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Prevalence of Musculoskeletal Symptoms Among Agricultural Workers in the United States: An Analysis of the National Health Interview Survey, 2004–2008

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ABSTRACT. Ergonomic risks from agricultural tasks can compromise musculoskeletal health of workers. This study estimated prevalence of musculoskeletal symptoms in a sample representing almost 2 million US agricultural industry workers. This study used National Health Interview Survey data from 2004 to 2008. Weighted prevalence was calculated by demographic and employment factors. Prevalence ratios were calculated using generalized linear models with the Poisson distribution assumption. Prevalence rates of low back and neck pain in the previous 3 months were 24.3% and 10.5%, respectively, among agricultural workers. Monthly prevalence of joint pain was 17.0% for hips/knees, 9.8% for shoulders, 9.5% for wrists/hands, 5.4% for elbows, and 4.7% for ankles/toes. Agricultural workers had a significantly higher prevalence of shoulder pain than all other industry workers (prevalence ratios [PR] = 1.28, 95% confidence interval [CI]: 1.02–1.61). This study provides detailed national estimates of musculoskeletal symptom prevalence to understand the burden and the need for intervention among agricultural workers.

KEYWORDS. Agriculture, joint pain, low back pain, musculoskeletal symptoms, national survey

INTRODUCTION

The agricultural industry relies substantially on physical labor and is well known to be one of the most hazardous industries. In the United States, during the past decade, 500–700 workers in the agriculture, forestry, fishing, and hunting sector have died annually

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health or the National Center for Health Statistics.

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from occupational injuries.[1] In 2011, farmers, ranchers, and other agricultural managers had a fatal occupational injury rate of 26.1 per 100,000 full-time equivalents (FTE), which was seventh highest among all occupations in the United States.[2] Nonfatal occupational injury rates were also higher in agriculture (5.1 per 100 FTE in crop production and 6.4 per 100 FTE in animal production vs. 3.6 for all industries combined).[3] Certain agricultural tasks can compromise the musculoskeletal health of agricultural workers. These agricultural tasks commonly involve heavy lifting, carrying objects, repetitive motions, and awkward postures, including stooping, twisting, and overreaching. Tractor work also imposes ergonomic risks from whole-body vibration and prolonged sitting.[4,5] Acute and cumulative exposures to these ergonomic risk factors contribute to the development of musculoskeletal disorders (MSDs).

In epidemiologic studies using varying measures and populations, the annual prevalence of musculoskeletal symptoms ranged between 40% and 73% among US agricultural workers,[6–9] and a medical visit due to back pain was reported among 23–34% of farmers or farm residents.[9,10] In 2011, more than 1,500 US farm workers or laborers lost work time for a median 7 days due to MSDs.[3] In the State of Washington, the direct cost spent for work-related MSDs in the neck, back, and upper extremity between 1995 and 2007 exceeded $136 million among workers employed in the agriculture, forestry, fishing, and hunting industries.[11] These findings are helpful to understand the magnitude and some characteristics of MSDs among US agricultural workers but are incomplete. Detailed MSD prevalence information from a nationally representative sample is needed for an understanding of the total burden and characteristics of MSDs among US agricultural workers.

The National Health Interview Survey (NHIS) is an annual survey of the US civilian noninstitutionalized population conducted by the National Center for Health Statistics (NCHS) and collects a wide range of health-related information, including MSDs, to monitor the health of the US population.[12] This study was conducted to estimate the prevalence of musculoskeletal symptoms in US agricultural workers by demographic and employment characteristics using NHIS data from 2004 to 2008.

MATERIALS AND METHODS

Study Sample

NHIS is a cross-sectional, in-person household interview survey using a complex sample design.[12] Every year, a nationally representative sample of 35,000–40,000 households containing 75,000–100,000 persons is selected by a multistage clustered sampling method. The sampling method involves creating geographically defined and stratified primary sampling units (PSUs) and systematic sampling of dwelling unit clusters within selected PSUs.[13] Black, Hispanic, and Asian persons are oversampled to better represent these minority groups. Black, Hispanic, and Asian adults aged 65 or older are also oversampled. The household response rate ranges from 87% to 91%.[12]

The 2004–2008 NHIS sample consisted of 132,203 adults aged 18 or older. Of these, 987 participants were currently employed in the agricultural industry, including crop and animal production and supportive activities for agriculture. Current employment was defined as those who were "working for pay at a job or business," "with a job or business but not at work," or "working, but not for pay, at a family-owned job or business" during the week prior to the interview. This definition is consistent with the methods used by NCHS[14] and captures workers who were on leave of absence or vacation and also unpaid family labor, which is relatively common in agriculture. Agricultural workers were identified based on industry and occupation information by two steps. First, by the 1997 North American Industry Classification System (NAICS), all cases coded as "crop production" or "animal production" were identified. Next, cases coded as "agricultural workers" for occupation by the 2000 Standard Occupational Classification (SOC) system were further identified among records with the NAICS category "support activities for agriculture and forestry."

