



The Health Status of Hispanic Agricultural Workers in Georgia and Florida

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Abstract

To examine the health status of Hispanic agricultural workers in Florida and Georgia. Health data from agricultural workers in the Farm Worker Family Health Program (June 2019) and research studies in Florida (May 2015 and May 2019) were examined. Data from 728 agricultural workers were collected through sociodemographic questionnaire and clinical data. In the Florida sample, 83% were overweight or obese, 70% elevated blood pressure, 60% met the definition of prediabetes. In Georgia, 64% were overweight or obese and 67% had elevated blood pressure. Weak correlations were observed between BMI and systolic blood pressure (unadjusted $r=0.20$), diastolic blood pressure (unadjusted $r=0.19$), and glucose (unadjusted $r=0.14$). Adjusting for age and gender did not show statistically significant correlation between BMI and systolic and diastolic blood pressure or glucose. While BMI has been shown to be strongly associated with high blood pressure and impaired glucose, we found a weak correlation among agricultural workers. Given the common and high use of pesticides and elevated rates of hypertension, impaired glucose, and adiposity in agricultural workers, the public health impact of this relationship may require and lead to occupational reform that protects the health of agricultural workers. Future studies should assess occupational and environmental factors and lifestyle differences between agricultural workers and the general population to better understand these discrepancies in health status.

Keywords Agricultural workers · Health · Chronic conditions · Environmental health · Occupational

The health of immigrant workers has been identified as a global priority [1, 2]. The U.S. agricultural work force is comprised primarily of Hispanic immigrant workers [3]. The latest National Agricultural Workers Survey (NAWS) from 2015–2016 [4] reported that agricultural workers have limited English proficiency, an 8th grade average education level, an average annual income of \$17,500, and are

comprised predominately (69%) of immigrant workers born in Mexico, which are all social determinants of health factors that contribute to the poor health [3]. National measures passed in 2010 such as the Healthy People 2020 prevention agenda and the Patient Protection and Affordable Care Act (ACA) which broadened health insurance coverage, have improved national health outcomes [5], but agricultural workers continue to have increased risk of premature death and morbidity. They remain uniquely vulnerable to injury [6], fatality related to weather conditions [7], precarious worksites [8, 9], lack of access to health care and other work-related benefits [9], and lack of regulatory protections provided to workers in other industries [10, 11]. The combination of occupational risks and underlying health conditions contributes to the vulnerability of this population [12].

Studies on the *health status* of agricultural workers have most often focused on occupational injuries [6], pesticide exposure [10], heat-related illness (HRI) [13], dermatological conditions [14], and, more recently, renal dysfunction [15]. While not negating the need to address workplace

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hazards, in the past decade The National Institute for Occupational Health and Safety (NIOSH) adopted a *Total Worker Health* [16] approach that recognizes how worker safety, health, and well-being are interrelated and that occupation is often a social determinant of health. The conditions in which people work, along with underlying health problems, predict health outcomes. For example, links have been found between work-related risk factors and underlying health conditions such as obesity [17, 18], sleep disorders [19], cardiovascular disease [20], depression [21, 22], and other health conditions. Slimi et al. conducted a literature review of the health issues experienced by temporary agricultural workers in Canada, summarizing that mental health, occupational health, poor housing and sanitation, and barriers to accessing healthcare including fear of deportation and language barriers are the most compelling concerns [23]. Others have described the impact of infectious disease and psychosocial factors in migrant populations [24].

The southeastern region of the U.S. is home to a large proportion of the nation's agricultural production. The agricultural workforce consists of settled workers and temporary workers employed through the H-2A federal visa program. It is estimated that the state of Florida has more than 100,000 agricultural workers [25], while Georgia has an estimated 50,000 agricultural workers [26]. In 2019, Florida and Georgia were the top two states with H-2A workers: 33,598 and 29,480, respectively [27]. This study examined the health status of Hispanic immigrant agricultural workers in Florida and Georgia.

