

Hired Crop Worker Injuries on Farms in the United States: A Comparison of Two Survey Periods From the National Agricultural Workers Survey

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Background *Hired crop workers in the United States are at high risk of occupational injury. Targeted surveillance is important for effective occupational safety efforts.*

Methods *The National Agricultural Workers Survey was utilized to collect injury data during the years 1999, 2002–2004 (period I) and 2008–2010 (period II).*

Results *The overall injury rate declined between the two periods from 4.3 to 2.9/100 per full-time week-based equivalents (FTE_{WB}). Injury rates remained high during both periods for those with greater than 20 years farm experience (3.6 and 3.8/100 FTE_{WB}) and pesticide handling work (4.9 and 5.0/100 FTE_{WB}). Overexertion, contact with objects and equipment, and falls from height were common during both periods. Older workers comprised a greater proportion of injury cases in period II.*

Conclusion *Overexertion that leads to sprains/strains, dangerous ladder use, and pesticide use should be targeted as important risk exposures on the farm. Am. J. Ind. Med. 59:408–423, 2016. Published 2016. This article is a U.S. Government work and is in the public domain in the USA*

KEY WORDS: *occupational injuries; injury rate; farm labor; crop workers; foreign-born workers*

INTRODUCTION

Hired crop workers play a central role within the agricultural labor force in the United States (US). Hand labor places these workers at risk for occupational injuries during planting, growing, and harvesting for production of crops such as fruit, vegetable, sugar cane, nut, tobacco, cotton, and nursery operations. Previous research shows that injuries on crop operations can be due to various hazards such as being

struck by or caught-in agriculture machinery, lacerations from hand tools such as knives, falls from ladders and other heights, pesticide poisoning, musculoskeletal conditions, and other environmental conditions such as extreme heat [McCurdy and Carroll, 2000].

The agriculture, forestry, fishing, and hunting industry consistently has one of the highest fatality rates of any industry in the US. This industry had a fatality rate of 22.8/100,000 full-time equivalent (FTE) workers in 2012 compared to a fatality rate of 3.4/100,000 FTE for all industries [Bureau of Labor Statistics [BLS], 2014a]. In 2012, 509 fatalities were reported in the agriculture industry. Of those, 224 fatal injuries occurred in the crop production sectors with 53% related to transportation and 32% due to contact with objects and equipment [BLS, 2014b]. Furthermore, during the same time period, the Survey of Occupational Injuries and Illnesses reported a non-fatal injury incidence rate for crop workers of 5.3/100 FTE. The injury rate for crop workers was 43% higher than the national incidence rate for all industries [BLS, 2013]. Leigh et al.

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[2014] have suggested that the agricultural injury rate estimate is likely an undercount.

The US Department of Labor, Employment and Training Administration (USDOL/ETA) provides insight into the demographics, employment, and health characteristics of hired crop workers in the US through the National Agricultural Workers Survey (NAWS). Over the past several decades, NAWS data have shown that a large majority of hired crop workers were male, native Spanish speakers, foreign born, had an income below poverty guidelines, and had completed relatively few years of education [Mines et al., 1997; Mehta et al., 2000; Carroll et al., 2005]. The National Institute for Occupational Safety and Health (NIOSH) collected injury data from NAWS through collaboration with the USDOL/ETA. Steege et al. [2009] presented injury data collected by NAWS in 1999 and Wang et al. [2011] summarized injury data collected for the years 1999, 2002–2004.

The goal of this study is to expand on the current knowledge of the hired crop worker population in the US on a national level using NAWS for the years that NIOSH collected injury data. The primary objectives of this study are as follows: (1) to provide a comprehensive analysis of the workforce demographic and work-related characteristics of hired crop workers on US farms; and (2) to describe injuries, including rates and risk, incurred by hired crop workers while working on a farm in the US. The data are presented and compared for two time periods, 1999, 2002–2004 (referred to as period I) and 2008–2010 (referred to as period II). Comparisons are made both between the two periods and within each period. These periods are reported separately as they were, generally, pre- and post-economic decline that affected the immigration patterns between the US and Mexico and thus changed the agricultural workforce demographics of hire crop workers on US farms.

METHODS

Study Design

The NAWS is a multistage probability sample of hired farm workers on crop operations across the US, excluding Alaska and Hawaii. Three interview cycles are conducted throughout the year across 12 geographic regions to account for seasonal and regional fluctuations in agricultural employment during the crop production process.

The primary stage of NAWS sampling consists of randomly selecting Farm Labor Areas from each of the 12 regions. Farm Labor Areas in the NAWS were created by the USDOL/ETA to represent homogeneous farming areas based on farm labor usage and farm size. The second stage of sampling involves randomly selecting farm operators.

Farm operators (the employers) are contacted by trained interviewers to gain permission to speak with hired crop workers. The tertiary sampling stage involves randomly selecting hired crop workers to interview using an established protocol at each of the selected farms.

The NAWS is subject to the Paperwork Reduction Act including a 60-day public comment notice in the Federal Register and review by the Office of Management and Budget with the survey control number 1205-0453. The hired crop workers are advised that their participation is voluntary and sign an informed consent form. The NAWS interview is administered at the worker's home or other location preferred by the worker during non-working hours and the worker is compensated for his/her time. The NAWS can be administered in English and Spanish. A complete description of statistical methodology for NAWS is published by the USDOL/ETA and available at <http://www.doleta.gov/agworker/naaws.cfm> under NAWS Survey Documentation. The NIOSH Human Subjects Review Board (HSRB) determined that the injury module was a routine, ongoing public health surveillance effort and, therefore, exempt from HSRB review.

Participants

Workers are eligible to participate in the NAWS if at the time of interview they had worked at least one 4-hr shift during the last 15 days at the current crop farm or nursery. A crop farm or nursery includes the production of plants or flowers, with work tasks such as planting, cultivating, fertilizing, grafting, and seeding plant crops or packing/canning products on the farm. A worker is excluded if he/she is less than 14 years of age, has completed the NAWS within the last 12 months while working at the same location, is a worker with a H-2A permit [United States Department of Homeland Security, 2016], works exclusively with livestock, does exclusively non-farm work for the employer, or works for a packing plant or cannery off the farm at a location where most of the produce originated elsewhere. A worker who sells, installs, or maintains trees or plants for a landscaping company is excluded as well. Lastly, the employer or contractor, family members of the employer, and those who make operational decisions, such as a sharecropper, are excluded from the NAWS.

Injury cases are identified as positive if a worker reports having been injured within the last 12 months of the interview date while performing crop work tasks on a farm in the US or traveling to or from the farm. Second, the injury must result in one or more of the following: (1) the worker was unable to work for at least 4 hrs, (2) the worker was unable to work normally for at least 4 hrs or had to be reassigned to an easier task, (3) the worker had to use strong medicine to keep working (other than over-the-counter

medication), or (4) the worker needed any kind of first aid or other medical treatment.