By the NAICS definition, support activities for agriculture refer to those providing support services essential for agricultural production and these support activities may be performed by the agriculture establishment or conducted independently.[15] When the survey sample weights were applied, the sample size of 987 for the 5-year time period was determined to represent an estimated 1,715,385 agricultural workers annually.

Variables and Measures

NHIS included questions about musculoskeletal symptoms for low back, neck, shoulders, elbows, wrists, fingers/thumbs (hands), hips, knees, ankles, and toes. Low back pain and neck pain were assessed by the questions "During the past 3 months, did you have low back pain [neck pain] that lasted a whole day or more?" Pain in other body regions was assessed by the questions "During the past 30 days, have you had any symptoms of pain, aching, or stiffness in or around a joint?" and "Which joints are affected?" For each outcome, those who answered "Yes" were defined as a case, and those who answered "No" or did not provide an answer were defined as not being a case.

Demographic variables included age, sex, and race/ethnicity. Employment variables included the type of current employment, the number of employees at the workplace, and types of agricultural industry and occupation. The type of current employment was categorized as paying job (working for pay at a job or business, or with a job or business but not at work) and nonpaying job (working, but not for pay, at a job or business). The type of agricultural industry included crop production, animal production, and support activities for agriculture. Based on the SOC codes, the type of occupation was categorized as farm workers, farm supervisors, management occupations, and other. Farm workers and farm supervisors were further categorized as those in crop production and in animal production.

Statistical Analysis

Data analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC) and SUDAAN version 10.0 (RTI International, Research Triangle Park, NC). Taking account of the design effects by complex sampling, variance estimates were adjusted for the survey sampling units, strata, and weights assigned by NCHS. Weighted prevalence rates of musculoskeletal symptoms among agricultural workers were estimated by demographic and employment characteristics. Point estimates with relative standard error (RSE) of $>30\%$ and $\leq 50\%$ are noted with an asterisk (*), and estimates with RSE of $>50\%$ are not reported as they do not meet the NCHS standards of reliability.[16] Total numbers of symptom cases within the US agricultural worker population were estimated by applying prevalence estimates to the annual population estimates from the survey sample. Prevalence estimates were compared by demographic and employment characteristics using the PROC LOGLINK procedure with a Poisson distribution assumption. Prevalence ratios (PRs) and 95% confidence intervals (CIs) were calculated adjusting for other demographic and employment variables. In addition, prevalence estimates of musculoskeletal symptoms were compared between agricultural workers and all other industry workers ($N = 76{,}632$), and PRs and their 95% CIs were calculated adjusting for demographic variables. As NHIS is a survey of the civilian population and is not designed to include a representative sample of the military population, persons in the armed forces ($n = 578$) were excluded from analysis.

RESULTS

Study Sample

Table 1 presents the study sample and the estimated average annual agricultural worker population by demographic and employment characteristics. Among the agricultural workers represented by the sample, 77.9% were male, 60.8% were between ages 25 and 54 years, 65.8% were non-Hispanic white, 83.0% were paid workers, 64.8% worked at small establishments with less than 10 employees, 55.5% worked in crop production, 41.1% worked in animal production, 41.8% were farm workers, and 45.8% had management occupations. Looking

TABLE 1. Sample[a] Size and Estimated Annual Population for Agricultural Industry Workers by Demographic and Job Characteristics, United States, 2004–2008

Characteristics	Sample size	Estimated annual population	Estimated population percent
Total	987	1,715,385	100.0
Sex			
Male	752	1,336,365	77.9
Female	235	379,020	22.1
Age			
18–24	113	214,079	12.5
25–34	212	358,722	20.9
35–44	198	345,299	20.1
45–54	190	340,483	19.8
55–64	156	254,165	14.8
65+	118	202,636	11.8
Race/ethnicity			
White, non-Hispanic	577	1,128,949	65.8
Hispanic	367	523,920	30.5
Other	43	62,516	3.6
Type of employment			
Paying job	827	1,423,007	83.0
Nonpaying job	160	292,378	17.0
No. of employees			
<10	597	1,111,484	64.8
10–99	249	395,649	23.1
100+	85	147,219	8.6
Unknown	56	305,166	17.8
Type of agricultural industry			
Crop production	562	951,980	55.5
Animal production	387	705,362	41.1
Supportive activities for agriculture	38	58,043	3.4
Type of occupation			
Ag workers, farming	460	716,849	41.8
Supervisors, farming	31	61,933	3.6
Management occupations	402	786,135	45.8
Other[b]	94	150,467	8.8
Type of agriculture and occupation combined			
Farm workers in crop production	288	444,100	25.9
Farm workers in animal production	134	214,706	12.5
Farm supervisors in crop production	26	55,459	3.2
Farm supervisors in animal production	5	6,474	0.4
Other	534	994,645	58.0

Data source: National Health Interview Survey, National Center for Health Statistics.
[a]Sample consists of adults of ages 18 and older who were working in the week prior to the survey.
[b]Included were various occupations (e.g., grounds maintenance workers, animal care workers, motor vehicle operators, financial clerks, business operations specialists, pest control workers, etc.).

at occupation by race/ethnicity of the sample, among non-Hispanic white workers, 64.5% had management occupations and 25.1% were farm workers (agricultural workers, farming); among Hispanic workers, 80.1% were farm workers and 4.4% had management occupations. For employment type, workers with nonpaying jobs accounted for 25.8% of non-Hispanic white workers and 1.1% of Hispanic workers (data not shown).