Methods

Study Design and Samples

Florida

In Florida, agricultural workers were recruited as part of the *Girasoles* (Sunflower) Study, a collaborative community-based research project by Emory University and the Farmworker Association of Florida (FWAF) between May 2015 and May 2019 that examined the physiological responses to heat stress. A trained bilingual field team from the FWAF recruited a convenience sample from five agricultural communities. Workers were eligible to participate if they were between 18 and 54 years of age, had been working in the agricultural industry for at least four weeks, did not have a history of type 1 diabetes, and were not pregnant. The *Girasoles* study excluded type 1 diabetes to protect from confounding due to metabolic predispositions to heat stress. The core body temperature sensor that participants swallowed was contraindicated during pregnancy. In addition, 63 workers participated in a pilot study that studied kidney function,

which excluded individuals with type 2 diabetes due to the interplay with kidney function. Informed consent and oral questionnaires were administered in Spanish. Demographic and clinical physical measurements were recorded at participants' initial visits on a non-workday, and blood work was performed before participants went to work.

Participants provided information on gender, age, nationality, educational level, and personal history of diagnosed hypertension or type 2 diabetes mellitus. Clinical research staff measured weight and height to calculate body mass index (BMI) using the formula $BMI = (kg/m^2)$ and used calipers to estimate body fat. BMI was classified [28] as: underweight (< 18.5), normal weight ($18.5 - < 25$), overweight ($25 - < 30$), and obese (≥ 30). A blood sample was drawn using a micro lancet to measure serum glucose, creatinine, hematocrit, and hemoglobin (iSTAT®, Abbott, Princeton, NJ). Serum glucose was reported for those reporting they had fasted in the previous 8 h and was categorized as normal (< 100 mg/dL), impaired ($100 - 125$), diabetic (≥ 126) [29]. Blood pressure measurements are from one-time point. Blood pressure was characterized [30] as: Normal: Less than 120/80 mm Hg; Elevated: Systolic between 120 and 129 and diastolic less than 80; Stage 1: Systolic between 130 and 139 or diastolic between 80 and 89; Stage 2: Systolic at least 140 or diastolic at least 90 mm Hg; Hypertensive crisis: Systolic over 180 and/or diastolic over 120. Detailed recruitment and data collection methods are described elsewhere [31, 32]. The Emory University Institutional Review Board (#IRB00075192) approved this study.

Georgia

In Georgia, agricultural worker data were collected as a part of the Farm Worker Family Health Program (FWFHP), a partnership between Emory University and Ellenton Farmworker Clinic. FWFHP is a nursing-led clinical service opportunity for pre-licensure and post-licensure students. Data were collected over a two-week period in June 2019 as part of the episodic mobile clinic. Each participant's data was recorded on a single visit; age, gender, nationality, height, weight, and blood pressure were measured on all clinic clients. Nursing students measured height and weight and calculated BMI. The same methods used in the *Girasoles* cohort were used to categorize BMI and blood pressure for this cohort.

Data Analysis

Descriptive statistics were reported as mean and standard deviation (SD) and percent and sample size. Pearson correlation coefficients were calculated to evaluate linear relationships among variables. Analyses were performed using SAS® 9.4 software [SAS Institute Inc., Cary, NC, USA].

Results

The health statuses of the two separate but comparable agricultural worker cohorts are presented in Table 1.

Florida

The Florida cohort comprises data from 301 agricultural workers. The mean age of workers was 39 (SD 8.7), 37% were male, 74% listed Mexico as their country of origin, and the mean years of education was 6.5 (SD 3.4; Table 1). Of those with self-reported diagnoses, 9% had a previous diagnosis of hypertension, and 7% had a previous diagnosis of type 2 diabetes mellitus. Only 16% of the workers were found to have a normal weight, < 1% underweight, 46% overweight, and 38% obese.

The mean serum blood urea nitrogen (BUN) was 14.2 mg/dL (SD 4.7), the mean serum creatinine was 0.6 mg/dL (SD 0.2), and the mean serum hemoglobin was 14.2 g/dL (SD 1.5). Fasting serum glucose was measured on 199 of the participants. According to the American Diabetes Association guidelines, [33] only 23% of workers had a normal fasting serum glucose, 60% classified as impaired, and 17% classified as diabetic (Table 1).

The mean resting pulse rate was 70 bpm (SD 11). For those under 40 years of age, following the American College of Cardiology/American Heart Association's blood pressure guidelines, only 40% had a normal blood pressure. Fifteen percent were found to have elevated blood pressure, 30% were found to have stage 1 hypertension, 16% were found to have stage 2 hypertension, and 0% were found to be in hypertensive crisis (Table 1). For those 40 years of age or older, only 21% were found to have normal blood pressure. Nineteen percent were found to have elevated blood pressure, 31% were found to have stage 1 hypertension, 27% were found to have stage 2 hypertension, and 3% were found to be in hypertensive crisis (Table 1).

