

# Work-related upper extremity musculoskeletal disorders in the United States: 2006, 2009, and 2014 National Health Interview Survey

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## Abstract.

**BACKGROUND:** The annual incidence rate of work-related upper extremity musculoskeletal disorders (WUEMSDs) is increasing in US workers according to the United States Bureau of Labor Statistics (BLS). However, the prevalence of WUEMSDs among US total workers has not been estimated.

**OBJECTIVE:** We aimed to estimate the prevalence of WUEMSDs among US total workers and among each of major occupations and industries.

**METHODS:** We analyzed data from the National Health Interview Survey Arthritis supplements (2006, 2009, and 2014) among 50,218 current workers (age  $\geq 18$  years) to estimate the 30-day prevalence of WUEMSDs and of WUEMSDs affecting work using the SAS-callable SUDAAN software.

**RESULTS:** About 11.2 million workers reported WUEMSDs based on three surveys (2006, 2009, and 2014). The 30-day prevalence of WUEMSDs was 8.23%; the prevalence of WUEMSDs affecting work was 1.24%. The Construction occupation and industry had the highest age- and sex-adjusted 30-day prevalence of WUEMSDs (10.98% for Construction occupation; 9.94% for Construction industry) and WUEMSDs affecting work (3.32% for Construction occupation; 2.31% Construction industry).

**CONCLUSIONS:** Our results show that construction workers had the highest prevalence of both WUEMSDs and WUEMSDs affecting work. They may be a priority group for interventions to reduce upper extremity musculoskeletal disorders.

Keywords: Work-related upper extremity musculoskeletal disorder, prevalence, occupation, industry

## 1. Introduction

It is well known that upper extremity musculoskeletal disorders (MSDs) are work-related [1, 2]. Work-related upper extremity MSDs (WUEMSDs) are commonly reported as upper extremity musculoskeletal pain [3], musculoskeletal complaints [4], or musculoskeletal discomfort or problems [5].

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If neglected, WUEMSDs will likely progress to severe conditions which have a negative impact on workers' well-being, productivity, and healthcare costs [2].

Although the annual incidence rate of work-related MSDs from all body sites (i.e., including trunk and lower extremities) has declined according to a recent report from the United States Bureau of Labor Statistics (BLS) [<https://www.bls.gov/iif/oshcdnew.htm>], the incidence rate of WUEMSDs (i.e., shoulders, arms, hands, and fingers) has shown an increasing trend: from 23.2 per 10,000 workers in 2007, 22.9 in 2009, 31.5 in 2011, 31.6 in 2012, 31.5 in 2014, and 32.6 in 2015 in private industries [<https://www.bls.gov/iif/oshcdnew.htm>]. Workers with WUEMSDs take more days to recuperate before returning to work. For example, workers with carpal tunnel syndrome (CTS) did not report to work for a median of 32 days and those with tendonitis took 15 days, compared with 9 days for all work-related illnesses and injuries in 2014 [<https://www.bls.gov/iif/oshwc/osh/case/osch0055.pdf>].

The reports from BLS serve as a major resource for policy makers. However, undercounting of work-related injury and illness cases has been known to be an issue in the BLS reports. A certain degree of underreporting is unavoidable because the survey design used by the BLS Survey of Occupational Injuries and Illnesses excludes persons who are self-employed and work in households and small-farms [6]. In addition, the underreported cases due to other issues have been confirmed by the studies comparing the BLS reports with the numbers derived from workers' compensation data or hospital records. In Connecticut, the unreported WUEMSDs were 131,462 cases over a 7-year period [7]. The underreporting of nonfatal occupational injury and illness is substantial at both state level such as in Michigan [8] and at national level [9] when comparing worker's compensation data with the BLS Survey of Occupational Injuries and Illnesses data. Therefore, the information on WUEMSDs from the BLS may not be generalizable to the total US working population.

Work-related hazards for upper extremity MSDs vary by occupation in the US working population [10], suggesting that the prevalence of WUEMSDs may also vary by occupation or industry. However, the data sources do not appear to be readily available for estimating the prevalence. Previous reports for the national prevalence of work-related musculoskeletal conditions in the US working population are restricted to clinically diagnosed disorders such

as CTS [11, 12], and to one specific industry such as Agriculture [13].

The occupation- or industry-specific prevalence of WUEMSDs in the working population in European countries has been reported [14], but these findings may not provide information for US policy makers due to the different levels of occupational ergonomic factors, different compensation policies, and workers' different health behaviors. Even within the US, the prevalence of WUEMSDs in certain specific working groups such as health care providers [15], construction workers [16], and farmers [17] may be quite different from that of US workers overall because of variation in work-related MSD risk factors and ergonomics across occupations and industries. This study estimated the national prevalence of WUEMSDs as well as the prevalence of WUEMSDs affecting work in US total workers and by major occupational group and industry.

## 2. Materials and methods

### 2.1. Study design and data source

We used data from the National Health Interview Survey (NHIS) collected in 2006, 2009, and 2014 for the present analysis. The NHIS is an annual survey conducted by the National Center for Health Statistics (NCHS) of the US Centers for Disease Control and Prevention. A detailed description of the NHIS (2006–2015) design can be found in Vital and Health Statistics [18]. Briefly, the survey uses a multistage complex sampling design to generate a representative sample for the civilian and non-institutionalized population of the United States. In addition to the four core questionnaires (Household, Family, Sample Child, and Sample Adult), a variety of supplementary questions collecting data about prioritized national health issues are periodically integrated into the core questionnaires. A supplemental questionnaire on adult arthritis was added to 2002, 2006, 2009, and 2014 Adult Core questionnaire to collect information on musculoskeletal disorders and self-reported doctor diagnosed arthritic conditions.