Musculoskeletal Symptom Prevalence: Agriculture Versus All Other Industries

Table 2 provides the estimated prevalence rates of musculoskeletal symptoms for agricultural and all other industry workers (see Appendix for prevalence by detailed industry). Among agricultural workers, the 3-month prevalence of low back or neck pain was 27.3%. The monthly joint pain prevalence was 17.3% for

TABLE 2. Weighted Prevalence (%) of Musculoskeletal Symptoms and Adjusted Prevalence Ratios (PRs)[a] for Agricultural Industry and All Other Industries, United States, 2004–2008

Symptoms	Agriculture ($N = 987$)				All other industries ($N = 77{,}152$)				Adjusted PR (Ref = all other)	95% CI
	n	%	*SE*	Estimated *N*[b]	*n*	%	*SE*	Estimated *N*[b]		
Low back/neck pain[c]	265	27.3	1.87	467,558	22,473	29.2	0.23	39,329,257	0.96	0.84–1.10
Low back pain	233	24.3	1.66	416,259	19,103	24.7	0.21	33,298,279	1.00	0.88–1.15
Neck pain	105	10.5	1.19	179,886	10,048	12.9	0.17	17,381,432	0.88	0.70–1.10
All upper extremity pain[d]	166	17.3	1.41	297,468	10,708	13.9	0.17	18,734,533	**1.18**	**1.01–1.38***
Shoulder pain	94	9.8	1.12	167,306	5,411	7.0	0.12	9,458,278	**1.28**	**1.02–1.60***
Elbow pain	50	5.4	0.74	93,036	3,030	4.0	0.10	5,359,644	**1.32**	**1.00–1.74***
Wrist/hand pain	85	9.5	1.16	163,696	6, 160	7.9	0.13	10,703,267	1.17	0.92–1.50
All lower extremity pain[d]	183	18.7	1.42	321,006	14,630	19.2	0.19	25,821,874	0.96	0.83–1.11
Hip/knee pain	163	17.0	1.31	291,578	13,079	17.1	0.17	23,041,694	0.97	0.84–1.13
Ankle/toe pain	49	4.7	0.80	80,823	4,233	5.6	0.11	7,517,506	0.86	0.62–1.21

Data source: National Health Interview Survey, National Center for Health Statistics.
[a]Prevalence ratios (PRs) are adjusted for age, sex, and race/ethnicity.
[b]The number of workers with the condition was estimated using the estimated total population from the survey.
[c]Pain lasting a day or more in the past 3 months.
[d]Any symptoms of pain, aching, or stiffness during the past 30 days.
*$P < .05$.

upper extremities (shoulders, elbows, wrists, or hands) and 18.7% for lower extremities (hips, knees, ankles, or toes). Compared with all other industry workers, agricultural workers had a significantly higher prevalence of upper extremity pain (17.3% vs. 13.9%; PR = 1.18, 95% CI: 1.01–1.38), specifically for shoulder pain (9.8% vs. 7.0%; PR = 1.28, 95% CI: 1.02–1.61), after adjustment for sex, age, and race/ethnicity. A nonsignificantly elevated prevalence of elbow pain among agricultural workers was also found (PR = 1.32, 95% CI: 0.99–1.76).

Prevalence by Demographic and Employment Characteristics Among Agricultural Workers

Table 3 provides musculoskeletal symptom prevalence rates among agricultural workers by sex, age, race/ethnicity, type of employment, the number of employees, and types of agricultural industry and occupation. Table 4 provides the prevalence ratio findings from multivariable analyses adjusting for all other covariates.

Female workers had higher prevalence rates than male workers for musculoskeletal symptoms in all body regions except for elbow. However, only neck pain (PR = 1.67, 95% CI: 1.08–2.56) and wrist/hand pain (PR = 1.67, 95% CI: 1.01–2.74) were significantly higher among female workers in the multivariable models. Increasing age was significantly associated with all musculoskeletal symptoms except for elbow pain. Compared with younger workers, workers in the 45–54 years age group had the largest PRs for low back pain (PR = 1.56, 95% CI: 1.14–2.12), shoulder pain (PR = 3.04, 95% CI: 1.47–6.31), and ankle/toe pain (PR = 2.72, 95% CI: 1.36–5.46). For the prevalence by race/ethnicity, non-Hispanic whites had higher prevalence rates for all symptoms except for ankle/toe pain compared with Hispanic or other workers. A significant difference by race/ethnicity was found only for hip/knee pain, where the adjusted prevalence was 48% lower among Hispanic workers than non-Hispanic white workers (PR = 0.52, 95% CI: 0.29–0.94).