As previously stated, most farmworkers reported no previous diagnosis of hypertension or diabetes. Of those that reported no previous hypertension diagnosis ($n = 267$), only 32% were found to have normal blood pressure according to the American College of Cardiology/American Heart Association's blood pressure guidelines.²⁵ Sixteen percent were found to have elevated blood pressure, 33% were found to have stage 1 hypertension, 18% were found to have stage 2 hypertension, and 1% were found to be in hypertensive crisis (Table 2). Of those that reported no previous diabetes diagnosis, only 25% were found to have normal fasting serum glucose levels as classified by

Table 1 Demographic and health characteristics of two farmworker cohorts

Characteristic	Florida Research Cohort (n=301)		Georgia Clinic Cohort (n=427)	
	Mean (std) or % [n]		Mean (std) or % [n]	
Demographics				
Age	39	(8.7)	29.7	(8.1)
Male	33%	[100]	100%	[427]
Nationality				
Mexican	74%	[224]	> 99%	[411]
Other Latin America	24%	[73]	< 1%	[1]
US	1%	[4]	–	–
Education, years	6.5	(3.4)	–	–
Health				
Self-reported Hypertension dx	9%	[26]	–	–
Self- reported Diabetes, Type2	7%	[22]	–	–
BMI status				
Underweight	< 1%	[1]	0%	[0]
Normal weight	16%	[48]	35%	[132]
Overweight	46%	[138]	41%	[156]
Obese	38%	[113]	23%	[88]
Body fat				
Males	24.4	(6.2)	–	–
Females	35.4	(5.9)	–	–
Serum BUN, mg/dL	14.2	(4.7)	–	–
Serum Creatinine, mg/dL	0.6	(0.2)	–	–
Serum Hemoglobin, g/dl	14.2	(1.5)	–	–
Serum Glucose, mg/dL (fasting ^a)				
Normal (< 100)	23%	[46]	–	–
Impaired (100–125)	60%	[119]		
Diabetic (> 125)	17%	[34]	–	–
Pulse, resting	70	(11)	–	–
Hypertension ^b				
Age < 40yrs				
Normal	40%	[59]	27%	[91]
Elevated	15%	[24]	19%	[64]
Stage 1	30%	[44]	34%	[117]
Stage 2	16%	[24]	20%	[69]
Crisis	0%	[0]	0%	[0]
Age > =40yrs				
Normal	21%	[31]	28%	[15]
Elevated	19%	[28]	4%	[2]
Stage 1	31%	[47]	43%	[23]
Stage 2	27%	[40]	25%	[13]
Crisis	3%	[4]	0%	[0]

^a199 participants

^bACC/AHA guidelines:

Normal: Less than 120/80 mm Hg, *Elevated*: Systolic between 120–129 and diastolic less than 80

Stage 1: Systolic between 130–139 or diastolic between 80–89, *Stage 2*: Systolic at least 140 or diastolic at least 90 mm Hg, *Hypertensive crisis*: Systolic over 180 and/or diastolic over 120

Table 2 Self-reported health history v clinical indicators; Florida Research cohort

Self-reported history					
Hypertension Diagnosis	ACC/AHA Hypertension Categorization % [n]				
	Normal	Elevated	Stage 1	Stage 2	Crisis
No	32% [86]	16% [42]	33% [87]	18% [49]	1% [2]
Yes	15% [4]	12% [3]	15% [4]	50% [13]	8% [2]
Diabetes, Type2	Fasting Serum Glucose				
	Normal (< 100)	Impaired (100–125)		Diabetic (> 125)	
No	25% [44]	63% [113]		12% [22]	
Yes	12% [2]	18% [3]		71% [12]	

the American Diabetes Association's guidelines. Sixty-three percent were found to have impaired fasting serum glucose, and 12% met criteria for classification as diabetic (Table 2).