A modification was made to the injury screening question prior to data collection of period II based on findings reported by Cooper et al. [2006] that “there is not a single word or phrase in Spanish that encompasses the meaning of the English phrase “work-related injury.” Concerns about perception or understanding of what is meant by an injury at work led NIOSH to add examples of injuries to refine the scope of the types of incidents being elicited and increase recall to reduce under-reporting of injuries. The examples utilized in the injury screening question during period II included the most common types of

incidents that were seen among hired crop workers as derived from a previous analysis of NAWs [Wang et al., 2011], including cutting oneself with a sharp tool or knife; strains from lifting heavy objects; falling from a ladder; and getting sick from exposure to the sun, sting or bite of an insect, or from pesticides. Figure 1 contains the injury screening questions used for periods I and II.

Injury Variables

Participants who report an injury complete an injury module that is separate from the core NAWs questionnaire.

Period I

“I would like to ask you some questions about injuries or accident that you may have had in the last 12 months. Again, any information that you share with me will be confidential. I would like you to think about any injuries you may have had while doing farm work in the USA. The injuries may have occurred while on a farm or your place of work, while working or not, or while traveling to or from a farm or a place of work.”

In the past 12 months, have you had any injury or accident that made you—

1. Unable to work for at least 4 hours?
2. Unable to work as hard as you normally do for at least 4 hours? Or because of the injury you were assigned to a different easier task?
3. Seek medical treatment, including any type of first aid?
4. Take strong medicine to allow you to keep working? By strong medicine I mean something other than over-the-counter medications.

Period II

[DIRECTIONS TO INTERVIEWER: ...ONLY IF THE RESPONDENT SEEMS HESITANT TO TALK ABOUT INJURIES, e.g., BECAUSE HE/SHE IS FEARFUL, SHOULD YOU REMIND THE RESPONDENT THAT ALL THE INFORMATION HE/SHE SHARES WITH YOU IS CONFIDENTIAL. USE YOUR JUDGMENT ABOUT REMINDING THE INTERVIEWER ABOUT CONFIDENTIALITY AT ANY POINT WHILE ADMINISTERING THIS SUPPLEMENT.]

“I would like to ask you some questions about injuries or accidents that you may have had while doing farm work in the United States. These injuries include a car accident while traveling to and from work. They could also be things like cutting yourself with a sharp tool or knife; hurting yourself lifting heavy objects, such as crates; hurting yourself by falling, for example falling off a ladder or crate, or tripping in the field; or getting sick from working too long in the hot sun, being bitten or stung by an insect, or breathing pesticides while working in the fields.”

In the past 12 months, have you had any injury or accident that made you—

1. Unable to work for at least 4 hours?
2. Unable to work as hard as you normally do for at least 4 hours? Or were assigned a different job (or different task) that was easier because the injury prevented you from doing the first job (or task)?
3. Use any type of first aid, such as a bandage to stop bleeding or antiseptic to clean a wound (or ice packs for a bruise, etc.) or seek medical treatment at a clinic or from a nurse or doctor?
4. Take strong medicine, except aspirin (or Tylenol or ibuprofen), to allow you to keep working?

FIGURE 1. Injury screening questions within the National Agricultural Workers Survey period I (1999, 2002–2004) and period II (2008–2010).

The first injury module was added to the core NAWS questionnaire and administered in 1999, 2002–2004. The second injury module was administered in 2008–2010. The injury module consists of categorical questions related to type of injury, body part affected, medical treatment venue, and source of payment for medical costs. The injury narrative within the module includes a detailed description from the worker of how the injury occurred, the source of the injury, diagnosis, and other etiological factors. The injury source and event are coded by NIOSH researchers using the BLS Occupational Injury and Illness Classification System (OIICS) Version 2.01 Manual [BLS, 2012].

Statistical Methods

Analyses were conducted using SAS[®] Version 9.3 (SAS Institute, Cary, NC). Proc SurveyMeans, SurveyFreq, and SurveyLogistic procedures were utilized to provide statistically weighted unbiased sample estimates and account for the complex sample design for standard error (SE) calculations. This paper presents nationally weighted percentage distributions with 95% confidence intervals (CI) but does not extrapolate to national count estimates due to the lack of definitive estimates for the number of hired farm workers on crop farms in the US. Injury rates were calculated using employment estimates adjusted for weeks of farm work during the previous 12 months (as self-reported by the hired crop workers) and referred to as week-based full-time equivalents (FTE_{WB}). One FTE_{WB} was set equal to 50 weeks of farm work. The injury rates are presented per 100 FTE_{WB} with corresponding CI.

Adjusted odds ratios (OR_{ADJ}) were calculated using the SAS SurveyLogistic procedure. Non-injury cases were coded 0 and injury cases as 1. To develop an exposure-based index for the occupational injuries that incorporated the amount of work (in the previous 12 months), the injury cases were divided by the number of weeks of farm work. Injuries with less work exposure (e.g., a lower value for the number of weeks of farm work) are scored higher on the index compared to injured crop workers reporting a larger number of weeks worked. For example, an injured crop worker with 25 weeks of farm work would be scored 0.04 ($1_{injury}/25_{weeks}$) compared to a value of 0.02 ($1_{injury}/50_{weeks}$) for a crop worker with 50 weeks of work exposure. Odds ratios were used instead of alternatives such as an incident rate ratio from a Poisson regression because the SAS SurveyLogistic procedure provides a mechanism to calculate error estimates that take into account the complex sample of the NAWS. Additionally, the adjusted odds ratios should be very similar to rate ratios as injury prevalence is less than 5%. Two-tailed significance tests were calculated for $P < 0.05$.

RESULTS

Survey Response

A total of 13,604 hired crop workers with 374 injury cases were recorded in period I. The grower response rate during period I was 69.0%, with a worker response rate of 94.0%. This compares to 5,873 hired crop workers during period II and 141 reported work-related injury cases. In period II, the overall grower response rate was 66.0%, with the same worker response rate as in period I.

Workforce Demographics

The workforce distribution did not change substantially by gender, with males making up the majority of the sample population during periods I and II (76.9% and 75.7%, respectively) (Table I). The median age of the overall hired crop workforce increased from 31 to 35 years. Nearly three quarters of the workers reported being of Mexican origin (74.9% in period I and 69.1% in period II). The number of workers who reported speaking English somewhat well and well increased between the two survey periods. In both periods, foreign-born workers had a median education of 6 years compared to a median education of 12 years for crop workers born in the US. In period I, 64.2% of foreign-born workers had a sixth grade education or less. These workers comprised 50.1% of the total crop worker labor force interviewed during period I (Table I). The percent of foreign-born workers with a sixth grade education or less declined to 59.9% in period II. This group comprised 44.5% of the total crop worker labor force interviewed during period II (Table I). Among US born workers, 57.3% (period I) and 70.4% (period II) had completed 12th grade. These US born workers comprised 12.7% (period I) and 18.0% (period II) of the total labor force (Table I).