Regarding employment characteristics, workers with a nonpaying job and employed in small-size establishments (<10 employees) tended to have higher prevalence rates of musculoskeletal symptoms, but none of the differences were statistically significant. For type of agricultural industry, crop production workers had higher prevalence rates of shoulder pain, elbow pain, and ankle/toe pain than animal production

TABLE 3. Musculoskeletal Symptom Prevalence (Weighted) in Agriculture by Sex, Age, Ethnicity, Number of Employees, and Type of Agricultural Industry and Occupation, United States, 2004–2008

Characteristics	Low back[b]		Neck[b]		Shoulders[c]		Elbows[c]		Wrists/hands[c]		Hips/knees[c]		Ankles/toes[c]	
	%	*SE*	%	*SE*	%	*SE*	%	*SE*	%	*SE*	%	*SE*	%	*SE*
Sex														
Male	23.6	1.7	9.2	1.2	9.4	1.3	5.5	0.9	8.3	1.3	16.0	1.4	4.3	0.9
Female	26.7	3.7	14.9	2.6	11.0	2.3	5.2	1.5	13.9	2.7	20.4	3.0	6.2	1.6
Age														
18–24	14.9	4.4	§		0	—	0	—	0	—	§		0	—
25–34	20.0	3.2	6.5*	2.2	§		3.6*	1.6	6.0*	2.3	11.2	2.6	3.9*	1.4
35–44	22.8	3.5	11.2	2.4	8.3	2.2	6.4	2.0	9.5	2.2	11.2	2.8	4.4*	1.5
45–54	33.9	3.8	13.6	2.9	15.4	2.7	7.7	2.3	12.8	2.9	23.5	3.2	7.7	2.2
55–64	23.9	3.4	12.2	2.8	16.7	3.4	7.6	2.2	12.7	2.9	23.8	3.2	6.9*	2.1
65+	28.5	4.9	16.4	4.0	16.0	3.4	6.1*	2.5	16.6	4.8	33.6	4.6	3.9*	1.7
Race/ethnicity														
White, non-Hispanic	26.7	2.1	11.3	1.6	12.1	1.6	5.8	1.0	11.1	1.5	21.0	1.7	4.6	0.9
Hispanic	18.8	2.6	8.9	2.0	4.7	1.2	5.0	1.3	6.9	1.9	8.5	2.0	4.7*	1.7
Other	25.3*	9.1	8.8*	4.3	§		§		§		16.3*	5.6	§	
Type of employment														
Paying job	23.8	1.8	9.4	1.2	8.2	1.1	5.0	0.8	8.8	1.3	16.2	1.4	4.5	0.9
Nonpaying job	26.3	4.1	15.6	3.9	17.2	3.3	7.3	2.0	13.3	3.0	20.9	3.1	5.6	1.7
No. of employees[a]														
<10	26.1	2.1	12.3	1.7	12.4	1.6	5.7	1.0	11.7	1.5	20.7	1.8	5.4	1.0
10–99	18.8	2.9	7.0	1.7	4.6*	1.5	5.0*	1.6	5.7*	1.8	10.4	2.1	3.9*	1.4
100+	28.8	6.1	9.2*	3.3	§		§		6.9*	3.2	10.9*	3.6	§	
Type of Ag industry														
Crop production	22.2	2.1	10.3	1.4	10.7	1.5	6.6	1.2	8.6	1.4	16.5	1.8	5.0	1.2
Animal production	27.6	2.5	11.1	1.8	8.3	1.8	3.3	0.9	10.3	1.9	17.9	2.2	4.2	1.0
Supportive activities	17.8*	7.5	§		12.1*	5.6	12.6*	6.1	16.7*	7.6	§		§	
Type of Ag occupation														
Ag workers, farming	21.1	2.3	9.4	1.6	9.0	1.4	7.1	1.3	9.6	1.7	15.7	2.0	5.9	1.5
Supervisors, farming	§		§		0	—	0	—	0	—	§		§	
Management occupations	27.6	2.5	12.4	2.2	11.8	1.9	4.7	1.0	10.9	1.8	19.7	2.1	4.1	1.1
Other	28.0	4.9	7.1*	2.5	6.5*	2.4	3.2*	1.4	6.0*	2.3	15.1	3.8	3.0*	1.4
Type of agriculture and occupation combined														
Farm workers in crop production	20.4	2.0	9.9	1.2	11.2	1.6	8.4	1.2	9.7	1.6	15.9	1.7	6.5	1.7
Farm workers in animal production	23.5	3.0	9.2	2.4	§		3.0*	1.5	7.4*	2.2	15.8	4.0	4.7	0.8

Data source: National Health Interview Survey, National Center for Health Statistics (NCHS).

[a]The category of unknown is not presented.

[b]Pain lasting a day or more in the past 3 months.

[c]Any symptoms of pain, aching, or stiffness during the past 30 days.

*These estimates have a relative standard error (RSE) of >30% and ≤50%. Caution is required as they do not meet the NCHS standards of reliability/precision.

§Estimates with a RSE of >50% are not reported, as they do not meet standards of reliability/precision.

