HHS Public Access

Author manuscript

J Immigr Minor Health. Author manuscript; available in PMC 2023 October 01.

Published in final edited form as:

J Immigr Minor Health. 2022 October ; 24(5): 1129–1136. doi:10.1007/s10903-021-01326-0.

The Health Status of Hispanic Agricultural Workers in Georgia and Florida

Roxana C. Chicas[1,5], **Lisa Elon**[2], **Madelyn C. Houser**[1], **Abby Mutic**[1], **Estefani Ignacio Gallegos**[1], **Daniel J. Smith**[1], **Lori Modly**[1], **Nezahualcoyotl Xiuhtecutli**[3], **Vicki S. Hertzberg**[1], **Joan Flocks**[4], **Jeff M. Sands**[5], **Linda McCauley**[1]

[1]Nell Hodgson Woodruff School of Nursing, Emory University, 1520 Clifton Road, Atlanta, GA, USA

[2]Rollins School of Public Health, Emory University, Atlanta, GA, USA

[3]Farmworkers Association of Florida, Apopka, FL, USA

[4]Levin College of Law, University of Florida, Gainesville, GL, USA

[5]Renal Division, Department of Medicine, School of Medicine, Emory University, Atlanta, GA, USA

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

✉Roxana C. Chicas rchicas@emory.edu.

Author Contribution All authors contributed to data analysis, data interpretation, the structure and content of the manuscript, and approved the final version for publication.

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 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/m2) 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 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]. Agricultual 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.

Funding

funding was provided by National Institute for Occupational Safety and Health (R01OH010657, R01OH0011782), National Institute of Diabetes and Digestive and Kidney Diseases (T32 - DK 07656).

References

1. Health of refugees and migrants. World Health Organization. 2018.
2. Artiga S, Pham O. Addressing Health and Social Needs of Immigrant Families: Lessons from Local Communities. Kaiser Family Foundation. 2019.
3. USDHHS. Social Determinants of Health. In: Services USDoHaH, editor.: US Department of Health and Human Services; 2020.
4. Hernandez T, Gabbard S. Findings from the National Agricultural Workers Survey (NAWS) 2015–2016: a demographic and employment profile of United States farmworkers. Washington: Department of Labor, Employment and Training Administration; 2019. p. [84]
5. Statistics NCfH. Healthy People 2020 Midcourse Review Hyattsville, MD: US Department of Health and Human Services; 2016 [Available from: https://www.cdc.gov/nchs/healthy_people/hp2020/hp2020_midcourse_review.htm.
6. BLS. NATIONAL CENSUS OF FATAL OCCUPATIONAL INJURIES IN 2018. In: Labor UDo, editor. 2019.
7. Gubernot DM, Anderson GB, Hunting KL. Characterizing occupational heat-related mortality in the United States, 2000–2010: An analysis using the Census of Fatal Occupational Injuries database. Am J Ind Med. 2015;58(2):203–11. [PubMed: 25603942]
8. Wadsworth G, Courville M, Schenker M. Pay, power, and health: HRI and the agricultural conundrum. Labor Stud J. 2019;44(3):214–35.
9. Guild A, Figueroa I. The neighbors who feed us: Farmworkers and government policy—challenges and solutions. Harv Law Policy Rev. 2018;13:157–86.
10. Flocks J The Environmental and Social Injustice of Farmworker Pesticide Exposure. Georget J Poverty Law Policy. 2012;19(2):255–82.
11. Moyce SC, Schenker M. Occupational exposures and health outcomes among immigrants in the USA. Curr Environ Health Rep. 2017;4(3):349–54. [PubMed: 28812286]
12. Frank AL, Liebman AK, Ryder B, Weir M, Arcury TA. Health care access and health care workforce for immigrant workers in the agriculture, forestry, and fisheries sector in the southeastern US. Am J Ind Med. 2013;56(8):960–74. [PubMed: 23532981]
13. Mitchell DC, Castro J, Armitage TL, Vega-Arroyo AJ, Moyce SC, Tancredi DJ, et al. Recruitment, methods, and descriptive results of a physiologic assessment of latino farmworkers: The California heat illness prevention study. J Occup Environ Med. 2017. 10.1097/JOM.0000000000000988.
14. Campbell K, Baker B, Tovar A, Economos E, Williams B, McCauley L. The association between skin rashes and work environment, personal protective equipment, and hygiene practices among female farmworkers. Workplace Health Saf. 2017;65(7):313–21. [PubMed: 28628754]

