Kidney Function: Outdoor vs. Indoor Hispanic Agricultural Workers

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An abstract of

A thesis submitted to the Faculty of the

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Abstract

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There is a heightened risk of acute kidney injury (AKI) among farmworkers associated with dehydration and strenuous work. However, we are unaware of studies of renal function of agricultural workers that work in cold environments, such as in refrigerated packing houses. This study compares the rates of AKI, reduced estimated glomerular filtration rate (eGFR), dehydration, and heat-related illness (HRI) among agricultural workers in refrigerated (indoors) vs. non-refrigerated (outdoors) conditions in central Florida. We examined renal dysfunction indicators among Hispanic agricultural workers in Central Florida, comparing 67 outdoor farmworkers in January 2020 and 37 indoor farmworkers in January 2023. Data collection included demographics, health metrics, and urine and blood samples taken before and after a workday. Using REDCap, SAS 9.4, and RStudio for analysis, we applied Little's MCAR test to validate the randomness of missing data and employed six regression models, including Linear Quantile Mixed Modelling (LQMM) to evaluate the impact of being an indoor worker, incorporating variables like age, body mass index (BMI), blood pressure, and total beverage intake, with household clusters as a random intercept. Given that the data from the two cohorts were collected during the winter, we did not expect to see stark contrasts of AKI or other outcome indicators between the two groups. However, the indoor group exhibited higher rates of dehydration, lower eGFR, AKI, and symptoms of HRI. Since many workers were already dehydrated before starting work, there is also a need to strengthen training related to hydration habits. The observation that indoor workers in cool environments face similar issues to those working outdoors suggests that the root causes may extend beyond temperature exposure to broader working conditions and systemic issues in the workplace. This insight prompts a reevaluation of current occupational health paradigms and underscores the need for comprehensive strategies that address the multifaceted nature of workplace health risks.

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INTRODUCTION

Over the last few decades, with evidence dating back to the 1970s, the global research community has observed the troubling emergence of renal dysfunction, a phenomenon that poses significant health challenges worldwide[1–5]. The rise of renal dysfunction among farmworkers coincided alarmingly with an increase in extreme heat events, otherwise known as heat waves[2,6]. There are several regions worldwide that have reported heat-related kidney disease. For example, a distinct pattern of kidney disease, termed Mesoamerican Nephropathy (MeN) or Chronic Kidney Disease (CKD) of unknown etiology (CKDu), has emerged among young male workers in industries such as sugarcane, cotton, corn farming, construction, mining, and others in El Salvador, Costa Rica, Nicaragua, Guatemala, and Mexico[2,4,7,8]. In the regions of Sri Lanka and the Uddanam Costal Region of India, CKDu has predominantly affected male farmworkers engaged in rice, cashew, and coconut cultivation, with a similar age range to those in Central America[1,2,9,10]. Furthermore, in Mesoamerica, Sri Lanka, and the Uddanam Costal Region of India, many of the farmworkers afflicted with CKDu lack traditional CKD risk factors, such as diabetes and hypertension. In Florida and California, cross-sectional studies indicate a heightened risk of acute kidney injury (AKI) among farmworkers[10–12]. In California's Central Valley, research found significant pre- to post-work shifts in serum creatinine levels, with heat strain and piece rate work linked to AKI[12]. A study of farmworkers in Florida reported that for every 5-degree Fahrenheit increase in heat index, the odds of AKI increased by 47%[11]. These findings underscore the increasing vulnerability of farmworkers to heat-related kidney disease amid rising global temperatures. A meta-analysis of heat strain that included diverse populations, exposures, and occupations found a 15% incidence of AKI or kidney diseases among those who worked in high ambient temperatures for a minimum of 6 hours per day, 5 days per week, for 2 months of the year[13].