In both survey periods, around one third of the study sample worked in California. Non-migrant (settled) workers increased from 60.5% in period I to 73.6% in period II. Hired crop workers self-reporting to be undocumented account for about half of the population during both periods (Table I). The proportion of workers who were hired by the farm operator as a direct hire (compared to those who are hired by a labor contractor, or indirect hire) in period II (86.6%) was higher than in period I (78.6%). Although the majority of crop workers reported working for only one employer the previous year, workers reporting two or more employers were more likely to be classified as migrant (52.0% in period I and 46.7% in period II).

Field work was the primary task reported in both survey periods (73.4% and 70.4%, respectively). The median years worked on a US farm increased from 6 years to 10 years between the two survey periods, with 48.2% having worked

TABLE I. Demographic and Work Characteristics Among Hired Crop Workers in the United States During NAWS Period I (1999, 2002–2004) and Period II (2008–2010)

Characteristic	Data collection years			
	Period I		Period II	
	Weighted percent n = 13,604	95%CI	Weighted percent n = 5,873	95%CI
Age (years)				
14–17	3.8	3.0–4.6	2.3	1.2–3.3
18–24	27.4	25.7–29.1	20.7	17.7–23.8
25–34	27.9	26.3–29.6	24.7	22.0–27.4
35–44	22.3	21.1–23.6	23.0	20.3–25.7
45–54	11.7	10.7–12.7	18.7	16.3–21.1
55+	6.8	6.0–7.8	10.6	8.9–12.3
Gender and age (years)				
Male	76.9	74.6–79.3	75.7	72.6–78.8
<25	24.8	23.2–26.6	18.0	15.3–20.7
25–34	21.2	19.7–22.6	18.8	16.4–21.3
35–44	16.6	15.4–17.8	16.7	15.1–18.6
45+	14.3	13.2–15.5	22.1	19.4–24.8
Female	23.1	20.7–25.4	24.3	21.2–27.4
<25	6.3	5.2–7.5	5.0	3.8–6.2
25–34	6.8	5.8–7.7	5.9	4.8–7.0
35–44	5.8	4.7–6.8	6.2	4.5–7.9
45+	4.2	3.5–4.8	7.2	5.3–9.0
Country of birth/ethnicity				
US White	10.9	9.0–12.7	17.2	13.5–20.9
US Hispanic	7.0	5.6–8.4	5.7	3.7–7.7
US other	4.1	3.0–5.2	2.6	1.6–3.6
Mexican	74.9	72.3–77.6	69.1	64.4–73.8
All other	3.1	2.1–4.1	5.3	3.7–6.9
English language fluency				
Not at all	43.0	40.5–45.4	32.6	28.6–36.7
Somewhat	34.3	32.5–36.0	38.4	35.1–41.6
Well	22.8	20.5–25.0	29.0	24.3–33.7
Highest grade completed by country				
Foreign born	78.1	75.6–80.5	74.5	69.9–79.0
No education	4.0	3.3–4.7	4.5	3.4–5.6
1st–6th grade	46.1	43.9–48.2	40.0	36.4–43.7
7th–11th grade	21.6	20.0–23.3	18.5	16.2–20.9
12th+ grade	6.3	5.5–7.1	11.4	8.9–13.8
US born	21.9	19.4–24.5	25.5	21.0–30.1
No education	0.1	0.06–0.23	–	–
1st–6th grade	1.8	1.2–2.3	0.9	0.2–1.6
7th–11th grade	7.4	6.2–8.6	6.6	4.9–8.3
12th+ grade	12.7	10.8–14.6	18.0	8.9–13.8
Region where interviewed				
East	15.4	12.8–17.9	12.9	10.0–15.8
Southeast	12.7	10.5–14.9	11.7	9.0–14.5
Midwest	16.4	13.5–19.4	19.7	13.5–25.9
Southwest	8.1	6.3–9.8	7.6	5.7–9.5

(Continued)

TABLE I. (Continued)

Characteristic	Data collection years			
	Period I		Period II	
	Weighted percent n = 13,604	95%CI	Weighted percent n = 5,873	95%CI
West	12.2	9.2–15.1	16.4	12.4–20.5
California	35.3	31.9–38.8	31.6	26.6–36.6
Migrant ^a				
Non-migrant (settled)	60.5	57.4–63.6	73.6	69.1–78.1
Migrant	39.5	36.4–42.6	26.4	21.9–30.9
Follow the crop	8.9	7.2–10.5	6.8	4.9–8.7
Shuttle	30.7	28.0–33.3	19.6	15.1–24.1
Documentation status				
Citizen	24.6	21.8–27.4	30.0	24.9–35.1
<25	6.8	5.6–8.0	7.4	4.4–10.4
25–34	4.7	3.6–5.8	4.4	3.2–5.6
35–44	5.5	4.6–6.4	5.2	3.9–6.5
45+	7.6	6.6–8.6	13.0	10.7–15.3
Documented	25.3	22.4–28.2	20.4	17.5–23.3
<25	2.8	1.9–3.7	1.9	0.7–3.1
25–34	5.7	4.8–6.6	2.2	1.5–2.9
35–44	9.4	8.2–10.6	6.4	5.0–7.8
45+	7.4	6.5–8.3	9.8	8.4–11.2
Undocumented	50.1	45.3–55.0	49.6	40.6–58.6
<25	21.7	19.2–24.2	13.8	10.0–17.6
25–34	17.6	15.7–19.5	18.2	15.2–21.2
35–44	7.4	6.1–8.7	11.5	7.8–15.2
45+	3.4	2.8–4.0	6.2	4.9–7.5
Number of employers				
One	72.9	70.6–75.3	80.1	76.3–83.9
Two or more	27.1	24.7–29.4	19.9	16.1–23.7
Type of hire				
Direct	78.6	75.4–81.9	86.6	82.4–90.8
Indirect (labor contractor)	21.4	18.1–24.6	13.4	9.2–17.6
Type of work				
Field work	73.4	69.5–77.3	70.4	65.1–75.8
Nursery	20.4	17.1–23.8	23.1	18.1–28.0
Packing	6.2	3.7–8.7	6.5	3.8–9.2
Duration of farm work in US				
<12 months	17.2	15.3–19.1	10.3	7.5–13.2
12–23 months	8.8	7.6–10.0	5.6	4.6–6.6
2–5 years	19.6	18.2–21.1	15.8	13.8–17.8
6–10 years	15.6	14.3–16.8	20.1	17.3–23.0
11–20 years	21.3	20.0–22.6	21.0	18.5–23.5
21+ years	17.5	16.0–18.9	27.2	24.0–30.3
Handled pesticides in the last year with “yes” by age (years)				
No	88.5	86.9–90.0	84.0	81.4–86.5
Yes	11.4	9.9–13.0	16.0	13.5–18.6
<25	2.1	1.6–2.6	2.5	1.6–3.3
25–34	2.5	2.1–2.9	3.8	2.9–4.8