TABLE 4. Adjusted Prevalence Ratio (PR)[a] and 95% Confidence Intervals for Musculoskeletal Symptoms in Agriculture, United States, 2004–2008

Characteristics	Low back[b]		Neck[b]		Shoulder[c]		Elbow[c]		Wrists/hands[c]		Hips/knees[c]		Ankles/toes[c]	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Sex														
Male	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Female	1.01	0.72–1.41	**1.67**	**1.08–2.56**	1.15	0.70–1.89	0.88	0.43–1.77	**1.67**	**1.01–2.74**	1.19	0.86–1.65	1.31	0.65–2.63
Age														
18–44[d]	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
45–54	**1.56**	**1.14–2.12**	1.68	0.93–3.02	**3.04**	**1.47–6.31**	2.15	0.89–5.18	**2.11**	**1.05–4.22**	**2.26**	**1.44–3.54**	**2.72**	**1.36–5.46**
55–64	1.11	0.76–1.63	1.49	0.79–2.79	**2.92**	**1.54–5.55**	2.13	0.88–5.14	**2.01**	**1.01–4.00**	**2.36**	**1.49–3.75**	**2.43***	**1.10–5.36**
65+	1.30	0.88–1.90	**1.91**	**1.06–3.45**	**2.65**	**1.33–5.29**	1.51*	0.57–4.01	**2.61**	**1.12–6.10**	**3.11**	**2.00–4.82**	1.30*	0.45–3.75
Race/ethnicity														
White, non-Hispanic	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Hispanic	0.86	0.58–1.28	1.39	0.73–2.63	0.62	0.29–1.31	0.68	0.24–1.92	1.04	0.46–2.35	**0.52**	**0.29–0.94**	1.21*	0.44–3.35
Other	1.01*	0.48–2.12	0.82*	0.27–2.44	§		§		§		0.75*	0.36–1.56	§	
Type of employment														
Paying job	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Nonpaying job	0.93	0.65–1.33	1.25	0.71–2.20	1.40	0.89–2.19	1.42	0.70–2.86	1.04	0.60–1.80	0.83	0.58–1.17	1.11*	0.52–2.35
No. of employees														
<10	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
10–99	0.90	0.61–1.31	0.66	0.35–1.22	0.59*	0.27–1.30	0.96*	0.39–2.40	0.59*	0.31–1.11	0.78	0.50–1.20	0.62*	0.27–1.40
100+	1.45	0.87–2.41	0.87*	0.42–1.80	§		§		0.74*	0.26–2.11	0.78*	0.37–1.63	§	
Type of Ag industry														
Crop production	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Animal production	1.17	0.92–1.49	0.99	0.66–1.48	0.64	0.39–1.04	**0.46**	**0.25–0.86**	1.03	0.64–1.65	0.90	0.65–1.24	0.87	0.45–1.68
Supportive activities	0.87*	0.37–2.06	§		1.08*	0.37–3.13	1.45*	0.47–4.47	1.90*	0.70–5.13	§		§	
Type of Ag occupation														
Ag workers, farming	0.94	0.66–1.32	0.98	0.55–1.74	1.46	0.85–2.49	**2.09**	**1.06–4.12**	1.32	0.77–2.24	**1.49**	**1.02–2.20**	2.19	0.97–4.91
Management occupations	1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Other	1.02	0.62–1.69	0.60*	0.26–1.39	0.87*	0.38–2.03	0.83*	0.27–2.57	0.65*	0.28–1.55	1.02	0.59–1.79	1.00*	0.33–3.04

Data source: National Health Interview Survey, National Center for Health Statistics.

[a] Prevalence ratios (PRs) are adjusted for all other covariates.

[b] Pain lasting a day or more in the past 3 months.

[c] Any symptoms of pain, aching, or stiffness during the past 30 days.

[d] Ages 18–44 were collapsed to one category because most prevalence estimates for age categories from 18 to 34 were unreliable.

*These estimates have a relative standard error (RSE) of >30% and ≤50%. Caution is required as they do not meet the NCHS standards of reliability/precision.

§ Estimates with a RSE of >50% are not reported as they do not meet standards of reliability/precision.

workers. A significant difference was found only for elbow pain; the adjusted prevalence was 54% lower in animal production than in crop production (PR = 0.46, 95% CI: 0.25–0.86). Regarding occupation, workers with management occupations had higher prevalence rates for neck pain, shoulder pain, wrist/hand pain, and hip/knee pain than other workers. However, after adjustment for covariates, farm workers had significantly higher prevalence rates than management workers for hip/knee pain (PR = 1.49, 95% CI: 1.02–2.20) and elbow pain (PR = 2.09, 95% CI: 1.06–4.12).

DISCUSSION

This study estimated national prevalence rates of musculoskeletal symptoms in the low back, neck, and upper and lower extremities by demographic and employment characteristics for US agricultural workers using a nationally representative sample. Low back pain was most prevalent, affecting one quarter of workers both in agriculture and other industries. Findings also suggest that agricultural workers have significantly increased risks of shoulder pain compared with other workers.