Studies indicate that recurrent exposure to heat, combined with physical exertion and insufficient hydration, is associated with heat-related kidney disease that is independent of other factors such as diabetes or hypertension[1]. An alternative hypothesis, particularly in regions like Sri Lanka and El Salvador, suggests a link between CKDu and agrochemicals rather than heat stress[9,10]. This theory emerged from observations of CKDu in individuals not engaged in intensive agricultural labor and the absence of the disease in northern Sri Lanka, where agrochemical use is minimal[9,10]. However, this hypothesis faces contradictions, such as the low levels of agrochemicals in Sri Lankan wells and the higher incidence of CKDu among sugarcane cutters compared to pesticide applicators[1,2,14].

Dehydration, which is often prevalent among farmworkers is another factor thought to play a crucial role in both CKDu and AKI[2]. This hypothesis centers around recurrent volume depletion during work shifts[4]. In a study on rats, recurrent dehydration resulted in hyperosmolarity of both plasma and urine with stimulation of vasopressin levels, which in turn resulted in renal injury and oxidative stress[4]. Recurrent dehydration might also cause renal injury through a fructokinase-dependent mechanism, possibly due to endogenous fructose generation via the polyol pathway[1,15]. Dehydration's impact can be compounded by factors like NSAID (non-steroidal anti-inflammatory drugs) use[7]. Additionally, elevated serum creatinine levels, heightened body temperature, and insufficient fluid consumption indicate that AKI may be a consequence of recurrent dehydration and intensive labor in high-temperature conditions [1,3,15]. Dehydration, particularly through sweat and heat, activates vasopressin release, which has been recently recognized as a potential mediator of chronic kidney disease[1,15]. It can also increase serum osmolarity and activate aldose reductase, leading to fructose generation in the proximal tubule, causing tubular injury and inflammation[15–17].

Although research has established exposure to high ambient temperature as a risk factor associated with AKI, we are unaware of studies of renal function of agricultural workers that have physically demanding jobs that work in cold environments, such as refrigerated packing houses. This study aimed to identify if agricultural workers laboring in refrigerated conditions differ from similar workers in non-refrigerated conditions in their risk of AKI, reduced eGFR, dehydration, and heat-related illness symptoms.

METHODS

Study Design

This study was approved by the Institutional Review Board of Emory University (IRB00112681), and informed consent was obtained. The cohort consisting of outdoor agricultural workers was a subset of workers recruited for a longitudinal study in Central Florida in January 2020; these workers were primarily plant nursery workers. For the cohort consisting of indoor agricultural workers, a convenience sample of 37 agricultural workers engaged in work within a refrigerated environment in the same community in January 2023; these workers were mainly vegetable packing farmworkers. Both studies were run in cooperation with the Florida Farmworkers Association (FWAF) and employed the same research methods, including biomonitoring and sample collection, as those utilized in our previous studies with heat-exposed agricultural workers in Florida[18,19]. Criteria excluded individuals who were currently pregnant, diagnosed with hypertension, diagnosed with type I or II diabetes mellitus, or diagnosed with renal disease. The study was limited to workers ages 18-49 to minimize some of the confounding or influence on AKI due to age.

Data Collection

On the first visit, participants were orally queried in the participant's primary language for basic demographics, which included the following: age at visit (in years), sex (male or female), marital status (married/coupled or single), education level (in years), nationality, indigenous status (yes or no), whether the participant spoke English, whether the participant spoke Spanish, age that the participant started agricultural work, and the number of years that the participant worked in Southern agriculture (Florida and neighboring states). Some participants lived in the same household or were relatives, representing data clustering; this information was collected and adjusted for during data analysis. Participants' body mass index (BMI), body fat percentage, blood pressure, and HbA1C percentage were also collected. Body fat percentage was measured by a handheld bioelectrical impedance analysis device. Measured height and weight were used to calculate BMI. HbA1c levels were assessed using the A1CNow® system which involved collecting a capillary blood sample[20,21]. A participant with an A1C percentage greater than or equal to 5.7 was considered to be in the diabetic or pre-diabetic range.