Georgia

The Georgia cohort comprises data from 427 agricultural workers. The Georgia cohort mean age of workers was 29.7 years (SD 8.1), all were male (100%), and > 99% listed Mexico as their country of origin (Table 1). Only 35% of the workers were found to have a normal weight with 0% being underweight, 41% being overweight, and 23% being obese. For those under 40 years of age, following the American College of Cardiology/American Heart Association's blood pressure guidelines, only 27% had a normal blood pressure. Nineteen percent were found to have elevated blood pressure, 34% were found to have stage 1 hypertension, 20% were found to have stage 2 hypertension, and 0% were found to be in hypertensive crisis (Table 1). For those 40 years of age or older, only 28% were found to have normal blood pressure. Four percent were found to have elevated blood pressure, 43% were found to have stage 1 hypertension, 25% were found to have stage 2 hypertension, and 0% were found to be in hypertensive crisis (Table 1).

Although the correlations between BMI and systolic blood pressure (unadjusted $r=0.20$), diastolic blood pressure (unadjusted $r=0.19$), and glucose (unadjusted $r=0.14$) are statistically significant and positive, the correlations are weak. Adjusting for age and gender did not show statistically significant correlation between BMI and systolic and diastolic blood pressure or glucose.

Discussion

Our study contributes to the growing evidence that Hispanic immigrant agricultural workers are a vulnerable subgroup within the U.S. Hispanic population and points to the compelling need to assure that this essential workforce has access to healthcare in the U.S.

Impaired Glucose

We found alarming levels of prediabetes and diabetes in Florida agricultural workers. The number of workers in the Florida sample meeting the definition of prediabetes is much higher than the general rate for U.S. Hispanics (60% compared to 35%) [34]. In spite of this substantial difference in prediabetes frequency, differences in diabetes blood sugar levels as measured by fasting serum glucose were less pronounced; 17% of the Florida agricultural workers had diabetes level glucose, only slightly higher than the 14.7% [34] reported nationally for Hispanics. The difference in prediabetes percentage and diabetes glucose levels may be due to the lack of access to diabetes screenings performed in physicians' offices and in other health care settings.

Differences in glycosylated hemoglobin (HbA1c) or plasma glucose exist between Hispanics and non-Hispanic whites even when controlling for age, sex, and BMI [35]. Researchers have frequently cited dietary factors as risks for diabetes in the Hispanic population; [36] however Swaminathan postulated that the association between pesticide exposure and diabetes is worth investigation [37].

Epidemiological studies and animal studies have provided some plausibility that environmental endocrine-disrupting chemicals such as pesticides, phthalates, polychlorinated bisphenyls, bisphenol A, and heavy metals contribute to diabetes [38, 39]. Supporting this idea that occupational exposures rather than just dietary factors could contribute to diabetes risk, a recent study of 105 agricultural workers in Guatemala who had a mean age of 29.5 (SD 8.1) and a mean BMI of 23.2 (SD 2.5) at the start of the harvest season, 50% were found to have pre-diabetes HbA1c values of 5.7–6.4 [40].

Elevated Blood Pressure

Agricultural workers had a much higher proportion of elevated blood pressure (70% Florida sample, 67% Georgia sample) than the national average reported by National Health and Nutrition Examination Survey (NHANES) in Hispanics (44%) [41]. Pesticide exposure could also contribute to this discrepancy, as meta-analysis has found a potential association between persistent organic pollutants (POPs), including pesticides, and an increased risk for hypertension [42–44]. Kidney injury among workers could be another contributing factor. Recent studies have shown an increasing global prevalence of Chronic Kidney Disease of unknown origin (CKDu) among seemingly healthy agricultural workers [45, 46]. Although CKDu has not been documented in agricultural workers in the United States, recent studies in Florida [31] and California [47, 48] found that agricultural workers develop acute kidney injury (AKI) according to the criteria established by Kidney Disease: Improving Global Outcomes (KDIGO) organization during a single work shift [49]. A retrospective cohort study of adult patients who were hospitalized found that AKI was independently associated with a 22% (95%CI, 12% to 33%) increase in the odds of developing elevated blood pressure within 180 days [50]. A study of pesticide applicators in Iowa and North Carolina found an association between end stage renal disease and chronic exposure to pesticides; however, this was based on questionnaires and not the analysis of pesticide residues and their metabolites [51]. Although dietary factors have most frequently been attributed as risk factors for hypertension in the Hispanic population [36]. Further research is needed to understand the mechanistic pathways by which pesticides may result in the development of AKI and lead to increased rates of elevated blood pressure in agricultural workers.