### 2.2. Study participants and sample size

The data used for the present analysis were collected from the Family and Sample Adult questionnaires with the integrated supplemental questions on musculoskeletal disorders collected in 2006,

2009, and 2014. The response rate for the combined three data years was 79.1% for Family and 63.8% for Sample Adult. Calculation of the response rates for combined data years are described in Appendix I in the Survey Description Document of each year [<https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm>]. The combined sample size was 88,703 for adults 18 years and older at the date of the interview. A final sample size of 50,218 was generated after excluding those who were not working during the week prior to the interview ( $n = 30,141$ ) or did not have information on employment status ( $n = 8,344$ ).

### 2.3. Attainment of upper extremity musculoskeletal disorders and effects on work

Information on upper extremity musculoskeletal disorders was collected using the Adult Arthritis supplemental questions, which asked the following: 1) “During the past 30 days, have you had any symptoms of pain, aching, or stiffness in or around a joint?”; 2) “which joints are affected: shoulder-right; should-left; elbow-right; elbow-left; hip-right; hip-left; wrist-right; wrist-left; knee-right; knee-left; ankle-right; ankle-left; toes-right; toes-left; finger/thumb-right; finger/thumb-left; and other joint not listed”; and 3) “Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?”. The information on traumatic injury was collected through the Family Core by asking two questions: 1) “During the past three months, that is, since (91 days before today date), (were/was) (you/anyone in the family) injured or poisoned seriously enough that (you/they) got medical advice or treatment? 2) At the time, what part(s) of (your/subject name)’s body was/hurt? A body site-specific joint disorder (outcome variable or case) was defined as having pain, aching, or stiffness in or around joint(s) of shoulder, elbow, wrist, or finger/thumb. Information on the joint disorders affecting work was collected by asking “Do arthritis or joint disorders now affect whether you work, the type of work you do or the amount of work you do? (Referring to work for pay).”

### 2.4. Definition of work-related upper extremity musculoskeletal disorders

A previous study has suggested that a simpler upper extremity musculoskeletal disorder definition

(such as having pain and discomfort) yields similar associations with putative occupational risk factors to those obtained using sophisticated case definitions [19]. Due to lack of diagnostic information on WUEMSDs in the NHIS data, we decided to use the simpler case definition in the present study. The WUEMSD was defined as having joint symptom(s) (i.e., pain, aching, or stiffness in or around a joint) on the aforementioned sites of upper extremity and was free from any of the condition(s) including osteoarthritis, rheumatoid arthritis, gout, lupus, fibromyalgia, or traumatic injuries occurring within the past three months to the corresponding site [20].

### 2.5. Occupational information

Occupational information was collected using the Sample Adult Questionnaire. Participants aged 18 years and older, who reported any of following: “working 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 their interview, were asked a series of questions about their job and work status. These responses were subsequently reviewed by Census Bureau coding specialists to assign each eligible adult appropriate industry and occupation codes. These codes were consistent with the Standard Occupational Classification (SOC) and the North American Industry Classification System (NAICS). For confidentiality, however, a two-digit recode was available for public use and was used in the present study. Occupations were collapsed into 22 occupational categories while industries were collapsed into 20 major sectors all consistent with those used by the BLS from 2006 to 2015.

### 2.6. Demographic and lifestyle variables

Age, sex, race/ethnicity, educational level, and birthplace (i.e., born in US vs. outside of US) were obtained from the Family Core Questionnaire. Race/ethnicity was collapsed into four groups including White (Non-Hispanic), Black (Non-Hispanic), Hispanic, and Others (Non-Hispanic). Information on smoking, physical activity (PA), weight, and height were collected from the Sample Adult Core Questionnaire. Cigarette smoking status was categorized as current, ever, and never. Body mass index (BMI) was calculated for each participant using the formula:  $BMI = \text{weight in kilograms} / \text{height in meters squared} (\text{kg}/\text{m}^2)$ . Leisure time PA was categorized as sufficiently active ( $\geq 150$  minutes of PA in

moderate-intensity per week, or  $\geq 75$  minutes of PA in vigorous-intensity per week), insufficiently active (10–149 minutes of PA in moderate-intensity per week), and inactive (not engaged or  $< 10$  minutes of PA in any intensity per week) using an approach that was described in a previous study [21]. Leisure time muscle strengthening activity such as lifting weights or doing calisthenics was collapsed into three groups: never but capable, ever, and unable. Written informed consent was obtained from all subjects. All procedures were approved by the NCHS Research Ethics Review Board.

### 2.7. Data analysis

The NHIS data were obtained through a complex sample design involving stratification, clustering and multistage sampling. To account for the complex sample design, SAS-callable SUDAAN software version 11.0 (Research Triangle Institute 2011) with Taylor series linearization was used to produce reliable national estimates. For upper extremity, the number of WUEMSDs was those who had WUEMSDs on any of the four body sites. Bilateral musculoskeletal symptoms of the shoulder, elbow, wrist, and hand/finger were counted as one case for the relevant site. Unadjusted 30-day prevalence of WUEMSDs and of WUEMSDs affecting work on upper extremity and four specific body sites including shoulder, elbow, wrist, and hand/finger were estimated. The 30-day prevalence of WUEMSDs and the prevalence of WUEMSDs affecting work were estimated across the categories of demographic and lifestyle characteristics. *P*-values were obtained from Chi-square test for the significance of the prevalence across the categories of demographics and lifestyle characteristics. The 30-day adjusted

prevalence of WUEMSDs and of WUEMSDs affecting work were estimated across major occupations and industries using the 2006 age- and gender-specific standard population. An estimated prevalence with a relative standard error (RSE) was calculated using the formula: (standard error of prevalence/prevalence)  $\times 100\%$ . A RSE equal to or greater than 30% was considered as lacking precision and was not reported. The weights provided by the NHIS were applied to all the estimates.