After taking the aforementioned baseline measurements, these agricultural workers were then followed for one workday. Participants were seen before and after their work shift at the local FWAF office. Urine and blood samples were collected at those times. Urine specific gravity (USG) was measured using an automatic digital refractometer, the Atago PAL-10S[22]. A participant was considered dehydrated if their USG was ≥1.020. Creatinine was measured using an iStat® Blood Analyzer with a Chem8+ cartridge[23] and eGFR was calculated using the 2021CKD-EPI Creatinine Equation[24] as recommended for U.S. adults by the joint National Kidney Foundation/American Society of Nephrology Task Force. The definition of AKI was based on the KDIGO criteria[25]: an increase in creatinine ≥0.3 mg/dL or an increase in creatinine ≥1.5 times.

At the end of the workday participants were queried about working conditions and hydration habits that day, including the following: HRI symptoms (sweating, dizziness, headache, nausea, confusion, fainting, cramps, or dysuria), number of times urinated at work, duration of lunch break, number of additional breaks, hours worked, and beverage consumption. The beverage survey included specific questions on type (water, coffee, tea, juice, sports drinks, soda, diet soda, energy drinks, and alcohol) and amount (visually aided by props of various sizes); total consumption and total sugary drink consumption were calculated. Additionally, participants were equipped with a wearable Zephyr™ chest strap heart rate monitor that recorded heart rate (bpm) and physical activity (vector magnitude units, g) every 30 seconds[26]. Median heart rate and mean physical activity were calculated for the workday.

A median heat index for each participant's work hours was calculated using data from the Florida Automatic Weather Network (FAWN)[27] monitoring station located in the area the participants were working; it was calculated using the Lu and Romps extended heat index (HI) algorithm based on ambient temperature and relative humidity[28].

Clinical and questionnaire data were collected in the Research Electronic Data Capture (REDCap) system[29].

Statistical Analysis

Summary statistics were calculated for demographics, work habits, HRI symptoms, clinical biomarkers, and renal biomarkers by calculating the median, along with quartiles and standard deviations, stratified by the indoor and outdoor groups. Missingness was tested using Little's MCAR test[30]; data was determined to be missing completely at random (d^2=98.6, df=105, p=0.658, alpha=0.05). Missing data were not imputed due to the low number of participants and a small percentage of missing data; since data was determined to be MCAR, estimates would not be biased[31].

To address the question of whether indoor agricultural workers have different indicators of renal dysfunction compared to outdoor workers, six regression models were applied. Our outcome variables were presence of AKI, morning eGFR, afternoon eGFR, change in eGFR between morning and afternoon, afternoon urine specific gravity, and presence of serious HRI symptoms. Serious HRI symptoms were the following: Headaches, nausea, confusion, dizziness, fainting, cramps, and dysuria. Our main predictor variable in all models was the heat exposure group (referent = outdoor group). Covariates that may have been clinically relevant confounders were selected *a priori*: centered age, sex, centered BMI, centered median heartrate, centered mean activity score, blood pressure (normal/elevated/high), and a dichotomized A1C variable (nondiabetic or diabetic/pre-diabetic). Models contained a random intercept term for household clusters, as warranted. After observing different beverage intake habits across groups, we also adjusted for total beverage intake *a posteriori*.

The outcome AKI was modelled using a logistic mixed regression analysis. Due to the limited occurrences of AKI within the dataset, we refrained from incorporating the covariates to maintain model integrity and focus. A random intercept for household clusters was offered but dropped as the intraclass correlation coefficient was zero.

Models for morning eGFR, afternoon eGFR, the change in eGFR (afternoon minus morning), and afternoon urine specific gravity (USG) utilized linear quantile mixed modelling (LQMM) to examine the estimated 25th percentile, median, and 75th percentile. The R package LQMM utilizes the asymmetric Laplace (AL) distribution likelihood and is closely associated with the L1-norm objective function[32–34]. We also chose to employ LQMM based on its handling of heteroscedasticity, as LQMM does not assume constant variance across the levels of the predictor variable, and variances can vary across quantiles[34]. The full list of predictors (heat-exposure and all covariates) was included. A check was run for multicollinearity, assessed by variance inflation factors (VIFs), but no multicollinearity was evident.

