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RESEARCH ARTICLE

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Acute joint pain in the emerging green collar workforce: Evidence from the linked National Health Interview Survey and Occupational Information Network (O*NET)

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Background: Green jobs are a rapidly emerging category of very heterogeneous occupations that typically involve engagement with new technologies and changing job demands predisposing them to physical stressors that may contribute to the development of joint pain.

Methods: We estimated and compared the prevalence of self-reported acute (past 30 days) joint pain between green and non-green collar workers using pooled 2004-2012 National Health Interview Survey (NHIS) data linked to the Occupational Information Network Database (O*NET).

Results: Green collar workers have a higher prevalence of acute joint pain as compared to non-green collar workers. Green collar workers with pain in the upper extremity joints were significantly greater than in the non-green collar workforce, for example, right shoulder [23.2% vs 21.1%], right elbow [13.7% vs 12.0%], left shoulder [20.1% vs 18.2%], and left elbow [12.0% vs 10.7%].

Conclusions: Acute joint pain reported by the emerging green collar workforce can assist in identifying at risk worker subgroups for musculoskeletal pain interventions.

KEYWORDS
acute joint pain, epidemiology, green collar workers, musculoskeletal disorders, surveillance

1 | INTRODUCTION

In response to the call for more environmentally sustainable industries over the past decade in the United States, a new workforce, the so-called "Green collar" workforce, has emerged to fill these professions. Green jobs are a very heterogeneous group of occupations that typically involve tasks such as protecting ecosystems, reducing pollution and energy usage, and lowering carbon emissions.[1–3] The Green Jobs Act of 2007, which was passed as part of the Energy Independence and Security Act of 2007, allocated up to $125 million in federal funding to promote training and job growth in greenindustries, further spurring the growth of this emerging workforce.[4]

With this shift towards green jobs in the US workforce, the introduction of new job tasks and the evolution of existing job demands can expose these workers to new occupational hazards that may be associated with an increase in various health conditions, such as acute musculoskeletal pain.[5–7] The integration of new green technology and evolution of how work is designed, organized, and managed have not always been an easy transition, as there has often been lags between the application and adoption of green technologies, and the physical and psychosocial hazards these new technologies impart on the workforce. Little is known about the individual job demands and physical exposures of the workforce that is engaged in sustainability, energy conservation, and resource preservation. Given the limited data on individual physical exposures, it may be useful to first characterize health conditions, such as acute joint pain to discern if they are similar to those workers employed in non-green collar occupations. Green collar workers can be exposed to lead and

asbestos during the weatherization process of older buildings and respiratory hazards from exposure to fiberglass and other materials in re-insulation projects.[2,3] Furthermore, they can face ergonomic hazards from the installation of large insulation panels and fall hazards in the installation of heavy energy-efficient windows and solar panels, or in the construction and maintenance of wind turbines.[2,3] Green collar occupations are as diverse as non-green collar occupations, and are comprised of jobs requiring varying levels of physical activity from workers in the blue collar, white collar, service, and agricultural industries. These varied and sometimes novel job activities could also be exposing green collar workers to different occupational physical stressors, such as awkward body postures, heavy material handling, and workplace injuries. Despite the marked growth of this new US workforce, there is little evidence characterizing the musculoskeletal disorders and anatomic joint pain experienced by this relatively new worker group.

As there are no national surveillance systems dedicated to describing the health status, functional limitations, and injuries incurred by this rapidly developing and dynamic workforce, it is possible to link existing large federal datasets to examine musculoskeletal pain in the green collar workforce.[8–10] Leveraging national databases that routinely collect information on industry, occupation, employment status, and musculoskeletal pain among the US population provides a unique and low-cost mechanism to describe and monitor potential occupational physical hazards encountered by workers of various groups across the US economy.[11–13] Each year, millions of US workers are injured on the job or become ill from hazardous exposures in the workplace,[14–16] and green collar occupations are not exempt from these hazards. However, the physical hazards associated with work-related musculoskeletal disorders have never been documented at the population level in this workforce. Given that joint pain is frequently associated with substantial activity limitation,[17] work disability,[18–20] and reduced quality of life,[21–23] the identification and classification of acute joint pain (ie, non-chronic pain, aching, or stiffness in or around a joint) reported by green collar workers can assist in identifying at risk worker groups and prioritizing workplace intervention efforts.

In the present hypothesis generating epidemiologic study, we estimated and compared the prevalence of self-reported acute joint pain between green collar and non-green collar US workers using a linked, nationally representative database of the US population. We ask the research question "What is the prevalence and anatomic site location of joint pain reported by green and non-green collar US workers?"

2 | METHODS

2.1 | Data source

We linked and analyzed data from two publicly available national databases, the NHIS, and the (O*NET). The NHIS is a nationally representative, multistage household survey of the civilian non-institutionalized population of the United States. Administered annually by the National Center for Health Statistics (NCHS), the NHIS collects information on individual health status, medical conditions (ie, musculoskeletal pain), health-care utilization and access, health-related behaviors, employment status, and job type. Trained interviewers from the United States Census Bureau administer the NHIS on portable computers continuously throughout the year by conducting standardized interviews at the survey respondents' homes. In the present study, we used a cross-sectional study design and pooled 9 years of NHIS data, from 2004 to 2012.