Study Population

This study identified agricultural workers based on NAICS industry codes. Using this industry-based definition, the study sample included heterogeneous occupations, not limited to farm operators and farm workers. The annual average size of the agricultural worker population 18 years of age or older estimated from the NHIS sample was about 1.7 million workers. This is smaller than the 2008 Bureau of Labor Statistics (BLS) Current Population Survey estimate of 2.2 million workers 16 years of age or older who were employed in the agricultural industry.[17] Both estimates are quite different from United States Department of Agriculture (USDA) data. In the 2007 Census of Agriculture,[18] more than 2.2 million principal farm operators and 1.1 million secondary farm operators were identified, and another USDA survey[19] estimated that over 900,000 workers were hired by farm operators in 2012. The discrepancy between BLS and USDA data clearly indicates a challenge in identifying accurate case numbers and prevalence and incidence rates in agricultural workers. The difference in the estimates between BLS and NHIS may be attributed to the discrepancy in the age inclusion criteria, sampling errors, and possible misclassification errors in identifying agricultural cases from the data.

Agricultural workers tend to live in rural areas and are more difficult to reach for interviews. They may also have multiple jobs—with agricultural work being just one of them. If NHIS participation occurs during a slow season, the worker may be working in another industry (e.g., construction, sales, etc.) and would not be coded as an agricultural worker. Additionally, it is likely that many hired farm workers are not captured in the NHIS, as it is primarily a household survey, and these farm workers may live in employer provided housing and may migrate (move to follow the crop) and hence be harder to locate. Many who lack authorization to work in the United States may be less willing to complete an interview.[20] Because we suspect that hired farm workers experiencing greater vulnerability were underrepresented in this study sample, our findings are likely to underestimate the true magnitude of MSDs among agricultural workers.

This study combined 5 years of data, yet the total sample of 987 agricultural workers was relatively small. Compared with BLS, the NHIS sample had a similar sex distribution and a lower proportion of workers aged 45 years or older; workers in animal production were overrepresented; and workers in establishments of supportive activities for agriculture were underrepresented.[21] On the other hand, whereas the BLS Survey of Occupational Injuries and Illnesses excludes self-employed and small farms with fewer than 11 employees,[22] our NHIS sample better represents this worker group by capturing a large proportion (64.8%) of workers in small establishments (<10 employees). Assuming that farms with a small workforce are synonymous with farms of small size, our NHIS sample is also similar to the USDA

Census data on the proportion (68.5%) of farms less than 179 acres in size.[18] Given the lower population estimates produced by NHIS, the estimated case numbers in this study should be regarded as underestimates of the true numbers, whereas its impact on the prevalence estimates is uncertain. In our study, some categories had sample sizes that were too small to produce reliable prevalence and PR estimates. Estimates with large relative standard errors (i.e., $>30\%$ and $\leq 50\%$) require special caution in interpretation.

Prevalence and Risk Factors

It should be noted that this study estimated 3-month prevalence for low back pain and neck pain and monthly prevalence for other joint pain. Along with this different time frame, low back and neck prevalence rates were about pain lasting a day or more, whereas other joint pain prevalence rates were about any symptoms. Prevalence rates measured by different definitions cannot be directly compared. As considerable variation in measuring MSDs exists across studies, the outcome definition should be carefully noted when comparing study findings. Our study estimates can be considered more conservative estimates, as we regarded unknown or missing answers for symptoms questions as noncases.

Our study estimated that one out of four US agricultural workers experienced low back pain in the previous 3-month period. Literature suggests that low back is the most common body part affected by ergonomic exposures, and the annual prevalence of low back pain ranged between 17% and 48% among agricultural workers.[6–9,23–25] In our study, the low back pain prevalence was similar between agriculture and all other industry workers. A British study using a national sample of workers also showed that the prevalence of low back pain was not significantly different between farm workers and blue-collar workers, but farm workers had a significantly higher prevalence than white-collar workers.[5] In a Swedish population-based study, farmers were shown to have a significantly higher prevalence of low back pain than nonfarmers.[26] Increased risk of back pain among agricultural workers are associated with heavy lifting, awkward posture such as stooping, and tractor work.[4,6,9,27] Ergonomic and administrative innovations to address these risk factors need to be adopted to protect back health among agricultural workers.

We found that agricultural workers had an increased prevalence of upper extremity pain compared with all other industry workers. In particular, shoulder pain prevalence was significantly higher among agricultural workers. Walker-Bone and Palmer[5] also found a higher prevalence of shoulder pain among farmers than other blue-collar and white-collar workers (11.8%, 9.7%, and 7.1%, respectively), but the differences were not significant. In a Swedish study,[26] Holmberg et al. measured shoulder and neck pain together and found no significant difference between farmers and nonfarmers. Considering that our study found a lower prevalence of neck pain among agricultural workers than all other industry workers, combining shoulder and neck pain might have masked an excess prevalence of shoulder pain among Swedish farmers. Our study estimated that 9.8% of US agricultural workers experienced shoulder pain in the previous month. Annual prevalence of shoulder pain ranged from 10% to 54% in other studies.[6–9,28] Risk factors such as working while arms are elevated, heavy lifting, and carrying loads on the shoulder should be considered in designing interventions for agricultural workers.[4,29]