(Continued)

TABLE I. (Continued)

Characteristic	Data collection years			
	Period I		Period II	
	Weighted percent n = 13,604	95%CI	Weighted percent n = 5,873	95%CI
35–44	3.5	2.8–4.2	4.4	3.3–5.5
45+	3.3	2.7–4.0	5.4	4.2–6.6
Used healthcare in the last 2 years in the US				
No	53.5	51.3–55.8	40.5	37.2–43.7
Yes	46.5	44.2–48.7	59.5	56.3–62.8
Health condition				
No	84.2	82.8–85.6	81.1	78.7–83.5
Yes	15.8	14.4–17.2	18.9	16.5–21.3
Musculoskeletal complaints				
No	79.5	77.8–81.2	85.1	83.1–87.2
Yes	20.5	18.8–22.2	14.9	12.8–16.9

NAWS, National Agricultural Workers Survey; n, sample size; CI, confidence interval.

^aNAWS classifies hired crop workers as non-migrant (or settled) or migrant, with migrant workers being further subcategorized as either shuttle or follow-the-crop [Carroll et al., 2005]. Shuttle workers travel 75 miles or more from their home for farm work within a single location. Follow-the-crop workers are those that travel to multiple locations for farm work.

more than 10 years in period II as compared with 38.8% in period I (Table I). The proportion of workers who reported they “mixed, loaded or applied pesticides” within the last year increased from 11.4% to 16.0% between periods I and II (Table I). From periods I to II, California (5.7% and 10.9%, respectively) and the Midwest (10.7% and 14.9%, respectively) had the lowest percent of workers reporting handling pesticides during both survey periods. The highest proportions of pesticide handling among hired crop workers were observed during period II in the Southwest (22.7%) and Southeast (22.6%). Healthcare use in the US within the last 2 years increased from 46.5% in period I to 59.5% in period II. Lastly, the percent of workers who reported musculoskeletal complaints decreased by 5.6% from periods I to II, but reports of a health condition increased by 3.1% (Table I).

Injury Characteristics

The statistically weighted percentage of hired crop workers self-reporting an injury during period I was 2.6% (95%CI 2.1–3.1) and 1.9% (95%CI 1.4–2.5) during period II. The overall injury rate per 100 FTE_{WB} for hired crop workers declined 32.6% between the two periods, from 4.3 (95%CI 3.5–5.1) in period I to 2.9 (95%CI 2.0–3.8) in period II. The adjusted odds ratio between the two periods showed hired crop workers in period I to be at greater injury risk (OR_{ADJ} = 1.5, 95%CI 1.1–2.1, *P* = 0.02) compared to period II.

The injury rate declined 42.9% between the two periods among females and 31.1% among males although the adjusted odds ratios were not significant for either sex (*P* = 0.13 for females and *P* = 0.06 for males) (Fig. 2). A comparison of females to males within each period showed that males accounted for the majority of injuries (83.7% in period I and 84.6% in period II), and had higher injury rates in both periods although the adjusted odds ratios were non-significant (*P* = 0.34 for period I and *P* = 0.13 for period II). The median age of injured crop workers rose from 34 to 39 years between the two survey periods. A comparison of

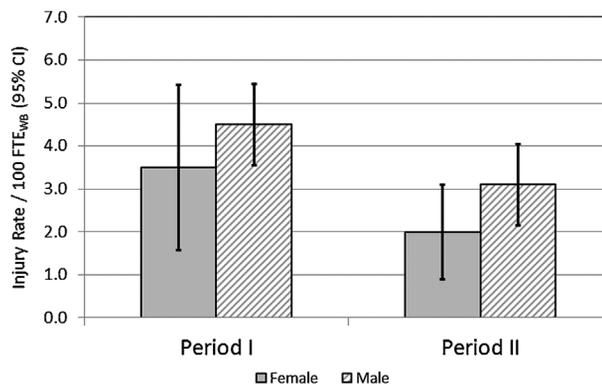


FIGURE 2. Injury rates per 100 FTE_{WB} of hired crop workers in the United States by gender during NAWS period I (1999, 2002–2004) and period II (2008–2010) with 95%CI. NAWS, National Agricultural Workers Survey; CI, confidence interval; FTE_{WB}, week-based full-time equivalent.

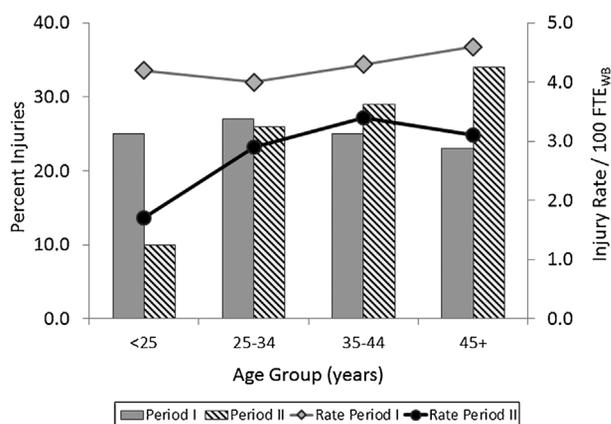


FIGURE 3. Percent injuries and injury rates per 100 FTE_{WB} of hired crop workers in the United States by age during NAWS period I (1999, 2002–2004) and period II (2008–2010). NAWS, National Agricultural Workers Survey; FTE_{WB}, week-based full-time equivalent.

age groups between the two periods showed a significant difference only for the <25-year-old age group, with this younger age group at higher injury risk during period I ($OR_{ADJ} = 2.5$, 95%CI 1.3–5.0, $P < 0.01$). Within each period, no significant injury risk difference was observed between the age groups (Fig. 3).

The injury rate for non-migrant workers decreased 22.2% between the two periods but the decline was non-significant ($P = 0.17$) (Table II). In period I, the odds of an injury were 1.6 times higher for migrants than for non-migrants ($P = 0.01$) (Table II). The same comparison could not be made in period II because the error estimate for migrant workers did not meet the reportable limit. Hired crop workers classified as citizen or documented had the highest injury rates during both periods although only period II showed citizen to be at significant increased risk compared to undocumented ($OR_{ADJ} = 2.1$, CI 1.1–3.8, $P = 0.05$) (Table II).

Between the two periods, workers with two or more employers were at greater risk during period I than workers with two or more employers in period II ($OR_{ADJ} = 1.9$, 95%CI 1.1–3.5, $P = 0.03$) but this difference was not observed for workers with one employer between the two periods (Table II). The injury rate for direct hire workers decreased by 40.8% between the periods with direct hire workers at significantly greater risk during period I compared to direct hire in period II ($OR_{ADJ} = 1.7$, 95%CI 1.2–2.4, $P < 0.01$) (Table II). An examination of direct hire compared to indirect hire in period I showed the odds of an injury were 2.6 times greater for direct hire ($P < 0.01$) (Table II). The same comparison could not be made in period II because the error estimate for indirect hire workers did not meet the reportable limit.