The sixth model was a logistic mixed regression analysis with presence of serious HRI symptoms as the dependent variable, and independent variables including the main predictor and all covariates. A random intercept for household clusters was offered but dropped as the intraclass correlation coefficient was zero. Logit linearity was checked through scatter plots, and influential values were checked through Cook's distance.

All data were prepared for analysis in SAS® 9.4, and tables, figures, and analyses were conducted in R version 4.2.0[35,36]. Statistical significance was evaluated using alpha=0.05.

RESULTS

Cohorts for the outdoor vs. indoor groups had different demographics. While their ages were similar, with median ages at 38 and 41 years old respectively, the indoor group had more males than the outdoor group; 16% of the outdoor group were male, while 59% of the indoor group were male [Table 1]. Additionally, educational attainment differed across groups; 79% of the outdoor group had less than 12 years of education, while only 11% of the indoor group had less than 12 years of education. Marital status, nationality, and indigenous status differed across groups; the outdoor group mainly came from Guatemala and Mexico and were married and/or indigenous, while the indoor group mainly came from Venezuela and were not married nor indigenous. The median BMIs were similar(28 v 26) as were median body fat percentage (males: 24% v 22%; females: 34% v 31%). The indoor group had about twice the rate of elevated blood pressure than did the outdoor. A1C Level was not different across groups. The outdoor group had worked fewer years in agriculture overall.

During the workday, participants reported working around 9 hours for both groups, and the median heat index for the outdoor group was 65 degrees Fahrenheit [Table 2]. Both groups also had similar median heart rates (91 v 95 bpm). However, the indoor group took fewer work breaks, with 3% taking more than one work break versus 69% in the outdoor group. They also drank less water, with a median of 16 ounces compared to the outdoor group's median of 32 ounces. More of the indoor group also reported drinking sugary drinks (59% compared to 38% in the outdoor group).

Both the outdoor and indoor groups had similar rates of AKI, with the outdoor at 10% and the indoor at 17% [Table 3]. However, the indoor group reported overall more serious symptoms of HRI, with 19% reporting two or more symptoms compared to the outdoor group's 2%. Individual symptoms were reported as follows: Confusion: 0% vs. 2%; cramps: 19% vs. 5%; dizziness: 14% vs. 9%; dysuria: 3% vs. 0%; fainting: 0% vs. 2%; headaches: 14% vs. 23%; and nausea: 8% vs. 0%. The outdoor and indoor groups had similar levels of eGFR in both the morning and post-workday; morning median eGFRs were

121.2 and 119.0 respectively, and afternoon eGFRs were 116.8 and 111.3 respectively. However, the indoor group had much higher rates of dehydration, especially in the morning, than the outdoor group (54% v 30%). In the afternoon, 42% of the indoor group was dehydrated compared to 28% of the outdoor group.

In a generalized mixed model, the indoor group did not have significantly different odds of AKI compared to the outdoor group (OR = 1.8, 95% CI: (0.6, 6.7)) [Table 4]. They also did not have significantly different odds of serious HRI symptom occurrence, even when accounting for total beverage intake (OR = 0.41, 95% CI: (0.09, 1.64)).

The indoor group was significantly associated with lower in AM eGFR for only the 25th percentile (-6.2; 95% CI: (-11.3, -1.2)) [Table 5]. The indoor group was also significantly associated with approximately 10 units lower PM eGFR for all quantiles compared to the outdoor group when adjusting for total beverage intake. When examining the change in eGFR from PM-AM, at the 25th percentile, the indoor group was associated with a -10.7 overall larger gap compared to the outdoor group (95% CI: -20.1, -1.4); however, this change was rendered non-significant once adjusting for total beverage intake (6.5; 95% CI: (-13.8, 0.9)). Finally, afternoon USG was significantly higher in the indoor group at all quantiles even after adjusting for beverage consumption (0.007; 95% CI: (0.008, 0.013)).