Our study found that hip or knee pain was more prevalent than pain in any other extremity joint. Hip or knee pain was experienced among 17.0% of US agricultural workers in the previous month, and the risk increased with age. Hip or knee pain, particularly among older workers, might be related to arthritis. In our study, non-Hispanic workers showed 2 times significantly higher prevalence of hip or knee pain than Hispanic workers and this finding is in line with a report of a higher prevalence of arthritis among non-Hispanic adults in the general population.[30] Epidemiologic evidence suggests that occupational activities such as heavy lifting, standing, squatting, kneeling, or tractor work are

risk factors for pain or osteoarthritis in hips or knees.[6,31–33]

Among agricultural workers, this study identified only a few significant associations between musculoskeletal symptoms and employment characteristics. Our findings show that workers in crop production have 2 times higher prevalence of elbow pain than workers in animal production. Also, increased, albeit not significant, risk of shoulder pain was suggested for crop production. According to BLS, overall incidence of occupational illnesses is higher for crop production, whereas the incidence of occupational injuries is higher for animal production.[3] Our findings provide a broad snapshot of MSD prevalence for crop and animal production workers, and a detailed explanation for the higher MSD risk in crop production requires more research.

Farm workers' job assignments are more likely to be physically demanding on the extremities compared with farm managers. On the other hand, farm workers, particularly migrant and seasonal farm workers, might be more reluctant than managers to report injuries or symptoms, due to fears of job loss or of being perceived as unfit for work, or language and sociocultural barriers.[34] Our findings suggested that farm workers had an increased risk for pain in each of the extremity joints compared with those with management occupations, and these risks were significantly increased for elbow pain and hip/knee pain. The prevalence rates for extremity pain were 1.3–2.2 times higher among farm workers than workers with management occupations.

We hypothesized that working conditions and health and safety outcomes might be different by size of establishments. We, however, did not find significant differences in musculoskeletal symptom prevalence by employment size, although smaller and larger farms tended to have higher prevalence rates than medium-sized establishments. It should be noted that relative standard errors for large farms were high for most symptoms due to the small sample size. Our finding is consistent with the report by Gomez et al., who found no significant association between farm size and musculoskeletal symptoms.[6]

Among demographic factors, our study found that older age was significantly associated with increased prevalence of all musculoskeletal symptoms except elbow pain. Similarly, previous studies of farmers have shown significant associations between older age and back pain[25] and hand/wrist, neck/shoulder, hip, and knee troubles.[6] Degenerative changes with wear and tear and loss of muscle mass, strength, and function occur with aging,[35] and these contribute to the higher prevalence of MSDs among older workers. In our study, females were found to have a 1.7-fold higher prevalence of neck pain and wrist/hand pain compared with males, and this finding was statistically significant. This is consistent with findings by Gomez et al.[6] Women, in general, have shorter stature and less muscular mass than men. Because of their shorter height, women may be more likely to engage in frequent and prolonged neck extension for tasks above their heads. Because of having lower muscle mass, women may be more likely to be assigned hand labor tasks, placing them at risk of exposure to excessive wrist/hand forces when performing these tasks. Such differences in physical and task factors compared with men may contribute to the increased risk of neck and hand/wrist pain among female workers. Alternatively, perceptions and reporting of pain can be affected by sex and cultural factors, and higher prevalence may be due to higher reporting.[36–38] For race/ethnicity, Hispanic workers had a significantly lower prevalence of hip/knee pain compared with non-Hispanic white workers. Similarly, Alterman et al.[8] found a significantly lower prevalence of musculoskeletal pain and knee trouble among Latino farm operators than non-Latino white farm operators. It is not certain whether the lower prevalence among Hispanic workers is attributed to lower risk or lower reporting.

Limitations

This study has several limitations, which requires that our findings be interpreted cautiously. First, although this study used a nationally representative sample, the study sample may not be fully representative of the agricultural worker population, given the

discrepancy in agricultural workforce estimates produced by various government surveys, as addressed earlier. Second, healthy worker effects and survival bias may have resulted in underestimation of the prevalence of musculoskeletal symptoms. Third, this study relied on self-reported symptom data, which are subject to reporting bias. Underreporting is a known serious concern in passive occupational health surveillance systems;[39] however, it is not certain how much underreporting plays a role in face-to-face surveys such as NHIS, where data were collected confidentially and directly from workers. As the NHIS used relatively short time frames of 1 month or 3 months, errors in recall might be minor, especially for joint pain. Fourth, causal relationships cannot be determined with findings from this cross-sectional data. In addition, musculoskeletal symptoms asked in the NHIS are nonspecific regarding work-relatedness. Therefore, some of the musculoskeletal symptoms reported by agricultural workers may not have been caused by agricultural exposures. Lastly, multiple comparisons were made in this study, which may inflate the Type I error. However, this study did not make adjustments for multiple comparisons because such adjustments to control the Type I error increases the Type II error and can lead to errors of interpretation for observed data.[40]

CONCLUSION

Detailed prevalence data provided in this study are helpful to understand the national burden and distribution of musculoskeletal symptoms among US agricultural workers and related needs for intervention and healthcare resources. Our findings indicate the need for more effective MSD prevention strategies, especially for prevalent low back pain. Our study also showed that shoulder pain prevalence was significantly higher among agricultural workers than among workers in other industries. More research is needed to identify the ergonomic risk factors for specific agricultural worker groups and to identify specific interventions that are effective and acceptable to workers and employers.