The median years of farm work experience in the US among injured workers increased from 7 years in period I to 16 years in period II. A comparison of work experience between the two periods showed that categories of workers with 2–5 and 6–10 years of work experience were both at significantly higher risk in period I compared to the respective categories in period II (2–5 years $OR_{ADJ} = 2.5$, 95%CI 1.2–5.6, $P = 0.02$ and 6–10 years $OR_{ADJ} = 2.0$, 95%CI 1.1–3.7, $P = 0.02$). An examination of injury risk within each period did not show substantial increased risk by farm work experience.

The injury rates for workers who reported that they “mixed, loaded, or applied pesticides” within the last year were nearly equivalent for the two periods (Table II). Within each period, the adjusted odds ratio of an injury was 2.1 times higher ($P = 0.02$) in period II for those handling pesticides compared to those who reported not handling pesticides. In period I the odds of an injury were 1.5 times higher for those handling pesticides but the finding was non-significant ($P = 0.08$) (Table II).

Injury rates among workers with a pre-existing health condition declined 43.8% between the two periods, although the increased risk in period I was not significant ($P = 0.09$) (Table II). A comparison of workers with a pre-existing health condition to those with no reported health condition within each period showed a 1.7 times increased risk of injury for those with a health condition during period I ($P = 0.02$), but a significant difference was not observed in period II (Table II).

Type of Injury

On examining the type of injuries, the proportion of sprains and strains increased from 38.8% to 50.3% of all injuries between periods I and II (Table III). Cuts or lacerations (just over 21% for both periods) and fractures or dislocations (12.5% for period I and 12.3% for period II) were also common. By body part injured, hand, wrist, and finger accounted for a larger proportion of injuries in period I than period II (32.8% and 22.0%, respectively), while injuries to the back (24.5% and 26.8%, respectively) comprised a greater proportion of injuries than lower extremities (15.4% and 20.3%, respectively) for both survey periods (Table III).

By injury event, during survey period II overexertion accounted for the largest proportion of injuries, followed by contact with objects and equipment and falls/slips/trips (Table IV). The injury narratives for overexertion events during period II often included the lifting of boxes, bags, and bales of produce. Narratives indicated that slipping of handheld objects were most often non-powered cutting tools used during the harvest of produce. Falls from height injury narratives often involved the workers picking fruit or

TABLE II. Injury Characteristics, Injury Rates, and Adjusted Odds Ratios Among Hired Crop Workers in the United States During NAWS Period I (1999, 2002–2004) and Period II (2008–2010)

Characteristic	Data collection years					
	Period I			Period II		
	Weighted percent injuries n = 374 (95%CI)	Injury rate/100 FTE _{WB} (95%CI)	Adjusted odds ratio (Wald 95%CI)	Weighted percent injuries n = 141 (95%CI)	Injury rate/100 FTE _{WB} (95%CI)	Adjusted odds ratio (Wald 95%CI)
Country of birth						
United States	26.4 (17.4–35.4)	5.2 (3.4–7.0)	1.3 (0.9–1.8)	32.2 (12.2–52.2)	3.8 (1.4–6.2)	1.4 (0.7–2.8)
Mexico	71.8 (55.2–88.4)	4.1 (3.1–5.1)	1.0 (–) ^a	66.5 (45.2–87.8)	2.7 (1.9–3.5)	1.0 (–) ^a
Other ^b	–(–)	–(–)	–(–)	–(–)	–(–)	–(–)
Migrant						
Non-migrant (settled)	60.0 (46.2–73.8)	3.6 (2.8–4.4)	1.0 (–) ^a	78.3 (55.4–99.9)	2.8 (2.0–3.6)	n/a (–) ^d
Migrant ^b	40.0 (26.7–53.3)	6.0 (4.0–8.0)	1.6 (1.1–2.4) ^c	–(–)	–(–)	–(–)
Documentation status						
Citizen	29.4 (19.9–38.9)	5.0 (3.4–6.6)	1.4 (1.0–2.1)	41.3 (19.0–63.6)	3.9 (1.8–6.0)	2.1 (1.1–3.8) ^c
Documented	30.9 (19.2–42.6)	4.8 (3.0–6.6)	1.3 (0.9–2.0)	25.7 (9.2–42.2)	3.4 (1.2–5.6)	1.8 (0.8–3.9)
Undocumented	39.7 (29.0–50.4)	3.6 (2.6–4.6)	1.0 (–) ^a	33.0 (22.4–43.6)	1.9 (1.3–2.5)	1.0 (–) ^a
Number of employers						
One	75.8 (57.8–93.8)	4.6 (3.4–5.8)	1.3 (0.9–1.8)	86.4 (58.1–99.9)	3.1 (2.1–4.1)	1.7 (0.9–3.3)
Two or more	24.2 (17.9–30.5)	3.5 (2.5–4.5)	1.0 (–) ^a	13.6 (6.3–20.9)	1.8 (0.8–2.8)	1.0 (–) ^a
Type of hire						
Direct	91.5 (72.3–99.9)	4.9 (3.9–5.9)	2.6 (1.6–4.2) ^c	88.3 (60.8–99.9)	2.9 (2.1–3.7)	n/a (–) ^d
Indirect (labor contractor) ^b	8.5 (4.6–12.4)	1.8 (1.0–2.7)	1.0 (–) ^a	–(–)	–(–)	–(–)
Duration of farm work in the US						
<2 years ^b	16.4 (7.9–24.9)	4.9 (2.4–7.4)	1.1 (0.6–2.1)	–(–)	–(–)	–(–)
2–5 years	22.6 (13.6–31.6)	4.5 (2.7–6.3)	1.0 (–) ^a	10.5 (3.6–17.4)	1.8 (0.6–3.0)	1.0 (–) ^a
6–10 years	21.7 (12.8–30.6)	5.4 (3.2–7.6)	1.2 (0.7–2.1)	19.6 (11.7–27.5)	2.7 (1.7–3.7)	1.5 (0.7–3.3)
11–20 years	21.2 (13.7–28.7)	3.6 (2.2–5.0)	0.8 (0.5–1.4)	21.0 (11.5–30.5)	2.6 (1.4–3.8)	1.5 (0.7–3.3)
21+ years	18.0 (12.5–23.5)	3.6 (2.4–4.8)	0.8 (0.5–1.3)	41.0 (19.7–62.3)	3.8 (1.8–5.8)	2.1 (0.5–5.0)
Handled pesticides in the last year ^e						
No	78.4 (57.6–99.2)	3.3 (2.5–4.1)	1.0 (–) ^a	65.3 (45.0–85.6)	2.3 (1.5–3.1)	1.0 (–) ^a
Yes	21.6 (13.0–30.2)	4.9 (2.9–6.9)	1.5 (1.0–2.3)	34.7 (15.7–53.7)	5.0 (2.3–7.7)	2.1 (1.2–4.0) ^c
Health condition						
No	74.9 (60.3–89.5)	3.9 (3.1–4.7)	1.0 (–) ^a	75.2 (50.3–99.9)	2.7 (1.7–3.7)	1.0 (–) ^a
Yes	25.1 (14.8–35.4)	6.4 (3.9–8.9)	1.7 (1.1–2.5) ^c	24.8 (11.8–37.8)	3.6 (1.6–5.6)	1.3 (0.8–2.4)