## 3. Results

### 3.1. Prevalence of work-related upper extremity musculoskeletal disorders by body site

Among the 50,218 adult workers in the United States, 8.23% (95% CI 7.90–8.58) reported having WUEMSDs, 4.02% (95% CI 3.80–4.26) having work-related shoulder musculoskeletal disorders, 2.23% (95% CI 2.06–2.43) having work-related elbow musculoskeletal disorders, 2.23% (95% CI 2.05–2.43) having work-related wrist musculoskeletal disorders, and 2.46% (95% CI 2.29–2.64) having work-related hand/finger musculoskeletal disorders (Table 1). The 30-day prevalence of WUEMSDs affecting work was 1.24% (1.11–1.38) for the upper extremities, 0.67% (95% CI 0.58–0.77) for shoulder, 0.36% (95% CI 0.30–0.43) for elbow, 0.48% (95% CI 0.41–0.57) for wrist, and 0.34% (95% CI 0.28–0.42) for hand/finger.

### 3.2. Prevalence of work-related upper extremity musculoskeletal disorders by demographic and lifestyle characteristics

The 30-day prevalence of self-reported WUEMSDs varied significantly across the categories of

Table 1  
Unadjusted 30-day prevalence of work-related upper extremity musculoskeletal symptoms (WUEMSDs) and of WUEMSDs affecting work in the United States: 2006, 2009, and 2014 National Health Interview Survey

	WUEMSDs			WUEMSDs Affecting Work		
	Unweighted No. of Cases <sup>†</sup>	Estimated Cases (in thousands)	Unweighted Prevalence % (95%CI)	Unweighted No. of Cases <sup>†</sup>	Estimated Cases (in thousands)	Unweighted Prevalence % (95%CI)
Upper extremity	4,190	11,199	8.23 (7.90–8.58)	636	1,683	1.24 (1.11–1.38)
Shoulder <sup>‡</sup>	2,048	5,469	4.02 (3.80–4.26)	339	908	0.67 (0.58–0.77)
Elbow <sup>‡</sup>	1,119	3,039	2.23 (2.06–2.43)	196	490	0.36 (0.30–0.43)
Wrist <sup>‡</sup>	1,142	3,039	2.23 (2.05–2.43)	251	657	0.48 (0.41–0.57)
Hand/finger <sup>‡</sup>	1,271	3,347	2.46 (2.29–2.64)	181	462	0.34 (0.28–0.42)

Abbreviation: SE=standard error; CI=confidence interval. Note: All estimates weighted unless otherwise noted. <sup>†</sup>: For upper extremity, the number of cases was those who had a musculoskeletal symptom(s) on any of the four upper extremities: shoulder, elbow, wrist, and hand/finger; and the number of cases for each individual upper extremity, bilateral symptoms on each upper extremity were counted as one. <sup>‡</sup>: Not mutually exclusive.

demographic and lifestyle characteristics (Table 2). A significantly higher prevalence of WUEMSDs was reported in workers age 55–64 years, in men, non-

Hispanic White, those with less than 4-year college education, and those who were born in the US, current smokers, insufficiently active workers, and those

Table 2  
30-day prevalence of work-related upper extremity musculoskeletal symptoms (WUEMSDs)  
and of WUEMSDs affecting work by demographic and lifestyle characteristics in the United States:  
2006, 2009, and 2014 National Health Interview Survey

Variable	Sample	Estimated Population <sup>†</sup> (in thousands)	WUEMSDs (%) (SE)	WUEMSDs Affecting Work (%) (SE)
Age (yrs)				
18–24	5,387	17,550	6.25 (0.47)	0.95 (0.18)
25–34	11,629	30,130	7.03 (0.32)	1.07 (0.12)
35–44	11,597	31,039	8.66 (0.33)	1.39 (0.13)
45–54	11,227	31,735	9.35 (0.35)	1.43 (0.15)
55–64	7,725	19,862	9.51 (0.40)	1.32 (0.17)
≥65	2,653	5,735	7.71 (0.67)	0.87 (0.21)
<i>p</i> -value			<0.001	0.070
Sex				
Male	24,833	72,487	8.84 (0.24)	1.26 (0.09)
Female	25,385	63,563	7.54 (0.24)	1.21 (0.08)
<i>p</i> -value			<0.001	0.644
Race/ethnicity				
White (Non-Hispanic)	30,434	92,645	8.98 (0.23)	1.22 (0.09)
Black (Non-Hispanic)	7,155	15,427	5.79 (0.33)	0.99 (0.15)
Hispanic	9,299	20,142	7.47 (0.38)	1.46 (0.18)
Others (Non-Hispanic)	3,330	7,837	6.12 (0.57)	1.34 (0.25)
<i>p</i> -value			<0.001	0.237
Education				
≤High school/GED	17,959	48,083	9.01 (0.31)	1.67 (0.13)
<4 yrs college	15,820	42,896	9.05 (0.29)	1.44 (0.13)
≥4 yrs college	16,095	44,162	6.63 (0.26)	0.57 (0.08)
<i>p</i> -value			<0.001	<0.001
Birth place				
US	40,304	112,547	8.62 (0.20)	1.24 (0.08)
Non US	9,889	23,452	6.38 (0.31)	1.25 (0.14)
<i>p</i> -value			<0.001	0.940
Smoking status				
Never	30,747	82,836	6.84 (0.21)	0.79 (0.07)
Ever	9,496	26,027	10.04 (0.43)	1.52 (0.16)
Current	9,719	26,524	10.94 (0.42)	2.39 (0.20)
<i>p</i> -value			<0.001	<0.001
Physical activity <sup>‡</sup>				
Inactive	14,558	38,491	7.87 (0.30)	1.45 (0.12)
Insufficiently active	9,918	27,124	9.39 (0.42)	1.49 (0.17)
Sufficiently active	25,225	69,082	8.01 (0.21)	1.01 (0.09)
<i>p</i> -value			0.004	0.002
Muscle strengthening activity				
Ever	129,1	3,330	7.85 (0.26)	1.01 (0.12)
Never but be capable	286,2	7,757	8.44 (0.21)	1.32 (0.08)
Unable	15	53	13.10 (4.24)	7.40 (3.35)
<i>p</i> -value			0.120	0.017
BMI (kg/m <sup>2</sup> )				
<25	17,537	47,664	7.57 (0.27)	1.07 (0.10)
25–<30	17,521	48,023	8.10 (0.27)	1.31 (0.10)
≥30	13,621	36,370	9.54 (0.34)	1.40 (0.15)
<i>p</i> -value			<0.001	0.096