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APPENDIX. Musculoskeletal Symptom Prevalence Estimates (Weighted) by Industry, United States, 2004–2008

Industry sector[†]	Low back			Neck			Shoulder			Elbow			Wrists/hands			Hips/knees			Ankles/toes		
	%	*SE*	Rank	%	*SE*	Rank	%	*SE*	Rank	%	*SE*	Rank	%	*SE*	Rank	%	*SE*	Rank	%	*SE*	Rank
Agriculture	24.3	1.7	13	10.5	1.2	20	9.8	1.1	1	5.4	0.8	3	9.5	1.2	4	17.0	1.3	9	4.7	0.8	16
Forestry, fishing, logging	29.6	3.9	1	22.5	3.5	1	6.8	1.9	12	8.2*	2.8	1	10.2	2.6	2	21.0	3.7	1	6.5*	2.3	2
Mining	26.1	2.9	9	11.8	2.0	16	7.8	1.6	7	2.6*	0.9	20	10.3	2.7	1	18.3	2.9	5	4.9	1.4	13
Utilities	23.9	2.0	16	11.7	1.6	17	9.2	1.3	2	4.7	0.9	5	6.5	1.1	17	16.5	1.6	13	4.9	1.0	13
Construction	27.2	0.7	3	12.2	0.5	14	8.4	0.4	3	5.5	0.4	2	8.4	0.5	9	16.9	0.6	11	5.4	0.3	9
Manufacturing	24.0	0.6	15	11.9	0.5	15	8.2	0.3	5	4.7	0.3	5	8.9	0.4	5	16.8	0.5	12	5.2	0.3	10
Wholesale trade	24.6	1.1	11	11.7	0.8	17	6.7	0.7	14	3.8	0.5	13	7.4	0.7	13	15.5	0.9	17	5.1	0.5	12
Retail trade	24.6	0.6	11	12.4	0.5	11	7.0	0.3	10	4.1	0.3	11	8.0	0.4	11	17.0	0.5	9	6.5	0.3	2
Transportation, warehousing	26.5	0.9	6	12.5	0.7	10	7.8	0.6	7	3.9	0.4	12	7.4	0.6	14	17.2	0.8	8	4.9	0.5	13
Information	22.9	1.2	17	11.1	0.8	19	4.6	0.5	20	2.4	0.4	21	7.1	0.7	15	14.0	0.9	19	4.5	0.6	19
Finance and insurance	21.4	0.8	21	13.3	0.8	7	6.1	0.5	16	2.7	0.3	19	5.9	0.4	20	14.8	0.7	18	3.9	0.4	20
Real estate, rental, leasing	24.7	1.2	10	14.0	1.0	3	7.7	0.8	9	4.6	0.7	7	8.4	0.8	8	16.5	1.1	13	7.5	0.8	1
Professional, scientific, and technical service	21.8	0.7	19	12.4	0.5	11	5.8	0.4	18	3.2	0.3	17	6.2	0.4	18	16.3	0.7	16	4.6	0.4	17
Management of companies and enterprises	27.4	7.3	2	§			§			§			§			13.3*	4.4	20	§		
Administrative and support and waste management and remediation services	26.4	1.0	8	13.6	0.7	5	6.9	0.5	11	4.9	0.5	4	8.6	0.6	7	18.3	0.9	5	6.5	0.6	2
Education services	22.0	0.6	18	13.0	0.5	8	6.2	0.3	15	3.5	0.2	14	8.1	0.4	10	17.9	0.5	7	5.8	0.3	7
Health care and social assistance	26.7	0.5	4	14.6	0.4	2	6.8	0.3	12	3.7	0.2	13	8.6	0.3	6	18.5	0.5	4	6.2	0.3	5
Arts, entertainment, and recreation	21.8	1.2	19	12.4	1.0	11	6.0	0.7	17	3.5	0.5	14	5.9	0.7	19	16.5	1.1	13	4.6	0.7	17
Accomodation and food service	26.7	0.7	4	12.7	0.6	9	5.0	0.3	19	2.9	0.3	17	7.0	0.5	16	13.3	0.6	20	5.2	0.5	10
Other services (excl. public administration)	26.5	0.8	6	13.6	0.7	5	8.4	0.5	3	4.5	0.3	8	9.8	0.6	3	18.9	0.7	3	5.7	0.4	8
Public administration	24.3	0.8	13	13.9	0.7	4	8.2	0.5	5	4.1	0.4	9	7.7	0.5	12	20.7	0.8	2	6.2	0.5	5

Data Source: National Health Interview Survey, National Center for Health Statistics (NCHS).

[†]Categories were by the 1997 North American Industry Classification System (NAICS) 2-digit codes.

[¶]These categories are under the same NAICS code, but were separated for this study purpose.

*These estimates have a relative standard error (RSE) of >30% and ≤50%. Caution is required as they do not meet the NCHS standards of reliability.

[§]Estimates with a RSE > 50% are not reported, as they do not meet standards of reliability.