15. Chicas R, Mix J, Mac V, Flocks J, Dickman NE, Hertzberg V, et al. Chronic kidney disease among workers: A review of the literature. Workplace Health Saf. 2019;67(9):481–90. [PubMed: 31179873]
16. National Institute for Occupational Safety and Health Total Worker Health.
17. Luckhaupt SE, Cohen MA, Li J, Calvert GM. Prevalence of obesity among U.S. workers and associations with occupational factors. Am J Prev Med. 2014;46(3):237–48. [PubMed: 24512862]
18. Nobrega S, Champagne N, Abreu M, Goldstein-Gelb M, Montano M, Lopez I, et al. Obesity/Overweight and the Role of Working Conditions: A Qualitative, Participatory Investigation. Health Promot Pract. 2016;17(1):127–36. [PubMed: 26333770]
19. Caruso CC. Negative impacts of shiftwork and long work hours. Rehabil Nurs. 2014;39(1):16–25. [PubMed: 23780784]
20. Luckhaupt SE, Calvert GM. Prevalence of coronary heart disease or stroke among workers aged <55 years–United States, 2008–2012. MMWR Morb Mortal Wkly Rep. 2014;63(30):645–9. [PubMed: 25078653]
21. Rayens MK, Reed DB. Predictors of depressive symptoms in older rural couples: the impact of work, stress and health. J Rural Health. 2014;30(1):59–68. [PubMed: 24383485]
22. Wulsin L, Alterman T, Timothy Bushnell P, Li J, Shen R. Prevalence rates for depression by industry: a claims database analysis. Soc Psychiatry Psychiatr Epidemiol. 2014;49(11):1805–21. [PubMed: 24907896]
23. Salami B, Meherali S, Salami A. The health of temporary foreign workers in Canada: A scoping review. Can J Public Health. 2016;106(8):e546–54. [PubMed: 26986918]
24. Sweileh WM. Global output of research on the health of international migrant workers from 2000 to 2017. Global Health. 2018;14(1):105. [PubMed: 30409221]
25. Migrant Farmworker Housing. Florida Health Across the State.
26. Feeding the economy. 2020.
27. OFFICE OF FOREIGN LABOR CERTIFICATION H-2A Temporary Agricultural Labor Certification Program - Selected Statistics, FY 2019. In: Labor UDo, editor. 2019.
28. WHO. Body mass index—BMI: World Health Organization.; [Available from: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi.
29. Diagnosis and Classification of Diabetes Mellitus. Diabetes care. 2006;29(suppl 1):s43. [PubMed: 16373932]
30. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults a report of the American college of cardiology/American heart association task force on clinical practice guidelines. Hypertension. 2018;71(19):e127–248.
31. Mix J, Elon L, Vi Thien Mac V, Flocks J, Economos E, Tovar-Aguilar AJ, et al. Hydration Status, Kidney Function, and Kidney Injury in Florida Agricultural Workers. J Occup Environ Med. 2018;60(5):e253–60. [PubMed: 29271837]
32. Mix JM, Elon L, Thein Mac VV, Flocks J, Economos J, Tovar-Aguilar AJ, et al. Physical activity and work activities in Florida agricultural workers. Am J Ind Med. 2019. 10.1002/ajim.23035.
33. Classification and Diagnosis of Diabetes. Standards of Medical Care in Diabetes-2020. Diabetes Care. 2020;43(Suppl 1):S14–s31. [PubMed: 31862745]
34. CDC. National diabetes statistics report 2020. In: Services UDo-HaH, editor.: Centers for Disease Control and Prevention; 2020.
35. Aviles-Santa ML, Hsu LL, Arredondo M, Menke A, Werner E, Thyagarajan B, et al. Differences in Hemoglobin A1c Between Hispanics/Latinos and Non-Hispanic Whites: An Analysis of the Hispanic Community Health Study/Study of Latinos and the 2007–2012 National Health and Nutrition Examination Survey. Diabetes Care. 2016;39(6):1010–7. [PubMed: 27208330]
36. Mora N, Golden SH. Understanding cultural influences on dietary habits in Asian, Middle Eastern, and Latino patients with type 2 diabetes: A review of current literature and future directions. Curr Diab Rep. 2017;17(12):126. [PubMed: 29063419]