NAWS, National Agricultural Workers Survey; n, sample size; FTE_{WB}, week-based full-time equivalent; CI, confidence interval.^aReference category.^bEstimates for periods I and/or II not displayed due to coefficient of variation not meeting reportable limit.^cSignificant at $P < 0.05$.^dNot applicable (n/a) due to lack of comparison group.^eData not available for 1999.

TABLE III. Type of Injury, Body Part, and Treatment Venue Among Hired Crop Workers in the United States During NAWS Period I (1999, 2002–2004) and Period II (2008–2010)

Injury variable	Data collection years			
	Period I		Period II	
	Weighted percent n = 374	95%CI	Weighted percent n = 141	95%CI
Type of injury				
Sprain, strain	38.8	30.5–47.0	50.3	41.5–59.1
Cut, laceration	21.2	14.9–27.5	21.1	16.5–25.6
Fracture, dislocation	12.5	8.2–16.8	12.3	4.8–19.8
Bruise, contusion	8.1	5.4–10.7	7.3	4.1–10.5
Scrape, abrasion	2.8	1.3–4.3	5.0	3.0–7.0
All other	16.7	11.3–22.1	4.0	0.5–7.5
Body part injured				
Head, face, neck	5.4	3.2–7.6	4.1	3.0–5.2
Eye	6.9	4.0–9.7	9.3	5.3–13.3
Back	24.5	17.3–31.7	26.8	19.3–34.3
Shoulder, arm, elbow	6.8	4.4–9.3	14.9	7.0–22.7
Hand, wrist, finger	32.8	24.9–40.8	22.0	15.4–28.6
Leg	8.9	5.2–12.5	11.9	7.0–16.3
Foot, ankle, toe	6.5	3.9–9.1	8.4	4.3–12.6
All other	8.2	4.8–11.6	2.5	0.0–5.2
Place of treatment				
Hospital, emergency department, doctor's office/clinic, or migrant health clinic	78.3	72.8–83.8	85.2	81.5–89.0
First aid at the scene only	5.2	3.0–7.4	9.4	6.1–12.6
All other	16.5	11.5–21.4	5.4	3.5–7.3

NAWS, National Agricultural Workers Survey; n, sample size; CI, confidence interval.

pruning trees from ladders. A similar rank order and percent distribution were seen in the first survey period. The most common sources of injury were plants/trees/vegetation, non-powered handtools, and agricultural and garden machinery in both survey periods (Table IV).

The majority of injuries required professional medical treatment (Table III). During period I, 78.3% of the injuries were treated in a hospital, emergency department, doctor's office/clinic, or migrant health clinic. First aid at the scene (5.2%) and other/missing (16.5%) comprised the remainder. During the second survey period, 85.2% of the injuries were treated at a hospital, emergency department, doctor's office/clinic, or migrant health clinic, with 9.4% classified as first aid at the scene (Table III).

To examine source of payment for medical expenses, injuries treated in a hospital, emergency department, doctor's office/clinic, or migrant health clinic (which suggested medical costs would have most likely been incurred) were selected, and cases reporting zero costs (e.g., a free visit to a migrant health clinic or public health department) removed. Cases that most likely incurred medical costs comprised 77.5% of the total injuries during

period I, and 83.6% of the total from period II (data not shown). Workers' compensation or an employer provided health plan were the source of payment for 60.9% of the cases thought most likely to involve medical costs during period I and 87.7% in period II. Further, the employer paid out of pocket in 12.2% of these cases in period I and 5.8% of the cases in period II.

DISCUSSION

The collaboration between USDOL/ETA and NIOSH enables the collection of data in order to provide injury estimates of hired crop workers in the US on a national level. NAWS is the only national level surveillance system providing case specific injury information for this population of workers that is often marginalized, underserved, and hard to reach. The aim of this study was to provide a descriptive analysis of the NAWS injury module for the 2008–2010 data collection period and provide a comparison of these data to the earlier data collection period. It is hoped that findings from this study will contribute to the awareness of, and

TABLE IV. Injury Event and Source of Injury Among Hired Crop Workers in the United States During NAWS Period I (1999, 2002–2004) and Period II (2008–2010)

Injury variable (OIGCS code)	Data collection years			
	Period I		Period II	
	Weighted percent n = 374	95%CI	Weighted percent n = 141	95%CI
Injury event ^a				
Transportation incidents (2)	7.5	4.4–10.6	2.6	1.9–3.3
Roadway incidents involving motorized land vehicle (26)	4.0	1.4–6.5	2.3	1.8–2.8
Falls/slips/trips (4)	21.1	16.2–26.1	25.8	17.3–34.2
Slip or trip without fall (41)	5.1	2.8–7.7	12.5	8.2–16.8
Falls to lower level (43)	10.2	6.8–13.7	–	–
Exposure to harmful substances or environments (5) ^b	8.2	4.7–11.7	–	–
Contact with objects and equipment (6) ^b	33.5	25.1–41.8	32.5	25.8–39.3
Struck by object or equipment (62)	20.5	14.3–26.8	23.6	18.7–28.5
Injured by handheld object or equipment (625)	13.1	9.2–17.0	10.9	7.3–14.6
Rubbed or abraded by friction or pressure (66)	2.9	1.5–4.3	3.9	2.4–5.3
Overexertion and bodily reaction (7)	26.5	18.2–34.9	33.3	24.6–42.1
Overexertion involving outside sources (71)	24.9	16.6–33.1	20.2	11.8–28.6
Overexertion in lifting, lowering (711)	22.3	13.8–30.8	17.3	9.2–25.5
Other exertions or bodily reactions (73)	–	–	9.3	5.2–13.4
All other	–	–	–	–
Source of injury ^a				
Chemicals (1) ^b	4.8	2.1–7.6	–	–
Containers (2)	15.0	8.1–22.0	14.1	4.7–23.5
Machinery (3)	10.3	5.5–15.1	8.3	4.5–12.2
Agricultural and garden machinery (31)	8.7	4.0–13.3	8.1	4.2–11.9
Parts and materials (4) ^b	–	–	8.2	7.0–9.4
Persons/animals/plants/minerals (5)	19.6	12.9–26.3	25.0	19.4–30.6
Plants/trees/vegetation—not processed (58)	12.9	6.5–19.4	13.6	9.6–17.6
Structures and surfaces (6)	11.1	7.7–14.4	6.7	4.0–9.4
Floors/walkways/ground (66)	8.9	5.7–12.1	6.2	3.5–9.0
Tools/instruments/equipment (7)	21.8	15.7–28.0	21.7	13.1–30.3
Handtools—non-powered (71)	13.1	9.2–17.0	11.5	7.7–15.2
Vehicles (8)	11.6	8.4–14.3	11.2	8.3–14.1
Offroad vehicles, non-industrial (84)	6.2	3.4–8.9	3.5	2.2–4.8
Industrial vehicles (86)	4.7	3.0–6.5	7.3	4.6–10.0
All other	5.0	2.0–8.0	–	–

NAWS, National Agricultural Workers Survey; n, sample size; CI, confidence interval.