DISCUSSION

Given that the data from the two cohorts —indoor and outdoor—were collected during the winter, we did not expect higher rates of AKI, lower EGFR, and dehydration in the indoor agricultural workers. It is notable that in these cool working environments both groups exhibited low rates of AKI and the indoor group exhibited much higher rates of dehydration and reported serious symptoms HRI more frequently.

These paradoxical findings suggest that behaviors such as water intake and taking work breaks—more common in the outdoor group—might mitigate some risks associated with heat exposure. The indoor group's tendency to consume more sugary drinks and take fewer breaks could also have contributed to their higher dehydration rates and HRI symptoms.

Since many workers were already dehydrated before starting work, there is a need to strengthen training related to hydration habits. Previous research has already shown that workers are already dehydrated before starting work[37]. This is again demonstrated through the median total beverage intake for the day in indoor workers, which was 16 ounces—far below the recommended amount of 104 ounces and 72 ounces for healthy men and women respectively[38]. Part of this may be due to a large portion of workers reporting that they were not thirsty due to working in a cool refrigerated environment. Anecdotally, workers reported that they refrained from drinking fluids because it increased the need to void. Workers expressed that they were often reprimanded for using the restroom too much. Additionally, 59% of the indoor participants drank sugary drinks during their shifts, which is consistent with the current notion that agricultural workers try to rehydrate using sugary drinks and that such habits may exacerbate dehydration and dehydration-associated renal injury[39].

Our study is subject to weaknesses. Our indoor worker sample is small, and given the low number of occurrences of AKI, our analysis is constrained by limited statistical power. By choosing not to impute missing data, we also compromise on some of the statistical power of our analysis. Additionally, only two types of agricultural work were examined: plant nursery work and vegetable packing work. Furthermore, conducting multiple comparisons elevates the risk of identifying statistically significant but spurious correlations. Given the ethical constraints, we were compelled to utilize a convenience sample, as it would be unethical to subject individuals to heat or poor working conditions intentionally. Some data was lost due to equipment malfunctions.

However, our study also has several strengths. We excluded individuals with diagnosed hypertension and diabetes, two risk factors for AKI, minimizing potentially confounding variables. Additionally, we adjusted for further confounding in our statistical models. To the best of our knowledge, this study represents the inaugural effort to examine kidney dysfunction among agricultural workers in refrigerated environments and to contrast their experiences with those of their counterparts working outdoors in the same community.

Our findings open up several avenues for future research, particularly in the context of heat exposure and its effect on worker health. The observation that indoor workers in cool environments face similar issues to those working outdoors, even during winter, suggests that the root causes may extend beyond temperature exposure to broader working conditions and systemic issues in the workplace. This insight prompts a reevaluation of current occupational health paradigms and underscores the need for comprehensive strategies that address the multifaceted nature of workplace health risks.

TABLES

Table 1. Demographic Characteristics of Heat-Exposed and Non-Exposed Agricultural Workers, Winter

	Heat Exposure	
Characteristic	**Exposed**, N = 67[1]	**Not Exposed**, N = 37[1]
Age at Visit	38 (33, 43)	41 (29, 46)
Male	16% (11)	59% (22)
Married/Coupled	60% (40)	30% (11)
Education <12 years	79% (52)	11% (4)
Nationality		
Colombia	0% (0)	14% (5)
Guatemala	24% (16)	0% (0)
Mexico	57% (38)	0% (0)
Other	19% (13)	32% (12)
Venezuela	0% (0)	54% (20)
Indigenous	63% (42)	5% (2)
Body Mass Index (BMI)	28 (25, 32)	26 (24, 29)
BMI Category		
Underweight	1% (1)	3% (1)
Normal Weight	27% (18)	30% (11)
Overweight	37% (25)	54% (20)
Obese	34% (23)	14% (5)
Body Fat Percentage		
Male	24% (11)	22% (22)
Female	34% (56)	31% (15)
Blood Pressure Normal/Elevated/High		
<120/80	55% (37)	27% (10)
120-139 or 80-89	33% (22)	38% (14)
140+ or 90+	12% (8)	35% (13)
Diabetic or Prediabetic	21% (14)	17% (6)
Speaks English	1% (1)	8% (3)
Speaks Spanish	91% (61)	100% (37)
Age Started Agricultural Work	21 (16, 29)	33 (25, 42)
Years in Southern Agriculture	5 (2, 13)	1 (1, 1)

