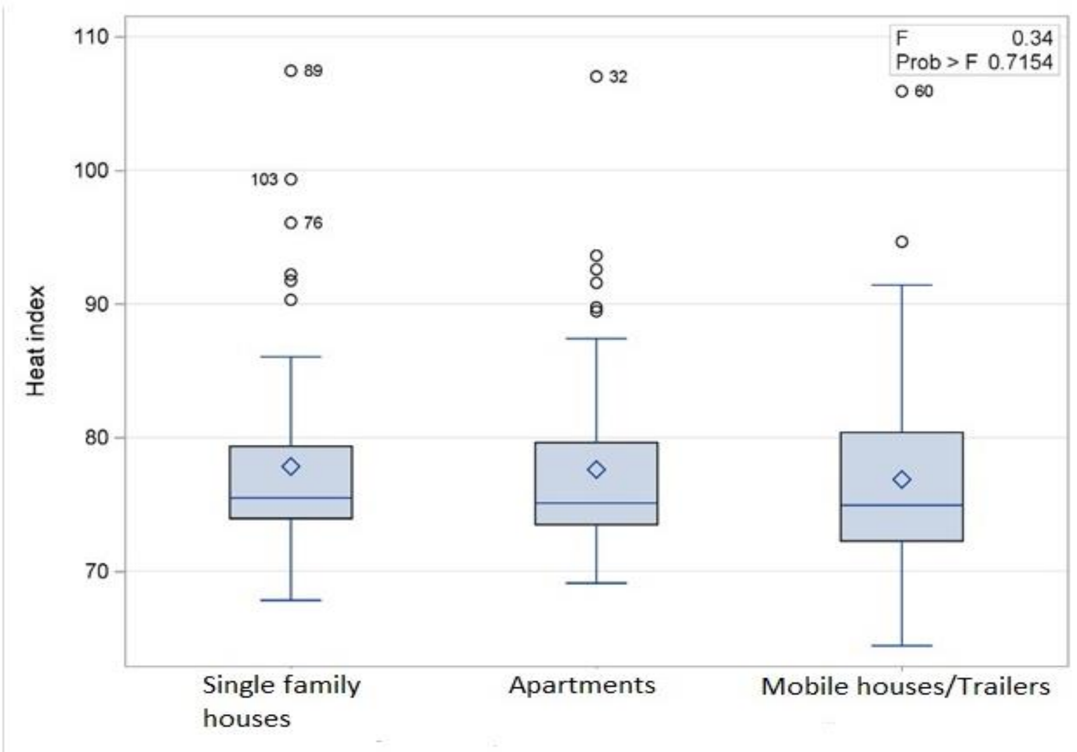
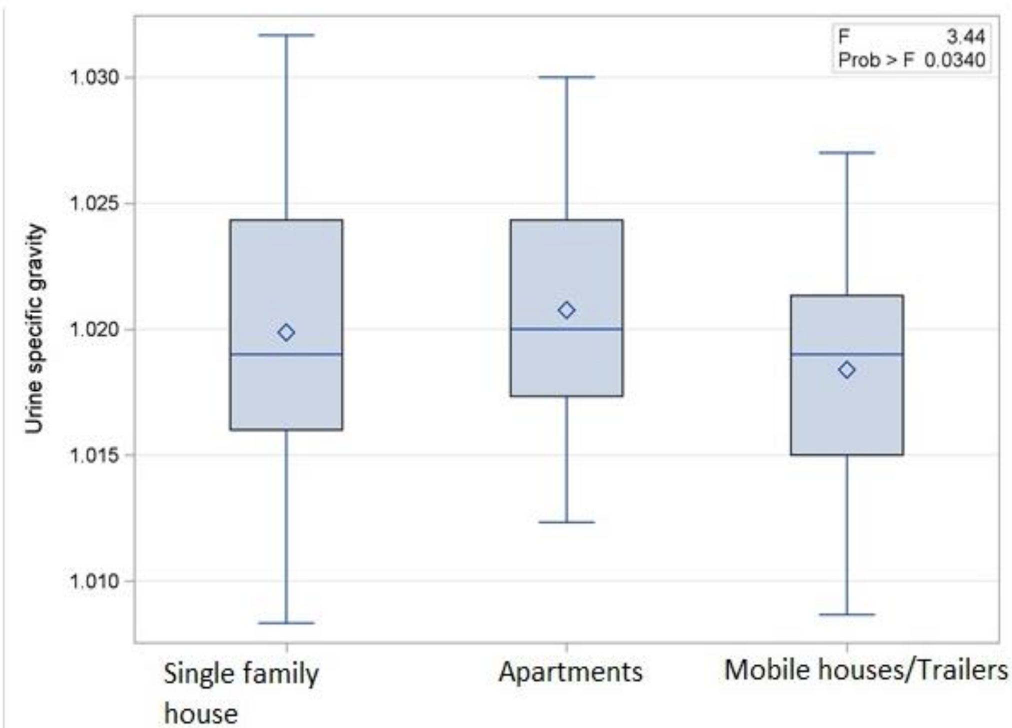