Note: *p*-values were obtained from Chi-square test. Prevalence was weighted. <sup>†</sup>: Estimated average annual number of adults (≥18 years) who were employed during the week before interview. The numbers were rounded down to the nearest 1,000. <sup>‡</sup>: Inactive, not engaged in or less than 10 minutes of leisure time physical in any intensity per week; insufficiently active, 10–149 minutes of leisure time physical activities in moderate-intensity or 10–75 minutes in vigorous-intensity per week; sufficiently active, at least 150 minutes leisure time physical activities in moderate-intensity or 75 minutes of leisure time physical in vigorous-intensity per week.

who had a BMI  $\geq 30$  kg/m<sup>2</sup> ( $p < 0.001$ ). Four factors, educational level, smoking status, PA, and muscle strengthening activity were significantly associated with the prevalence of WUEMSDs affecting work. The prevalence decreased with increased educational level (1.67% in high school/GED, 1.44% in  $< 4$  years college, and 0.57% in  $\geq 4$  years of college,  $p < 0.001$ ). The prevalence was 0.79% in never smokers, 1.52% in ever smokers, and 2.39% in current smokers ( $p < 0.001$ ). Also, workers who reported insufficiently active leisure time PA had a higher prevalence of WUEMSDs affecting work compared to those who were sufficiently active (1.49% vs. 1.01%,  $p = 0.002$ ). Participants who engaged in muscle strengthening activities reported significantly lower prevalence of WUEMSDs affecting work than those who were not able to do the activities (1.01% vs. 7.40%,  $p = 0.017$ ).

### 3.3. Prevalence of WUEMSDs by occupation

The 22 occupations were ranked by prevalence of WUEMSDs from the highest to the lowest (Table 3). The occupation with the highest prevalence of WUEMSDs was Construction and Extraction (10.98%, 95% CI 7.85–15.16), and that with the lowest was Healthcare Practitioners and Technical Support (5.91%, 95% CI 4.77–7.30). In addition to Construction and Extraction, seven other occupations which reported a higher than the national average prevalence (8.25%) of WUEMSDs were Life, Physical and Social Science (10.86%, 95% CI 7.83–14.88), Production (9.90%, 95% CI 8.74–11.20), Transportation and Material Moving (9.81%, 95% CI 8.12–11.80), Building and Grounds Cleaning and Maintenance (9.59%, 95% CI 8.20–11.18), Healthcare Support (9.33%, 95% CI 5.97–14.28), Food Preparations and Serving Related Occupations (8.91%, 95% CI 7.44–10.63), and Farming, Fishing, and Forestry (8.71%, 95% CI 5.76–12.97).

The 30-day prevalence of WUEMSDs that affected work also differed by occupation (Table 3). The prevalence was highest in Construction and Extraction (3.32%, 95% CI 1.85–5.88), followed by Production (1.88%, 95% CI 1.37–2.58), Transportation and Material Moving (1.74%, 95% CI 1.13–2.69), Building and Grounds Cleaning and Maintenance (1.72%, 95% CI 1.21–2.44), Art, Design, Entertainment, Sports, and Media (1.67%, 95% CI 0.92–3.01), Food Preparation and Serving

Related Occupations (1.59%, 95% CI 1.14–2.21), and Personal Care and Service Occupations (1.47%, 95% CI 0.90–2.40). The prevalence of WUEMSDs that affected work in these occupations was higher than the national average (1.24%, 95% CI 1.11–1.38).

### 3.4. Prevalence of work-related upper extremity musculoskeletal disorders by industry

The 30-day prevalence of WUEMSDs varied by industry (Table 4). The highest prevalence of WUEMSDs was in Construction (9.94%, 96% CI 8.41–11.72) and the lowest was in Information (6.21%, 95% CI 4.79–8.01). Following Construction, nine industries that had a higher prevalence than the national average were Other Services (except Public Administration) (9.87%, 95% CI 8.48–11.46); Agriculture, Forestry, and Fishing and Hunting (9.78%, 95% CI 7.24–13.07); Accommodation and Food Services (9.04%, 95% CI 7.63–10.68); Manufacturing (8.75%, 95% CI 7.85–9.75); Real Estate and Rental and Leasing (8.53%, 6.56–11.00); Transportation and Warehousing (8.50%, 95% CI 6.84–10.53); Retail Trade (8.46%, 95% CI 7.47–9.57); and Utilities (8.35%, 5.76–11.96).

The prevalence of WUEMSDs affecting work differed by industry as well (Table 4). Among 20 major industries, 13 of them had a sufficient sample size for a reliable estimate. Seven industries had a prevalence that was higher than the national average: 2.31% (95% CI 1.62–3.28) for Construction; 2.19% (95% CI 1.58–3.02) for Other Services; 1.79% (95% CI 1.33–2.39) for Retail Trade; 1.61% (95% CI 0.90–2.86) for Arts, Entertainment, and Recreation; 1.57% (1.11–2.23) for Accommodation and Food Services; 1.56% (95% CI 1.06–2.29) for Administrative and Support and Waste Management and Remediation Services; and 1.35% (0.98–1.85) for Manufacturing. The lowest prevalence was reported in Finance and Insurance, 0.57% (95% CI 0.32–1.00).