[1]Median (IQR); % (n)

Table 2. Work Conditions and Habits of Heat-Exposed and Non-Exposed Agricultural Workers, Winter

	Heat Exposure	
Characteristic	**Exposed**, N = 67[1]	**Not Exposed**, N = 37[1]
Hours Worked	9 (9, 10)	9 (8, 11)
Median Heat Index (Fahrenheit)	65 (58, 72)	NA
Median Heart Rate (Beats per Minute)	91 (85, 100)	95 (90, 102)
Mean Activity Score (VMU[2])	0.113 (0.090, 0.134)	0.104 (0.082, 0.125)
Duration of Lunch Break		
5-15 minutes	6% (4)	8% (3)
20-25 minutes	0% (0)	3% (1)
30 minutes	78% (51)	81% (30)
40-50 minutes	5% (3)	0% (0)
60+ minutes	9% (6)	3% (1)
No Lunch Break	2% (1)	5% (2)
Additional Break		
No Additional Breaks	0% (0)	14% (5)
One	31% (20)	84% (31)
Two	23% (15)	3% (1)
Three or More	46% (30)	0% (0)
Number of Times Urinated While at Work		
1	0% (0)	3% (1)
2	12% (8)	3% (1)
3	20% (13)	27% (10)
4	38% (25)	32% (12)
5	17% (11)	30% (11)
6	5% (3)	3% (1)
7	8% (5)	3% (1)
Total Water (oz)	32 (16, 48)	16 (16, 32)
Reported Drinking Sugary Drinks	38% (25)	59% (22)
Total Beverages (oz)	40 (24, 64)	34 (28, 48)

[1]Median (IQR); % (n)

[2]Vector Magnitude Units, where 0.20 is equivalent to walking during the whole workday.

Table 3. Kidney Injury Measurements, HRI Symptoms, and Dehydration of Heat-Exposed and Non-Exposed Agricultural Workers, Winter

	Heat Exposure	
Characteristic	**Indoor**, N = 37[1]	**Outdoor**, N = 67[1]
Presence of Acute Kidney Injury (AKI)	17% (6)	10% (6)
Missing	2	6
HRI Symptom: Confusion	0% (0)	2% (1)
Missing	0	2
HRI Symptom: Cramps	19% (7)	5% (3)
Missing	0	2
HRI Symptom: Dizziness	14% (5)	9% (6)
Missing	0	2
HRI Symptom: Dysuria	3% (1)	0% (0)
Missing	0	2
HRI Symptom: Fainting	0% (0)	2% (1)
Missing	0	2
HRI Symptom: Headaches	14% (5)	23% (15)
Missing	0	2
HRI Symptom: Nausea	8% (3)	0% (0)
Missing	0	2
Total Symptoms		
0	68% (25)	66% (44)
1	14% (5)	31% (21)
2	14% (5)	1% (1)
3	5% (2)	1% (1)
eGFR (AM)	119.0 (105.9, 128.3)	121.2 (117.1, 128.1)
Missing	0	6
eGFR (PM)	111.3 (92.0, 126.9)	116.8 (112.0, 124.5)
Missing	2	2
Difference in eGFR (PM - AM)	-5.9 (-12.5, 0.0)	0.0 (-6.5, 0.0)
Missing	2	6
Creatinine (AM)	0.7 (0.5, 0.8)	0.5 (0.5, 0.6)
Missing	0	6
Creatinine (PM)	0.8 (0.6, 0.9)	0.6 (0.5, 0.8)
Missing	2	2
Difference in Creatinine (PM - AM)	0.1 (0.0, 0.2)	0.0 (0.0, 0.1)
Missing	2	6
Urine Specific Gravity (AM)	1.022 (1.016, 1.023)	1.016 (1.012, 1.022)
Missing	0	4
Urine Specific Gravity (PM)	1.020 (1.017, 1.024)	1.012 (1.004, 1.021)
Missing	1	7
Difference in Urine Specific Gravity (PM - AM)	0.000 (-0.004, 0.003)	-0.001 (-0.011, 0.004)
Missing	1	8
Dehydrated (AM)	54% (20)	30% (19)
Missing	0	4
Dehydrated (PM)	42% (15)	28% (17)
Missing	1	7