^aInjury event and source of injury derived from Bureau of Labor Statistics (BLS) Occupational Injury and Illness Classification System (OIGCS) Version 2.01 (2012).

^bEstimates for periods I and/or II not displayed due to coefficient of variation not meeting reportable limit.

ultimately the reduction in, non-fatal injuries to hired crop workers on US farming operations.

Demographics

Similar to previous NAWS reports, hired crop workers in both survey periods are predominately male, foreign-

born, and of Mexican origin [Mines et al., 1997; Mehta et al., 2000; Carroll et al., 2005]. The change in demographic patterns observed in this study may be related to an overall shift in migration that initiated in 2007. A recent Pew publication reported that immigration from Mexico to the US dropped after the economic downturn and nearly twice as many Mexicans returned home than had done so previously according the 2010 Mexican census

[Passel et al., 2012]. Brownell and Rendall [2014] also reported a steep drop in migration from Mexico to the US immediately following the start of the recession in 2007 with the average number of migrants from Mexico declining from 790,000 per year (2005–2007) to 540,000 per year (2008–2011). Brownell and Rendall found that this decrease in Mexico to US migration was observed among undocumented migrants as opposed to a small increase observed for the number of migrants with “documents to work” who had made previous border crossings. This decline among the undocumented was most likely the younger and less experienced agricultural workers. Although a downturn of migration to the US might suggest a labor shortage, the USDA reported that the farm labor force remained relatively constant during the 2007–2009 recession [USDA Economic Research Service, 2014]. This suggests that either older workers remained in the workforce longer, or newly hired farm workers came from elsewhere, perhaps from the US labor force. These migration shifts would most likely lead to a larger proportion of the hired crop workers being older, US born, settled workers, with more years of farm work experience, all of which were observed in this study. Also observed were more workers speaking English and higher educational attainment. If this hypothesized relationship between migration and hired crop worker demographics is in fact strong, then the hired crop worker demographics might see an influx of young workers with less work experience as the economy gains strength. However, these changes could also be part of a permanent long-term shift in the farm labor force with the recession accelerating the changes.

Injury

Although the overall injury risk significantly decreased between the two survey periods, the NAWS data illustrate the differences of injury that persist on US farm operations. Significant risk was observed between the two periods and also within each period. Characteristics shown to put workers at higher risk during period I compared to period II included being less than 25 years of age ($OR_{ADJ} = 2.5$, $P < 0.01$), being a direct hire ($OR_{ADJ} = 1.7$, $P < 0.01$), having 2–5 years ($OR_{ADJ} = 2.5$, $P = 0.02$) and 6–10 years of farm work experience ($OR_{ADJ} = 2.0$, $P = 0.02$). The demographic shifts in immigration could partially explain the changes observed with regard to age and years of farm work experience, but more data are needed to examine the replacement labor force to account for the large decrease in workers that ceased migration to the US following the economic recession.

An examination of injury risks within period I showed workers at a significantly greater risk included those

classified as migrant ($OR_{ADJ} = 1.6$, $P = 0.01$), direct hire ($OR_{ADJ} = 2.6$, $P < 0.01$) and those self-reporting a health condition ($OR_{ADJ} = 1.7$, $P = 0.02$). In period II, there was a linear increase in injury rate as duration of farm work increased, but the relationship was not significant. This linear increase could also be misleading as the injury rates for inexperienced workers (less than 2 years) could not be reported; we are, therefore, unable to determine if inexperienced workers were at decreased or increased risk of injury compared to more experienced workers during period II. Also during period II, workers self-reporting as a citizen were at greater risk compared to those self-reporting as undocumented ($OR_{ADJ} = 2.1$, $P = 0.05$).

Those who self-reported handling pesticides had a significant increased injury risk ($OR_{ADJ} = 2.1$, $P = 0.02$) during period II. However, it is important to note that the pesticide handling item in NAWS is for crop workers who “mixed, loaded, or applied pesticides” and is not an overall pesticide exposure measure. Calvert et al. [2008] reported that of acute pesticide poisoning cases, 67% were doing routine farm work not associated with pesticide application. Off-target drift and contact with pesticide residues related to early re-entry into pesticide treated areas were the most common exposure mechanisms.

Both survey periods had a high proportion of injury events classified by the BLS OIICS injury event codes as “overexertion and bodily reaction,” comprising 26.5% and 33.3% of all injuries in the respective survey periods. The subcategories of overexertion, however, showed that the types of overexertion incidents varied between the two survey periods. During period I, nearly all of the overexertion incidents involved the exertion of force upon an external object, such as lifting or moving of boxes or crates. During period II, about one-third of the overexertion cases involved bodily reactions such as slipping, walking, or bending, without force being applied to an external object such as lifting heavy crates. These latter types of injuries were not seen in period I. Moreover, the elevated prevalence of a musculoskeletal condition among all study participants persisted between periods.

Musculoskeletal conditions are of particular concern on crop operations due to heavy lifting tasks; prolonged bending, stooping, and other awkward postures; and repetitive hand movements involved in planting and harvesting seasons. Previous studies have shown an association between agriculture work tasks and chronic musculoskeletal pain [Fathallah et al., 2008; Shipp et al., 2009; Swanberg et al., 2012; Xiao et al., 2013]. Moreover, many studies have demonstrated an association between musculoskeletal complaints and increased risk of injury on the farm [Zwerling et al., 1995; Sprince et al., 2003; Voaklander et al., 2006]. Compared to NAWS data, two recent regional studies reported a higher prevalence (40%) of musculoskeletal pain among hired crop workers [Villarejo

and McCurdy, 2008; Arcury et al., 2012]. Last, age has been found to be positively associated with chronic musculoskeletal pain [Xiao et al., 2013].