## 4. Discussion

Using the three Arthritis supplements to the NHIS data (2006, 2009, and 2014) we found that the 30-day prevalence of WUEMSDs was 8.23% in US workers. The shoulder musculoskeletal disorders were more prevalent than in other individual sites including the elbow, wrist, and hand/finger. Older age (55–64 years), male gender, White (Non-Hispanic), having

Table 3  
Age- and gender-adjusted<sup>†</sup> 30-day prevalence of work-related upper extremity musculoskeletal symptoms (WUEMSDs) and of WUEMSDs affecting work by occupation in the United States: 2006, 2009, and 2014 National Health Interview Survey

Occupation (Standard Occupational Code)	Sample	Estimated Population <sup>‡</sup> (in thousands)	WUEMSDs		WUEMSDs Affecting Work	
			No. of Cases	% (95% CI)	No. of Cases	% (95% CI)
Total	50,218	136,050	4,190	8.25 (7.92–8.60)	636	1.24 (1.11–1.38)
Construction and Extraction Occupations (47)	2,802	7,861	327	10.98 (7.85–15.16)	74	3.32 (1.85–5.88)
Life, Physical and Social Science Occupations (19)	547	1,418	51	10.86 (7.83–14.88)	7	$\bar{T}$
Production Occupations (51)	3,187	8,555	330	9.90 (8.74–11.20)	60	1.88 (1.37–2.58)
Transportation and Material Moving Occupations (53)	2,970	7,983	265	9.81 (8.12–11.80)	41	1.74 (1.13–2.69)
Building and Grounds Cleaning and Maintenance Occupations (37)	2,267	5,511	220	9.59 (8.20–11.18)	41	1.72 (1.21–2.44)
Health Care Support Occupations (31)	1,293	2,918	100	9.33 (5.97–14.28)	24	1.40 (0.83–2.36)
Food Preparation and Serving Related Occupations (35)	2,803	7,525	235	8.91 (7.44–10.63)	51	1.59 (1.14–2.21)
Farming, Fishing, and Forestry Occupations (45)	403	999	34	8.71 (5.76–12.97)	5	$\bar{T}$
Computer and Mathematical Occupations (15)	1,454	4,120	124	8.13 (6.41–10.26)	9	$\bar{T}$
Art, Design, Entertainment, Sports, and Media Occupations (27)	977	2,595	75	7.96 (6.11–10.31)	15	1.67 (0.92–3.01)
Architecture and Engineering Occupations (17)	919	2,741	78	7.78 (5.60–10.71)	7	$\bar{T}$
Office and Administrative Support Occupations (43)	6,637	17,467	518	7.75 (6.79–8.85)	76	0.82 (0.60–1.13)
Installation, Maintenance, and Repair Occupations (49)	1,659	5,075	197	7.82 (5.44–11.11)	32	0.99 (0.63–1.56)
Protective Service Occupations (33)	1,053	2,896	84	7.48 (5.44–10.22)	8	$\bar{T}$
Personal Care and Service Occupations (39)	1,847	4,677	167	7.47 (5.87–9.46)	36	1.47 (0.90–2.40)
Education, Training and Library Occupations (25)	3,281	8,896	246	7.27 (6.12–8.62)	20	0.44 (0.25–0.76)
Management Occupations (11)	4,498	12,944	344	7.17 (6.21–8.25)	35	$\bar{T}$
Community and Social Services Occupations (21)	903	2,285	70	7.11 (5.00–10.03)	5	$\bar{T}$
Legal Occupations (23)	580	1,615	47	7.10 (4.82–10.34)	3	$\bar{T}$
Sales and Related Occupations (41)	5,061	14,476	355	7.01 (6.10–8.05)	57	1.11 (0.80–1.55)
Business and Financial Operations (13)	2,279	6,056	160	6.94 (5.82–8.27)	13	$\bar{T}$
Healthcare Practitioners and Technical Support Occupations (29)	2,798	7,438	163	5.91 (4.77–7.30)	17	$\bar{T}$

Abbreviations: CI=confidence interval. Note: Prevalence was weighted. †: Adjustment included age and sex using 2006 US working population as the standard population. ‡: Estimated average annual number of adults who were employed during the week before interview. The numbers were rounded down to the nearest 1,000.  $\bar{T}$ : Prevalence with a relative standard error (RSE) equal to or greater than 30% was not reported as they do not meet National Health Interview Survey standards of reliability/precision (RSE = 100 × standard error/Estimated prevalence).

<4 years of college, born in US, currently smoking, insufficiently active, and having a BMI  $\geq 30$  kg/m<sup>2</sup> were significantly associated with a higher prevalence of WUEMSDs, while lower educational level ( $\leq$ High School/GED), current smoking status, being insuf-

ficiently physically active, and being unable to do muscle strengthening activities were associated with a higher prevalence of WUEMSDs affecting work. The age- and gender-adjusted 30-day prevalence of WUEMSDs and WUEMSDs affecting work varied

Table 4  
Age- and gender-adjusted<sup>†</sup> 30-day prevalence of work-related upper extremity musculoskeletal (WUEMSDs) symptoms and of WUEMSDs affecting work by industry in the United States: 2006, 2009, and 2014 National Health Interview Survey