Figure 4. ANOVA output of urine specific gravity across different types of houses



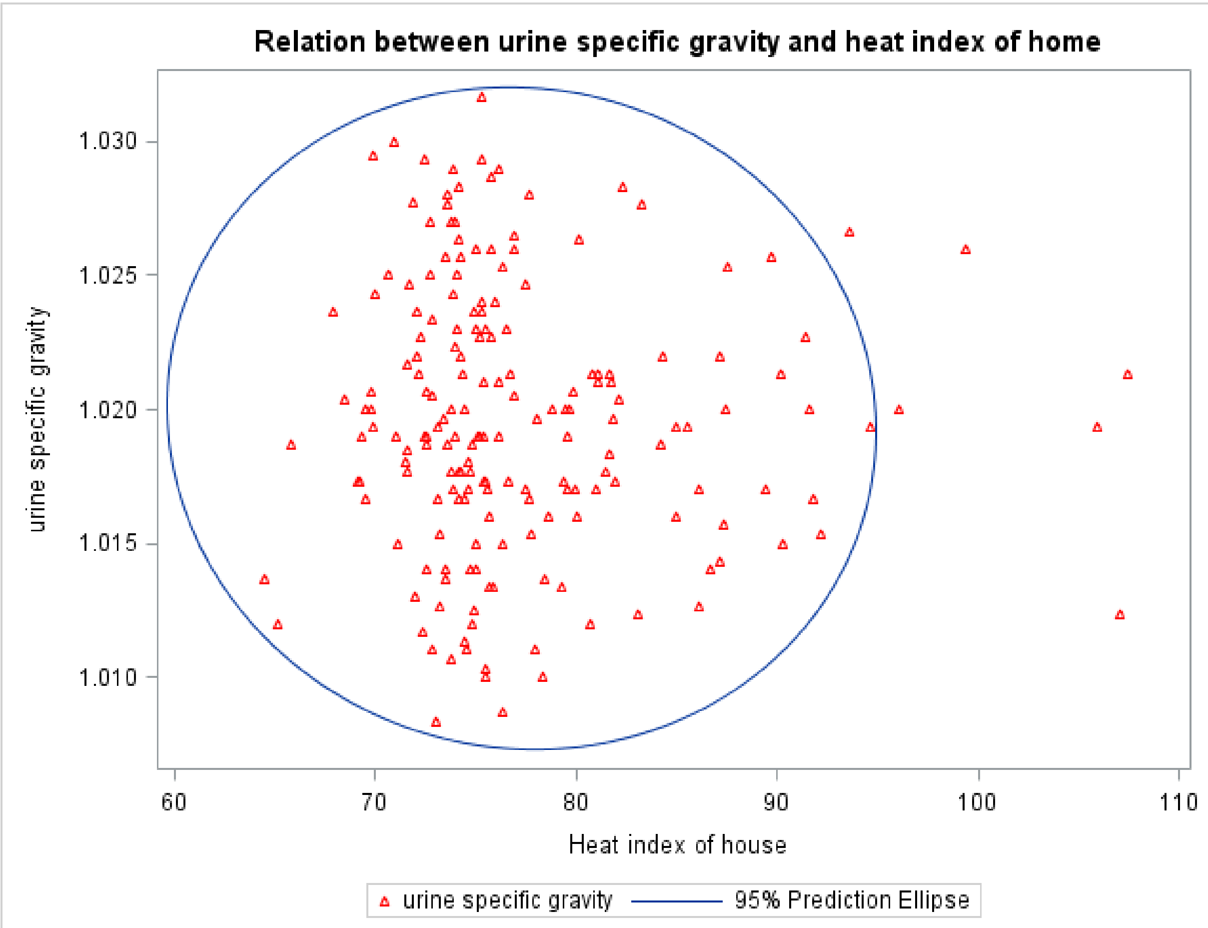
USG means across houses: Mean (SD)

Single family house – 1.020 (0.006)

Apartment – 1.021 (0.005)

Mobile home/Trailer – 1.018 (0.004)

Figure 5. Scatter plot between urine specific gravity and heat index



REFERENCES

Anderson, G. B., Bell, M. L., & Peng, R. D. (2013). Methods to calculate the heat index as an exposure metric in environmental health research. *Environ Health Perspect, 121*(10), 1111-1119. doi:10.1289/ehp.1206273

Atha, W. F. (2013). Heat related illness. *Emergency medicine clinics of North America, 31*(4). doi:https://doi.org/10.1016/j.emc.2013.07.012

Bethel, J. W., & Harger, R. (2014). Heat-related illness among Oregon farmworkers. *Int J Environ Res Public Health, 11*(9), 9273-9285. doi:10.3390/ijerph110909273

Budtz-Jorgensen, E., Keiding, N., Grandjean, P., & Weihe, P. (2007). Confounder selection in environmental epidemiology: assessment of health effects of prenatal mercury exposure. *Ann Epidemiol, 17*(1), 27-35. doi:10.1016/j.annepidem.2006.05.007

Chadha, V., Garg, U., & Alon, U. S. (2001). Measurement of urinary concentration: a critical appraisal of methodologies. *Pediatr Nephrol, 16*(4), 374-382.