BMI has been shown to be strongly associated with high blood pressure [52–55]. A study in Mexico with 111,911 participants found that BMI was a stronger predictor of blood pressure than central adiposity markers, such as waist circumference [54]. However, the findings in our study show only a weak correlation between BMI and hypertension among agricultural workers. This might be due to differences in

occupational and environmental factors and lifestyle difference between agricultural workers and the general population of previous large-scale studies.

Body Size

While agricultural workers have physically demanding jobs, their rates of being overweight and obesity are comparable to the Hispanic national average of 80% [56]. In the Florida sample, 83% were overweight or obese, and in Georgia 64% were overweight or obese. The difference between the rate of adiposity between both cohorts may be due to the Georgia cohort being all male and younger than the Florida cohort.

The strenuous nature of agricultural work would suggest that the BMI of agricultural workers would be less than that reported in non-agricultural Hispanic individuals, but that is not the case. Studies in Florida and California using accelerometers to monitor physical activity over the workday have shown that workers spend an ample amount of time in moderate to vigorous physical activity throughout the workday [32, 57]. Agricultural workers in Florida spend a median of 146 min per day in moderate-vigours physical activity. For comparison, the Centers for Disease Control (CDC) recommends at least 150 min to 300 min a week of moderate-intensity physical activity [58]. Meeting the CDC guidelines of moderate-to-vigorous physical activity reduces the risk of developing type 2 diabetes, high blood pressure, and helps maintain a healthy body weight [58]. Furthermore, exercise is not the only way to meet the physical activity recommendations. Time spent in physically active occupations counts toward meeting the physical activity recommendations [58]. Agricultural workers easily exceed the physical activity guidelines the CDC recommends per week.

Adiposity has been linked to increased consumption of high calorie foods and a sedentary lifestyle; however, emerging evidence in animals and humans suggests a link between chronic exposure to pesticides and obesity and other chronic disease [59–61]. Obesogens such as pesticides may interfere with metabolic processes and increase the risk of weight gain by increasing the number and size of fat cells; altering basal metabolic rate; and altering hormones regulating satiety, food preferences, and appetite [62]. Thus, the chronic exposure to pesticides in the occupational environment may be contributing to the higher BMIs and body fat percentages in this population.

Limitations

First, the convenience samples in two states may not be representative of all agricultural workers in the U.S. Southeast. The Georgia sample only includes male agricultural workers who attended the health screenings provided by

FWFHP. The prevalence of prediabetes and diabetes may be underestimated because a sub-study ($n=63$) within the larger Florida cohort excluded agricultural workers from participating if they had a medical diagnosis of diabetes type 2. Importantly to note is that is that one-time measures of elevated blood pressure may not accurately reflect a diagnosis of hypertension. Also lacking from this study is an assessment of dietary intake of the cohorts.

Recommendations

Pesticides have been linked to a number of health conditions; yet little is known about the full spectrum of pesticides and their mechanisms of action with regard to human physiology. While the US Environmental Protection Agency (EPA) issued the Worker Protection Standard (WPS) in 1974 and revised it in 2015 to reduce the risks of occupational pesticide poisoning in agricultural workers, the regulation does not address pesticide exposure at levels that do not cause acute toxicity.

Furthermore, research is needed to identify the associations and mechanisms underlying pathogenesis of chronic conditions such as hypertension, obesity, and diabetes due to pesticide exposure. To better understand the interaction between pesticide exposure and human health, a multi-omics approach could provide a global assessment and identify a causal relationship between hazardous exposures and health status [63]. Given the common and high use of pesticides and elevated rates of hypertension, impaired glucose, and adiposity in agricultural workers, the public health impact of this relationship may require and lead to occupational reform that protects the health of agricultural workers.

Conclusion

Our study found that agricultural workers have higher rates of impaired glucose and hypertension compared to the national averages reported by NHANES among Hispanics. While BMI has been shown to be strongly associated with high blood pressure, we found only a weak correlation between BMI and hypertension among agricultural workers. Future studies should assess occupational and environmental factors and lifestyle differences between agricultural workers and the general population to better understand these discrepancies in health status. A multi-omics research approach could help identify the associations and mechanisms underlying pathogenesis of chronic condition such as hypertension, obesity, and diabetes due to pesticide exposure.

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