Industry (North American Industry Classification System code)	Sample	Estimated Population <sup>‡</sup> (in thousands)	WUEMSDs		WUEMSDs Affecting Work	
			No. of Cases	% (95% CI)	No. of Cases	% (95% CI)
Total	50,218	136,050	4,190	8.25 (7.92–8.60)	636	1.24 (1.11–1.38)
Construction (23)	3,361	9,604	386	9.94 (8.41–11.72)	80	2.31 (1.62–3.28)
Other services (except public administration; 81)	2,597	6,800	257	9.87 (8.48–11.46)	56	2.19 (1.58–3.02)
Agriculture, Forestry, and Fishing and Hunting (11)	677	1,667	66	9.78 (7.24–13.07)	11	$\bar{T}$
Accommodation and Food Services (72)	3,451	8,995	292	9.04 (7.63–10.68)	60	1.57 (1.11–2.23)
Manufacturing (31–33)	5,138	14,766	479	8.75 (7.85–9.75)	63	1.35 (0.98–1.85)
Real Estate and Rental and Leasing (53)	1,036	2,826	82	8.53 (6.56–11.00)	12	$\bar{T}$
Transportation and Warehousing (48–49)	2,120	5,817	172	8.50 (6.84–10.53)	19	0.73 (0.41–1.30)
Retail Trade (44–45)	5,108	14,304	439	8.46 (7.47–9.57)	84	1.79 (1.33–2.39)
Utilities (22)	455	1,322	45	8.35 (5.76–11.96)	4	$\bar{T}$
Administrative and Support and Waste Management and Remediation Services (56)	2,262	5,811	189	8.09 (6.71–9.73)	38	1.56 (1.06–2.29)
Arts, Entertainment, and Recreation (71)	980	2,681	80	7.84 (5.80–10.52)	18	1.61 (0.90–2.86)
Educational Services (61)	4,960	13,213	396	7.83 (6.89–8.88)	31	0.44 (0.27–0.69)
Mining (21)	355	798	41	7.68 (4.33–13.24)	6	$\bar{T}$
Wholesale Trade (42)	1,263	3,775	105	7.46 (5.88–9.43)	9	$\bar{T}$
Professional, Scientific, and Technical Services (54)	3,287	9,177	243	7.18 (6.03–8.52)	25	0.65 (0.39–1.06)
Healthcare and Social Assistance (62)	6,973	17,734	481	7.01 (6.10–8.04)	74	1.03 (0.68–1.57)
Public Administration (92)	2,643	6,860	190	6.68 (5.66–7.86)	19	0.66 (0.38–1.14)
Finance and Insurance (52)	2,340	6,496	159	6.58 (5.48–7.88)	15	0.57 (0.32–1.00)
Information (51)	1,170	3,282	84	6.21 (4.79–8.01)	12	$\bar{T}$

Note: Prevalence was weighted. <sup>†</sup>: Adjustment included age and sex using 2006 US working population as the standard population. <sup>‡</sup>: Estimated average annual number of adults who were employed during the week before interview. The numbers were rounded down to the nearest 1,000.  $\bar{T}$ : Prevalence with a relative standard error (RSE) equal to or greater than 30% was not reported as they do not meet National Health Interview Survey standards of reliability/precision (RSE = 100 × standard error/Estimated prevalence). Management of companies and enterprises (55) met this criterion.

by occupation and industry with the highest prevalence in the Construction and Extraction occupation and the Construction Industry.

One needs to be cautious when comparing our findings with that of other reports because the timeframe for prevalence estimates and the definitions of WUEMSDs across studies are different. Roquelaure et al. [14] provided evidence that the 12-month prevalence of upper extremity MSDs was about twice that of the one-week prevalence (58% vs. 27%) in French male workers. Hegmann et al. [22] have reported a 1.2–3.4 fold differences in prevalence depending on the epidemiological case definition used. Therefore, when interpreting or comparing the prevalence of WUEMSDs, the timeframe for an estimate and definition of WUEMSDs need to be considered.

A few studies have estimated the prevalence or incidence of upper extremity musculoskeletal conditions using different timeframe in US working population, which were summarized in Table 5. Available data allowing for estimating the national prevalence of WUEMSDs in the US total workers is restricted to CTS. The most recent report of the national prevalence of work-related CTS in the US total workers was estimated by Luckhaupt et al. [12] using the NHIS data. The information on CTS was collected through the NHIS occupational health supplements (OHS) in 2010. CTS was a self-reported clinician diagnosis, but the case definition was not clearly defined. The information regarding work-relatedness was collected by asking “Have you been told by a doctor or other health professional

Table 5  
Comparisons between the present study and the published studies on musculoskeletal problems in the US

Author	Year study published	Study population	Work-relatedness	Musculoskeletal problem	Body site	Data collection method	Timeframe of the problems	Prevalence or incidence (%)
Ma et al.	Present study	Total workers in the US	Work-related	Pain, aching, or stiffness in or around a joint	Shoulders, elbows, Wrists, and fingers	Self-reported	30-day	Prevalence 8.23%
Luckhaupt et al.	2013	Total workers in the US	Work-related	Carpal tunnel syndrome	Arms, wrists, and fingers	Self-reported	12 months	Prevalence 3.1%
Waters et al.	2007	Total workers in the US	Work-related and nonwork-related	Upper extremity and low back pain	Arms and back	Self-reported	12 months	Prevalence 27.99%
Morse et al.	2005	Total workers in Connecticut state	Work-related	All types of upper extremity musculoskeletal disorders and symptoms	Shoulders, arms, wrists, and hand/fingers	Physician diagnosed	12 months	Incidence rate 1.33%
Lee et al.	2014	Agricultural workers in the US	Work- and nonwork-related	Pain, aching, or stiffness in or around a joint	shoulders, elbows, wrists, or hands	Self-reported	30-day	Prevalence 17.3%

that your carpal tunnel syndrome was probably work-related?" The 12-month prevalence of work-related CTS was estimated as 3.1%. Another data source which collected relevant information on WUEMSDs is the Quality of Work Life (QWL) module of the General Social Survey. However, the QWL does not collect information on systemic conditions that may produce musculoskeletal disorders. Using the QWL data, Waters, Dick [3] reported a 12-month prevalence of 27.99% of upper extremity musculoskeletal pain in US workers in 2002.

Another relevant study reported a broader category of doctor diagnosed WUEMSDs including peripheral neuropathies (carpal tunnel syndrome and cubital tunnel syndrome), tendonitis, epicondylitis (tendonitis, tenosynovitis, de Quervain's tenosynovitis, ganglion cysts, trigger digit, and medial and lateral epicondylitis, and all other MSDs and musculoskeletal symptoms (hand-arm vibration syndrome, bursitis, rotator cuff injuries, thoracic outlet syndrome, chronic joint strains and muscle pain/inflammation) [7]. Morse and colleagues applied the capture-recapture methodology to investigate the true number of WUEMSDs. They compiled data from two systems, i.e., the electronic data records of the Connecticut Workers' Compensation First Report of Injury system and physician reports to the Connecticut Departments of Labor and Public Health Occupational Disease Surveillance System. They found that the annual incidence rate of WUEMSDs

was 1.33% over a 7-year period in Connecticut total workers.