37. Swaminathan K Pesticides and human diabetes: a link worth exploring? Diabet Med. 2013;30(11):1268–71. [PubMed: 23587011]
38. Fénichel P, Chevalier N. Environmental endocrine disruptors: New diabetogens? C R Biol. 2017;340(9–10):446–52. [PubMed: 28826789]
39. Montgomery MP, Kamel F, Saldana TM, Alavanja MC, Sandler DP. Incident diabetes and pesticide exposure among licensed pesticide applicators: Agricultural Health Study, 1993–2003. Am J Epidemiol. 2008;167(10):1235–46. [PubMed: 18343878]
40. Sorensen CJ, Butler-Dawson J, Dally M, Krisher L, Griffin BR, Johnson RJ, et al. Risk Factors and Mechanisms Underlying Cross-Shift Decline in Kidney Function in Guatemalan Sugarcane Workers. J Occup Environ Med. 2019;61(3):239–50. [PubMed: 30575695]
41. Ostchega Y, Fryar C, Nwankwo T, Nguyen D. Hypertension prevalence among adults aged 18 and over: United States, 2017–2018. In: Statistics NCfH, editor. Hyattsville, MD: NCHS Data Brief, no 364; 2020.
42. Park SH, Lim JE, Park H, Jee SH. Body burden of persistent organic pollutants on hypertension: a meta-analysis. Environ Sci Pollut Res Int. 2016;23(14):14284–93. [PubMed: 27055888]
43. Ha MH, Lee DH, Son HK, Park SK, Jacobs DR Jr. Association between serum concentrations of persistent organic pollutants and prevalence of newly diagnosed hypertension: results from the National Health and Nutrition Examination Survey 1999–2002. J Hum Hypertens. 2009;23(4):274–86. [PubMed: 18843279]
44. Arrebola JP, Fernández MF, Martin-Olmedo P, Bonde JP, Martín-Rodriguez JL, Expósito J, et al. Historical exposure to persistent organic pollutants and risk of incident hypertension. Environ Res. 2015;138:217–23. [PubMed: 25725302]
45. Gonzalez-Quiroz M, Pearce N, Caplin B, Nitsch D. What do epidemiological studies tell us about chronic kidney disease of undetermined cause in Meso-America? A systematic review and meta-analysis. Clin Kidney J. 2018;11(4):496–506. [PubMed: 30094014]
46. Correa-Rotter R, Wesseling C, Johnson RJ. CKD of unknown origin in Central America: the case for a Mesoamerican nephropathy. Am J Kidney Dis. 2014;63(3):506–20. [PubMed: 24412050]
47. Moyce S, Joseph J, Tancredi D, Mitchell D, Schenker M. Cumulative incidence of acute kidney injury in California's agricultural workers. J Occup Environ Med. 2016;58(4):391–7. [PubMed: 27058480]
48. Moyce S, Mitchell D, Armitage T, Tancredi D, Joseph J, Schenker M. Heat strain, volume depletion and kidney function in California agricultural workers. Occup Environ Med. 2017;74(6):402–9. [PubMed: 28093502]
49. Khwaja A KDIGO clinical practice guidelines for acute kidney injury. Nephron Clin Pract. 2012;120(4):c179–84. [PubMed: 22890468]
50. Hsu C-y, Hsu RK, Yang J, Ordonez JD, Zheng S, Go AS. Elevated BP after AKI. J Am Soc Nephrol. 2016;27(3):914–23. [PubMed: 26134154]
51. Lebov JF, Engel LS, Richardson D, Hogan SL, Hoppin JA, Sandler DP. Pesticide use and risk of end-stage renal disease among licensed pesticide applicators in the Agricultural Health Study. Occup Environ Med. 2016;73(1):3–12. [PubMed: 26177651]
52. Landi F, Calvani R, Picca A, Tosato M, Martone AM, Ortolani E, et al. Body mass index is strongly associated with hypertension: Results from the longevity check-up 7+ study. Nutrients. 2018;10(12):1976. [PubMed: 30551656]
53. Feng R-N, Zhao C, Wang C, Niu Y-C, Li K, Guo F-C, et al. BMI is strongly associated with hypertension, and waist circumference is strongly associated with type 2 diabetes and dyslipidemia, in northern Chinese adults. J Epidemiol. 2012;22(4):317–23. [PubMed: 22672914]
54. Gnatiuc L, Alegre-Díaz J, Halsey J, Herrington WG, López-Cervantes M, Lewington S, et al. Adiposity and blood pressure in 110 000 Mexican adults. Hypertension. 2017;69(4):608–14. [PubMed: 28223471]
55. Bays HE, Chapman RH, Grandy S. The relationship of body mass index to diabetes mellitus, hypertension and dyslipidaemia: comparison of data from two national surveys. Int J Clin Pract. 2007;61(5):737–47. [PubMed: 17493087]
56. Statistics NCfH. Health, United States, 2018. In: Services UDo-HaH, editor. Hyattsville, MD.: Centers for Disease Control and Prevention; 2019.