[1]% (n); Median (IQR)

Table 4. Association of AKI and HRI Symptoms with Indoor-Outdoor Status During Agricultural Work, Estimated Using a Generalized Mixed Model[1]

Outcome	Variable	Adjusts for total beverages	Estimate (Lower CI, Upper CI)	P-value
AKI	Intercept	No	-2.2 (-3.2, -1.5)	<0.001
	Estimate		0.6 (-0.6, 1.9)	0.30
HRI Symptoms	Intercept	Yes	-0.5 (-2.5, 1.5)	0.64
	Estimate		-1.0 (-2.6, 0.4)	0.17
HRI Symptoms	Intercept	No	-0.9 (-2.7, 0.8)	0.31
	Estimate		-0.9 (-2.4, 0.5)	0.23

[1] Reference Group = Outdoor Group; Estimate = Indoor Group

Table 5. Association of eGFR and USG Measurements with Indoor-Outdoor Status During Agricultural Work, Estimated Using LQMM[1]

			25th Percentile		50th Percentile		75th Percentile	
Outcome	**Variable**	**Adjusts for total beverages**	**Estimate (Lower CI, Upper CI)**	**P-value**	**Estimate (Lower CI, Upper CI)**	**P-value**	**Estimate (Lower CI, Upper CI)**	**P-value**
AM eGFR	Intercept	No	116.3 (112.2, 120.3)	<0.001	119.4 (115.5, 123.3)	<0.001	122.3 (118.5, 126.1)	<0.001
	Estimate		**-6.2 (-11.3, -1.2)**	**0.017**	-2.6 (-6.6, 1.4)	0.20	-2.5 (-5.9, 0.97)	0.15
PM eGFR	Intercept	Yes	107.8 (97.7, 117.8)	<0.001	107.8 (97.8, 117.8)	<0.001	107.8 (97.8, 117.8)	<0.001
	Estimate		**-9.8 (-18.3, -1.1)**	**0.028**	**-9.7 (-18.3, -1.2)**	**0.028**	**-9.7 (-18.4, -1.0)**	**0.029**
	Intercept	No	105.5 (96.7, 114.3)	<0.001	111.0 (102.8, 119.1)	<0.001	116.5 (108.8, 124.2)	<0.001
	Estimate		**-14.9 (-23.5, -6.3)**	**0.0011**	-6.9 (-14.7, 1.0)	0.086	**-7.6 (-14.4, -0.8)**	**0.030**
Change eGFR (PM – AM)	Intercept	Yes	-9.2 (-16.7, -1.8)	0.016	-9.1 (-16.5, -1.6)	0.019	-9.0 (-16.5, -1.6)	0.018
	Estimate		6.5 (-13.8, 0.9)	0.083	-6.4, (-13.7, 1.0)	0.088	-6.4 (-13.7, 1.0)	0.088
	Intercept	No	-14.7 (-23.3, -6.1)	0.0012	7.7 (-15.9, 0.45)	0.063	-5.7 (-14.1, 2.8)	0.18
	Estimate		**-10.7 (-20.1, -1.4)**	**0.026**	-4.3 (-13.8, 5.2)	0.37	-3.4 (-11.7, 4.9)	0.41
PM USG	Intercept	Yes	1.018 (1.006, 1.029)	<0.001	1.018 (1.006, 1.029)	<0.001	1.018 (1.006, 1.029)	<0.001
	Estimate		**7.024 e-3 (7.929 e-3, 0.013)**	**0.028**	**7.027e-3 (7.922e-3, 0.013)**	**0.028**	**7.025e-3 (7.914e-3, 0.013)**	**0.028**
	Intercept	No	1.010 (1.000, 1.020)	<0.001	1.016 (0.002, 0.014)	<0.001	1.019 (1.008, 1.029)	<0.001
	Estimate		**0.011 (0.005, 0.017)**	**<0.001**	**0.008 (0.002, 0.014)**	**0.008**	**7.673e-03 (1.601e-3, 0.014)**	**0.014**