Fullagar, H. H., Duffield, R., Skorski, S., Coutts, A. J., Julian, R., & Meyer, T. (2015). Sleep and Recovery in Team Sport: Current Sleep-Related Issues Facing Professional Team-Sport Athletes. *Int J Sports Physiol Perform, 10*(8), 950-957. doi:10.1123/ijspp.2014-0565

Glazer, J. (2005). Management of Heatstroke and Heat Exhaustion. *American family physician*(june 1 2005).

Hancock, P. A., & Vasmatzidis, I. (2003). Effects of heat stress on cognitive performance: the current state of knowledge. *iNTERNATINAL JOURNAL OF HYPERTHERMIA, 19*, 355-372.

Hanna, E. G., & Tait, P. W. (2015). Limitations to Thermoregulation and Acclimatization Challenge Human Adaptation to Global Warming. *Int J Environ Res Public Health, 12*(7), 8034-8074. doi:10.3390/ijerph120708034

Jackson, L. L., & Rosenberg, H. R. (2010). Preventing heat-related illness among agricultural workers. *J Agromedicine, 15*(3), 200-215. doi:10.1080/1059924X.2010.487021

Libert, J. P., Di Nisi, J., Fukuda, H., Muzet, A., Ehrhart, J., & Amoros, C. (1988). Effect of continuous heat exposure on sleep stages in humans. *Sleep, 11*(2), 195-209.

Logan-Sprenger, H. M., & Spriet, L. L. (2013). The acute effects of fluid intake on urine specific gravity and fluid retention in a mildly dehydrated state. *J Strength Cond Res, 27*(4), 1002-1008. doi:10.1519/JSC.0b013e31826052c7

Luber, G., & McGeehin, M. (2008). Climate change and extreme heat events. *Am J Prev Med, 35*(5), 429-435. doi:10.1016/j.amepre.2008.08.021

Mac, V. V. T., & McCauley, L. A. (2017). Farmworker Vulnerability to Heat Hazards: A Conceptual Framework. *J Nurs Scholarsh, 49*(6), 617-624. doi:10.1111/jnu.12327

Mathes, R. W., Ito, K., Lane, K., & Matte, T. D. (2017). Real-time surveillance of heat-related morbidity: Relation to excess mortality associated with extreme heat. *PLoS One, 12*(9), e0184364. doi:10.1371/journal.pone.0184364

MMWR. (2008). *Heat-related deaths among crop workers--United States, 1992--2006.* Retrieved from https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5724a1.htm

NCEH. (2011). *CLIMATE CHANGE and EXTREME HEAT EVENTS* Retrieved from https://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf

Nerbass, F. B., Pecoits-Filho, R., Clark, W. F., Sontrop, J. M., McIntyre, C. W., & Moist, L. (2017). Occupational Heat Stress and Kidney Health: From Farms to Factories. *Kidney Int Rep, 2*(6), 998-1008. doi:10.1016/j.ekir.2017.08.012

OSHA. Heat related illness and first aid. Retrieved from https://www.osha.gov/SLTC/heatstress/heat_illnesses.html
Quandt, S. A. (2015). Farmworker Housing in the United States and Its Impact on Health. *A Journal of Environmental and Occupational Health Policy* Retrieved from http://journals.sagepub.com.proxy.library.emory.edu/doi/pdf/10.1177/1048291115601053
Quandt, S. A., & Wiggins, M. F. (2013). Heat Index in Migrant Farmworker Housing: Implications for Rest and Recovery From Work-Related Heat Stress. . *American Journal of Public Health.* doi:10.2105/AJPH.2012.301135
Relf, R., Willmott, A., Mee, J., Gibson, O., Saunders, A., Hayes, M., & Maxwell, N. (2017). Females exposed to 24 h of sleep deprivation do not experience greater physiological strain, but do perceive heat illness symptoms more severely, during exercise-heat stres. *Journal of Sports Sciences*. doi:10.1080/02640414.2017.1306652
Scovronick, N., & Armstrong, B. (2012). The impact of housing type on temperature-related mortality in SouthAfrica,1996–2015. *Environmental research*. doi:10.1016/j.envres.2012.01.004
Wheaton, T. M. S. A. G. (2013 -2014). *Short Sleep Duration by Occupation Group — 29 States, 2013–2014*. Retrieved from https://www.cdc.gov/mmwr/volumes/66/wr/mm6608a2.htm
WHO. (2000). *Obesity: preventing and managing the global epidemic*: World Health Organization.