The O*NET is a national occupational database that contains information on hundreds of standardized and occupation-specific descriptors classified using a hierarchical model divided into six broad domains. Each domain describes the day-to-day aspects of the job, and the qualifications and interests of each typical worker. Each occupation listed in O*NET is labeled with a Standard Occupational Classification (SOC) code that is backwards compatible with data collected in the NHIS. O*NET further classifies specific occupational titles as "Green collar work" based on the environmental economic activities and the technologies of each occupation. We used O*NET database version 19.0 in this study.

2.2 | Linking NHIS with O*NET using SOC codes

The primary goal of linking the NHIS data with the O*NET was to label the employment status of the NHIS respondent as either being employed in a "Green collar" or "Non-green collar" occupation. The two databases were linked by our research team through collaboration with the Research Data Center (RDC) in the NCHS using in-house NHIS data files with detailed occupational title codes. The in-house files (ie, not publicly available) contain a 4-digit occupational code that is linkable to the 8-digit O*NET SOC codes. The SOC code takes the form: 1 2. 3 4 5 6. 7 8. Each digit in this 8-digit O*NET code has significance in labeling the specific occupational title. The first two digits of the SOC code represent the major group; the third digit represents the minor group; the fourth and fifth digits represent the broad occupation; and the detailed occupation is represented by the sixth digit. The remaining seventh and eighth digits represent an extension or variation of the detailed occupation. For example, major group codes end with 0000 (eg, 47-0000, construction and extraction occupations), minor groups end with 000 (eg, 47-2000, construction trades workers), and broad occupations end with 0 (eg, 47-2020, Brickmasons, Blockmasons, and Stonemasons).

We are able to link the 4-digit in-house NHIS occupational codes (ie, digits 3 4 5 6) exactly with the 8-digit O*NET SOC codes (ie, 1 2. 3 4 5 6) at the RDC. When the O*NET SOC code had a seventh and eighth digit ending in .00, the match was exact with the NHIS data and either labeled as "Green" or "Non-green" in our NHIS dataset. However, when the seventh and eighth digit had an extension beyond .00, such as .01, .02, etc, we further evaluated if each of these detailed occupations were Green, Non-green, or "mixed collar" workers. For example, if an O*NET broad occupational group had three different extensions of the seventh and eighth digit codes (eg, .01, .02, and .03) of which two were classified as green and one was classified as Non-green, then we labeled that NHIS occupational code as "mixed" in

our database to indicate that the parent job title had mixed green and non-green jobs. In the present study, we were able to classify 91% of the NHIS respondents as being employed in either green (19%) or non-green (72%) collar occupations, while 9% of employed NHIS responded fell into the mixed green/non-green category. We excluded from our analyses the mixed green collars as their classification into pure green or non-green collar occupations was not possible in this study.

2.3 | Measures/variables

The main outcome variable in the present study was self-reported acute joint pain. During the 2004-2012 NHIS study period, respondents were asked "The next questions refer to your joints. Please do not include the back or neck. During the past 30 days, have you had any symptoms of pain, aching, or stiffness in or around a joint?" Response options were coded as a dichotomous variable with either an affirmative or negative response. Respondents were also asked "Which joints are affected?" with 17 anatomic joint response options (eg, shoulder-right, shoulder-left, knee-right, knee-left, etc).

NHIS respondents' employment status (ie, employed/unemployed) was based on the self-report of any job in the 1 week prior to the NHIS interview. Detailed job titles (4-digit occupational codes) were identified in the NHIS through the RDC and subsequently linked with the greencollar classification system available in O*NET as described above. Socio-demographic, occupational, and health-related characteristics collected in the NHIS used in this study include: respondent age, gender, race (white, black, or other), ethnicity (Hispanic or non-Hispanic), level of educational attainment (less than high school, high school or Graduate Equivalence Diploma (GED), or greater than high school), health insurance status (insured or uninsured), geographic location (Northeast, Midwest, South, or West), use of special equipment to ambulate, functional limitations, hearing and vision impairment status, body mass index (BMI), and number of jobs (one job or more than one job).

2.4 | Statistical analysis

Prevalence estimates of acute joint pain for green versus non-green collar workers were calculated for the aforementioned socio-demographic, occupational, and health-related characteristics. BMI was categorized using standard categories for weight: normal weight (BMI = 18.50-25.00), overweight (25.01-30.00), and obese (>30.00). Given the complex sample survey design of the NHIS, analyses were performed with SAS and the SUDAAN callable package to take into account sample weights and design effects. For pooled prevalence estimates, sample weights were adjusted to account for the aggregation of data over multiple survey years by dividing the original weight by 9 (the number of years combined in NHIS years 2004 through 2012). To assess trends in acute joint pain between green and non-green collar workers, we estimated the slope (ie, yearly change in the rate of acute joint pain) using the weighted linear regression of acute joint pain over time, its standard error, and the corresponding *P* value. The Rao-Scott chi-square test was used to determine significant differences in the proportions of green collar and non-green collar workers by sociodemographic, occupational, and health characteristics at the 5% alpha level. The study linkage protocol and analysis were approved by the Institutional Review Board of the University of Miami, Miller School of Medicine.