The clinical case definitions of upper extremity MSDs may not be feasible for a large population survey such as the NHIS. Using a simpler case definition such as musculoskeletal-related pain, or aching, or stiffness to estimate the prevalence of WUEMSDs has been suggested previously. Palmer, Harris [19] compared associations of simpler upper extremity MSD case definition (i.e., pain) and stricter case definition (i.e., symptom plus signs such as tenderness on palpation) or symptoms plus positive clinical investigations with occupational physical risk factors such as the following: repeated movements of the wrists/fingers; repeated bending and straightening of the elbow; repeated movements of the shoulder; work with the hands above shoulder height; lifting; use of a computer keyboard or mouse; vibration; and cumulative trauma. They found that the sophisticated case definitions for upper extremity MSD diagnosis yielded similar associations with putative occupational risk factors to those obtained using simpler case definitions.

Previous studies have suggested that non work-related personal factors also play a role in the risk of CTS [23] in addition to work-related biomechanical factors such as forceful exertions, repetitive movements, and awkward postures [24]. In the present study, age, sex, race/ethnicity, education, birthplace, smoking status, leisure time PA, and BMI were all

significantly associated with the 30-day prevalence of WUEMSDs. However, only educational level, smoking status, leisure PA, and muscle strengthening activity were significantly associated with the prevalence of WUEMSDs affecting work. Workers with the lowest educational level may be more likely to work in occupations with more biomechanical risk factors for upper extremity MSDs. The protective effects of nonsmoking and intense physical exercise on WUEMSDs are inconsistent in the literature. Current cigarette smoking has been reported as a risk factor for upper extremity MSDs [2]. However, recent findings from cross-sectional study did not find the associations of smoking status with CTS or median nerve function [25]. Harris-Adamson, Eisen [23] found that >3 hours of aerobic activity was not associated with decreased risk of CTS. More longitudinal studies to investigate the potential causal relationship between smoking and PA (especially muscle strengthening activities) with upper extremity MSD risk are warranted.

The present results showed that construction workers ranked the highest in the 30-day prevalence of WUEMSDs as well as in the prevalence of WUEMSDs affecting work. Our results are consistent with the study by Tak and Calvert [10] who reported that the US construction workers are more likely to have multiple well-known MSD risk factors such as repetitive motion, awkward postures, and vibration. In another comparable study using the NHIS data, Lee et al [13] reported that the monthly prevalence of upper extremity musculoskeletal pain was 17.3% for the agricultural industry, which is higher than the estimate from the present study (9.8%). The discrepancy may be partially due to the different case definitions. The former included systemic conditions which are known to cause musculoskeletal pain such as osteoarthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia, as well as traumatic injuries. By excluding these conditions, the present estimates might be more relevant to work than the previous report.

#### 4.1. Limitations

First, overestimation of the prevalence of WUEMSDs might occur due to unknown systemic diseases that could cause the conditions of pain, aching, or stiffness in addition to osteoarthritis, gout, lupus, or fibromyalgia. However, the prevalence of unknown diseases is likely to be small, especially in developed countries such as the US. Some researchers may argue that some of the symptoms,

especially pain, could be due to muscle strengthening activities such as lifting weights. However, our results show that the prevalence of WUEMSDs among the participants who ever did muscle strengthening activities was lower than those who were capable but never did the activities. These results indicate that muscle-strengthening activities seem to protect workers from having WUEMSDs. Second, the WUEMSDs were self-reported which might be subject to misclassification bias due to variations of pain perception. Third, the prevalence of WUEMSDs affecting work might be underestimated because the information was collected only among those who were working for pay. Fourth, the information on a traumatic injury was collected by asking each participant "During the past three months, that is, since 91 days before today, were/was you/anyone in the family injured or poisoned seriously enough that you/they got medical advice or treatment?" When the question was misinterpreted as to be asking about any condition that resulted in a doctor visit, the case numbers would likely to be underestimated.

We estimated the prevalence of WUEMSDs using a representative sample of the US working population. Overall, 8.23% (approximately 11.2 million) of the US workers experienced at least one WUEMSD in the past 30 days using 2006, 2009, and 2014 NHIS data, with the shoulder MSD being more common (4.02%, 5.5 million US workers) compared to the other three upper extremities including elbow (2.23%, 3.0 million), wrist (2.23%, 3.0 million), and hand/finger (2.46%, 3.3 million). The prevalence of WUEMSDs affecting work was 1.24% (1.7 million) in the US working population. The present results showed that the workers in Construction and Extraction occupation or Construction industry reported the highest prevalence of WUEMSDs as well as the highest prevalence of WUEMSDs affecting work. Future epidemiological studies are needed to investigate what other potential risk factors may contribute to the highest prevalence of upper extremity musculoskeletal symptoms in construction workers so that a comprehensive prevention strategy to reduce the prevalence of musculoskeletal symptoms may be developed.

#### Author contributions

Mrs. Ma drafted the analysis plan and the manuscript.

Mr. Gu conducted data analysis and revised the manuscript critically for important intellectual content.

Drs. Charles, Andrew, and Dong revised the manuscript critically for important intellectual contents.

Dr. Burchfiel conceived the research question and revised the manuscript critically for important intellectual content.

All authors approved the final version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work were appropriately investigated and resolved.

### Conflict of interest

The authors have no conflict of interest to report.