Similarly, muscular sprain and strain to the back and upper extremity were common in both survey periods, with sprain and strain increasing to 50% of the total injuries in period II. Other studies have also reported sprain and strain as the leading type of injury in farm workers across the US [Earle-Richardson et al., 2003; McCurdy et al., 2003; Brower et al., 2009; McCurdy et al., 2013; Weigel et al., 2014]. This is of particular concern for older workers as research has shown older workers experience more severe non-fatal injuries than younger workers [Myers et al., 2009]. These results suggest that hired crop workers in the US are becoming older, have prolonged exposure to manual labor from farm work, and are at risk for health effects related to musculoskeletal conditions due to the nature of the work on the farm.

Analyses from the injury narratives indicated that many of the overexertion injuries involved the lifting of boxes, bags, and bales of produce. Safe labor-aids or mechanization equipment for these tasks such as the use of adjustable extended handles, high-lifting platforms, and conveyors could reduce exposure to heavy lifting [Fathallah, 2010]. For example, a laboratory effort to redesign a typical apple picker bucket with a hip belt and modified shoulder strap showed significant load transfer of the apple bucket from the shoulders to the hips [Freivalds et al., 2006]. Earle-Richardson et al. [2005] tested the hip belt with an apple picking bag in a group of apple harvesters and found the majority of workers positively perceived the modified bag, citing upper back relief; however, workers were concerned that safety interventions could slow their work.

Many of the falls to a lower level involved a worker picking fruit or pruning trees. Among the pruning-related injuries, some narratives specified that pruning scissors were being used. This suggests that workers could have had both hands on the pruning shears and were, therefore, unable to maintain contact with the ladder. Not maintaining proper contact with the ladder is cited as one of the primary causes of falls from orchard ladders [Occupational Safety and Health Administration [OSHA], 2014]. This OSHA orchard ladder safety information addresses safe practices while picking fruit from a ladder while carrying heavy bags. Lacerations were also a common injury. Lacerations from slipping handheld tools during harvest may be reduced with the universal implementation of cut-resistance gloves and clothing.

In period II, 85% of the injuries required treatment by a professional healthcare establishment. Of these, 94% were paid by workers' compensation, an employer health plan, or the employer paid out of pocket. Previous reports indicated hired crop workers had limited access to healthcare due to fear of job loss, lack of knowledge navigating the US medical

system, and cultural and language barriers [Villarejo et al., 2000; Rosenbaum and Shin, 2005; Arcury and Quandt, 2007]. Therefore, a comprehensive analysis of NAWS healthcare variables could help describe present-day health services available and individual access-to-care barriers in the US for hired crop workers.

Strengths and Limitations

As previously outlined by Steege et al. [2009] and Wang et al. [2011], there are several strengths and limitations of NAWS. Starting with limitations, selection bias could exist in part due to non-response on the employer level between those who allowed their employees to participate in the NAWS and those who did not. Response bias could also occur on the participant level, for example, a worker not feeling comfortable talking with an interviewer due to fear of employer retribution; however, the worker participation rate was over 90% for each year of the study making this bias less likely.

The eligibility criteria of the NAWS may limit the ability to calculate a true injury rate as well. Workers who have not worked for at least one of the prior 15 consecutive work days are not eligible to participate in the survey. Due to the cross-sectional nature of the NAWS, workers not on the farm the day the interviewer is present could be missed, possibly due to a severe injury limiting ability to work during the last 15 days. Also, exclusion of workers participating in the H-2A permit program in NAWS is a factor to consider. It is not known how the exclusion of H-2A workers from the NAWS sampling methodology influences the injury rates in this study. H-2A workers face the same exposures and are at risk for the same injuries and illnesses as other hired crop workers. Lastly, the 12-month recall period could result in under reporting of injuries among workers participating in NAWS.

The sensitivity of the NAWS injury screening question to correctly identify work-related injuries among crop workers is currently unknown. There could be a cognitive bias among crop workers leading to varying degrees of understanding of the injury at work screening question but evaluation studies have not been conducted to the authors' knowledge. For example, it is possible that foreign-born hired crop workers with less employment experience on US farms might not have the same perception or understanding of what is meant by an injury at work. The language differences identified by Cooper et al. [2006] led NIOSH to modify the injury screening question used in NAWS to include examples of the most common incidents among this population to help define the scope of the types of injuries to be included, and to reduce both cognitive bias from language barriers and recall bias of the injury incidents. If these examples did reduce cognitive bias and recall bias then this

study saw increased sensitivity of injury identification in period II compared to period I, but further evaluation is required for confirmation.

The average sample size was about 3,400 per year during period I compared to an average of 1,900 per year during period II. The smaller sample sizes during period II did not allow for examination of the data in the same detail that was available during period I. For example, we could not calculate injury rates during period II for categories such as migrant workers, workers hired indirectly (through a labor contractor), and workers with less than 2 years of farm work experience. Also, an examination of medical treatment venue proved difficult. It was not always clear when trying to differentiate between a hospital, emergency department, private doctor's office/clinic, or migrant health clinic; thus, these are grouped together to represent a formal medical venue.

Despite the aforementioned limitations, the NAWS is currently the only national level surveillance available for hired crop workers. We believe that the NAWS multi-stage probability sample encompassing the geographical distribution of the crop production at the national level, with data collection nearly year-around to capture the seasonality of crops, provides work history information for development of denominators (yielding FTE_{WB} calculations); and with fairly acceptable response rates, provides data that can be generalized to hired crop workers across the US. The NAWS weighting procedures were also independently validated [Williams et al., 2009]. The specific definition of a work-related injury within the NAWS allows for precise injury identification, while excluding minor injuries.

Lastly, our study is unique in that we provide a comparison of injury rates between two periods of time while adjusting for the number of weeks worked on crop operations during the last 12 months. These data enable an understanding of the risk factors that lead to occupational injury (and, therefore, quality of life) outcomes for this group of workers in the US. This report finds many long-standing trends and also shows changes that are taking place in this labor force. Another NAWS injury module implemented in 2014 and 2015 will allow further insight into risk factors for injury on US crop operations over time.

CONCLUSION

The aim of this report was to provide occupationally related surveillance and injury data among hired crop workers working on US farms for the purpose of targeting risk exposures. Based on our findings, injury prevention efforts that target exposures to overexertion and repetitive motion tasks (thus being responsive to an aging workforce), unsafe ladder use, and pesticide exposure could benefit hired crop workers in the US. Communication between farm

operators and farm workers with agriculture safety and health organizations could lead to prevention innovations that are site/farm specific.

AUTHORS' CONTRIBUTIONS

Both authors made substantial contributions to analysis and interpretation of data, drafting of the manuscript, and are accountable for ensuring any questions related to the integrity of this work are appropriately resolved.

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AUTHORS' DISCLAIMER

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention or the Association of Schools and Programs of Public Health.

CONFLICT OF INTEREST

The authors have no known conflicts of interest associated with this publication that could have influenced its outcome.

DISCLOSURE BY AJIM EDITOR OF RECORDS

Rodney Ehrlich declares that he has no competing or conflicts of interest in the review and publication decision regarding this article.

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