[1] Reference Group = Outdoor Group; Estimate = Indoor Group

FIGURES

Figure 1. Total Beverage Consumption vs. Indoor-Outdoor Status During Agricultural Work

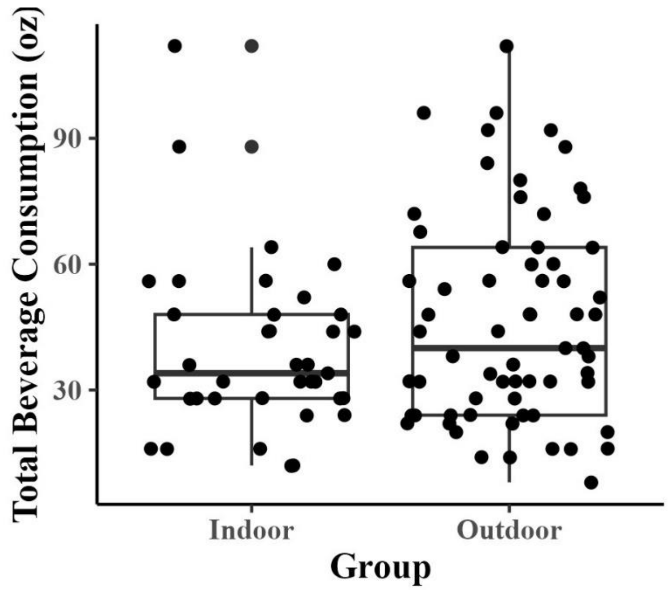
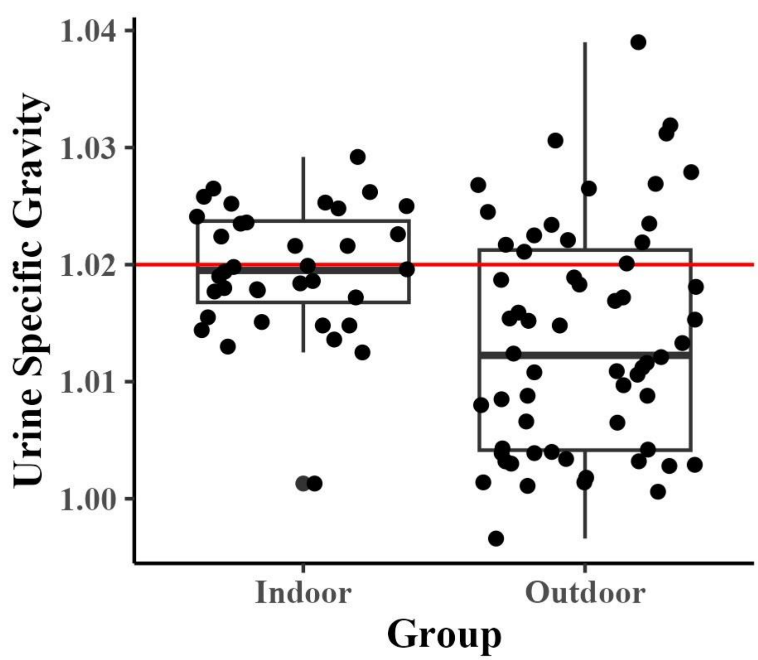


Figure 2. Afternoon Urine Specific Gravity (USG) vs. Indoor-Outdoor Status During Agricultural Work; Red Line >= 1.020 is Dehydrated



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