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### References

- [1] World Health Organization (WHO) Expert Committee. Identification and control of work-related diseases. Geneva: WHO, 1985; Technical report series 174 [cited 2017 May 17]. Available from: [http://apps.who.int/iris/bitstream/10665/40176/1/WHO\\_TRS\\_714.pdf](http://apps.who.int/iris/bitstream/10665/40176/1/WHO_TRS_714.pdf)
- [2] National research Council and Institute of Medicine. Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington, DC: National Academy Press, 2001 [cited 2017 February 2]. Available from: <http://www.nap.edu/read/10032/chapter/1>
- [3] Waters TR, Dick RB, Davis-Barkley J, Krieg EF. A cross-sectional study of risk factors for musculoskeletal symptoms in the workplace using data from the General Social Survey (GSS). *J Occup Environ Med.* 2007;49(2):172-84.
- [4] Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders *Scand J Work Environ Health.* 2001;27(Suppl 1):1-102.
- [5] Janga D, Akinfenwa O. Work-related repetitive strain injuries amongst practitioners of obstetric and gynaecological ultrasound worldwide. *Arch Gynecol Obstet.* 2012;286(2):353-6.
- [6] Ruser JW. Examining evidence on whether BLS undercounts workplace injuries and illnesses. *Monthly Labor Review,* 2008, pp. 1-13.
- [7] Morse T, Dillon C, Kenta-Bibi E, Weber J, Diva U, Warren N, Grey M. Trends in work-related musculoskeletal disorder reports by year, type, and industrial sector: A capture-recapture analysis. *Am J Ind Med.* 2005;48(1):40-9.
- [8] Rosenman KD, Kalush A, Reilly MJ, Gardiner JC, Reeves M, Luo Z. How much work-related injury and illness is missed by the current national surveillance system? *J Occup Environ Med.* 2006;48(4):357-65.
- [9] Boden LI, Ozonoff A. Capture-recapture estimates of non-fatal workplace injuries and illnesses. *Ann of Epidemiol.* 2008;18(6):500-6.
- [10] Tak S, Calvert GM. The estimated national burden of physical ergonomic hazards among US workers. *Am J Ind Med.* 2011;54(5):395-404.
- [11] Tanaka S, Petersen M, Cameron L. Prevalence and risk factors of tendinitis and related disorders of the distal upper extremity among U.S. workers: Comparison to carpal tunnel syndrome. *Am J Ind Med.* 2001;39(3):328-35.
- [12] Luckhaupt SE, Dahlhamer JM, Ward BW, Sweeney MH, Sestito JP, Calvert GM. Prevalence and work-relatedness of carpal tunnel syndrome in the working population, United States, 2010 National Health Interview Survey. *Am J Ind Med.* 2013;56(6):615-24.
- [13] Lee SJ, Tak S, Alterman T, Calvert GM. Prevalence of musculoskeletal symptoms among agricultural workers in the United States: An analysis of the National Health Interview Survey, 2004-2008. *J Agromedicine.* 2014;19(3): 268-80.
- [14] Roquelaure Y, Ha C, Leclerc A, Touranchet A, Sauteron M, Melchior M, Goldberg M. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. *Arthritis Rheum.* 2006;55(5):765-78.
- [15] Long MH, Bogossian FE, Johnston V. The prevalence of work-related neck, shoulder, and upper back musculoskeletal disorders among midwives, nurses, and physicians: A systematic review. *Workplace Health Saf.* 2013;61(5): 223-9.
- [16] Merlino LA, Rosecrance JC, Anton D, Cook TM. Symptoms of musculoskeletal disorders among apprentice construction workers. *Appl Occup Environ Hyg.* 2003;18(1):57-64.
- [17] Davis KG, Kotowski SE. Understanding the ergonomic risk for musculoskeletal disorders in the United States agricultural sector. *Am J Ind Med.* 2007;50(7):501-11.
- [18] Parsons V, Moriarity C, Jonas K. Design and estimation for the National Health Interview Survey, 2006-2015. *Vital Health Stat.* 2014;2(165):1-53.
- [19] Palmer KT, Harris EC, Linaker C, Cooper C, Coggon D. Optimising case definitions of upper limb disorder for aetiological research and prevention: A review. *J Occup Environ Med.* 2012;69(1):71-8.
- [20] Harrington JM, Carter JT, Birrell L, Gompertz D. Surveillance case definitions for work related upper limb pain syndromes. *Occup Environ Med.* 1998;55(4):264-71.
- [21] Gu JK, Charles LE, Ma CC, Andrew ME, Fekedulegn D, Hartley TA, Violanti JM, Burchfiel CM. Prevalence and trends of leisure-time physical activity by occupation and industry in U.S. workers: The National Health Interview Survey 2004-2014. *Ann Epidemiol.* 2016;26(10): 685-92.
- [22] Hegmann KT, Thiese MS, Wood EM, Garg A, Kapellusch JM, Foster J, Biggs J, Edwards H, Wertsch J, Kendall R.

- Impacts of differences in epidemiological case definitions on prevalence for upper-extremity musculoskeletal disorders. *Hum Factors*. 2014;56(1):191-202.
- [23] Harris-Adamson C, Eisen EA, Dale AM, Evanoff B, Hegmann KT, Thiese MS, Kapellusch JM, Garg A, Burt S, Bao S, Silverstein B, Gerr F, Merlino L, Rempel D. Personal and workplace psychosocial risk factors for carpal tunnel syndrome: A pooled study cohort. *Occup Environ Med*. 2013;70(8):529-37.
- [24] Harris-Adamson C, Eisen EA, Kapellusch J, Garg A, Hegmann KT, Thiese MS, Dale AM, Evanoff B, Burt S, Bao S, Silverstein B, Gerr F, Merlino L, Rempel D. Biomechanical risk factors for carpal tunnel syndrome: A pooled study of 2474 workers. *Occup Environ Med*. 2015;72(1):33-41.
- [25] Rempel D, Gerr F, Harris-Adamson C, Hegmann KT, Thiese MS, Kapellusch J, et al. Personal and workplace factors and median nerve function in a pooled study of 2396 US workers. *J Occup Environ Med*. 2015;57(1):98-104.