57. Moyce S, Armitage T, Mitchell D, Schenker M. Acute kidney injury and workload in a sample of California agricultural workers. Am J Ind Med. 2020;63(3):258–68. [PubMed: 31773783]

58. USDHHS. Physical Activity Guidelines for Americans. In: Services USDoHaH, editor. 2nd ed. Washington, DC: U.S. Department of Health and Human Services; 2018.

59. Mostafalou S, Abdollahi M. Pesticides: an update of human exposure and toxicity. Arch Toxicol. 2017;91(2):549–99. [PubMed: 27722929]

60. Egusquiza RJ, Blumberg B. Environmental Obesogens and Their Impact on Susceptibility to Obesity: New Mechanisms and Chemicals. Endocrinology. 2020;161(3):bqaa024.

61. Ren XM, Kuo Y, Blumberg B. Agrochemicals and obesity. Mol Cell Endocrinol. 2020;515:110926. [PubMed: 32619583]

62. Muscogiuri G, Barrea L, Laudisio D, Savastano S, Colao A. Obesogenic endocrine disruptors and obesity: myths and truths. Arch Toxicol. 2017;91(11):3469–75. [PubMed: 28975368]

63. Koh EJ, Hwang SY. Multi-omics approaches for understanding environmental exposure and human health. Mol Cell Toxicol. 2019;15(1):1–7.

Table 1.

Demographic and health characteristics of two farmworker cohorts.

Characteristic	Florida Research Cohort (n=301) Mean (std) or % [n]		Georgia Clinic Cohort (n=427) 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[1])				
Normal (<100)	23%	[46]	--	--
Impaired (100–125)	60%	[119]		
Diabetic (>125)	17%	[34]	--	--
Pulse, resting	70	(11)	--	--
Hypertension[2]				
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]

Characteristic	Florida Research Cohort (n=301)		Georgia Clinic Cohort (n=427)	
	Mean (std) or % [n]		Mean (std) or % [n]	
Stage 2	27%	[40]	25%	[13]
Crisis	3%	[4]	0%	[0]

[1]199 participants

[2]ACC/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	ACC/AHA Hypertension Categorization % [n]				
Hypertension Diagnosis	**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]
	Fasting Serum Glucose				
Diabetes, Type2	**Normal (<100)**	**Impaired (100–125)**	**Diabetic (>125)**		
No	25% [44]	63% [113]	12% [22]		
Yes	12% [2]	18% [3]	71% [12]		