3 | RESULTS

The socio-demographic, work-related, and health characteristics of green and non-green collar workers are shown in Table 1. Green collar workers represented 20.2% of our weighted sample while non-green collar workers accounted for 79.8%.

The prevalence of acute joint pain reported by green and non-green collar workers stratified by socio-demographic, occupational, and health-related characteristics are displayed in Table 2. Green collar workers reported slightly, but statistically significantly more acute joint pain than non-green collar workers (26.5% vs 25.7%). Compared to non-green collar workers, the prevalence of acute joint pain in the green collar workforce was significantly higher among: males (26.3% vs 24.3%), those of white race (28.0% vs 26.8%), non-Hispanics (28.0% vs 27.2%), those with greater than a high school education (27.0% vs 26.0%), workers with only one job (26.1% vs 25.2%), and workers without any use of special ambulatory equipment (26.0% vs 25.2%), functional limitations (17.9% vs 16.2%), or visual impairments (25.1% vs 24.0%). Non-green collar workers 65 years of age and older were significantly more likely to report acute joint pain than green collar workers in the same age category (42.6% vs 38.3%).

The observed and predicted trends in the reported annual prevalence of acute anatomic joint pain for green collar and non-green collar workers are presented in Fig. 1. Overall, the average yearly change (±SE) in acute joint pain rates increased 0.0021% (±0.0198) during the 2004-2012 study period. Green collar workers had a significantly higher average yearly change 0.0028% (±0.0231) when compared to the non-green collar workers 0.0019% (±0.0193) during the same time period ($P = 0.010$). We observed a decrease in prevalence from 2004 to 2006, a steep rise from 2007 to 2010, and then a decrease in acute joint pain from 2010 to 2012. There are significant differences in the prevalence of self-reported acute joint pain between green and non-green collar workers in the 2006 and 2009-2011 time periods. The lowest reported prevalence of anatomic joint pain for both workforces was observed in 2007, the same year the Green Collar Jobs Act was passed into US law.

The prevalence of specific anatomic joint pain between green and non-green collar workers is shown in Fig. 2. Statistically significant differences in the prevalence of acute joint pain were noted in 10 of the 16 anatomic joint locations. The proportion of green collar workers with pain in the upper extremity joints (eg, the right shoulder (23.2% vs 21.1%), right elbow (13.7% vs 12.0%), left shoulder (20.1% vs 18.2%), and left elbow (12.0% vs 10.7%)) was significantly greater than the proportions observed in the non-green collar workforce. In contrast, non-green versus green collar workers reported a significantly higher prevalence of acute joint pain in the lower extremity joints, including

TABLE 1 Sociodemographic and occupational characteristics of green and non-green collara US workers 18 years and older participating in the NHIS, 2004-2012

		Total employed population			Green collar			Non-green collar		
	Characteristics	US estimated population[b]	NHIS sample size[c] (*n*)	Percent of population[d] (95% CI)	US estimated population[a]	*n*	Percent of population[e] (95% CI)	US estimated population[a]	*n*	Percent of population[e] (95% CI)
	Total[d]	132 610 826	143 346	100.0 (100.0-100.0)	26 733 648	27 432	20.2 (19.9-20.5)	105 877 178	115 914	79.8 (79.5-80.1)
Gender	Male	71 343 271	71 267	53.8 (53.5-54.1)	20 245 879	19 847	75.7 (75.1-76.3)	51 097 391	51 420	48.3 (47.9-48.6)
	Female	61 267 555	72 079	46.2 (45.9-46.5)	6 487 769	7585	24.3 (23.7-24.9)	54 779 786	64 494	51.7 (51.4-52.1)
Race	White	108 972 510	111 347	82.2 (81.7-82.6)	22 308 061	21 868	83.5 (82.8-84.1)	86 664 449	89 479	81.8 (81.4-82.3)
	Black	15 541 152	21 864	11.7 (11.3-12.1)	2 873 592	3714	10.7 (10.2-11.3)	12 667 560	18 150	12.0 (11.6-12.4)
	Other	8 097 164	10 135	6.1 (5.9-6.3)	1 551 995	1850	5.8 (5.4-6.2)	6 545 169	8285	6.2 (5.9-6.4)
Age	18-24	17 038 595	15 210	12.8 (12.5-13.2)	2 765 222	2374	10.3 (9.8-10.8)	14 273 373	12 836	13.5 (13.1-13.9)
	25-64	110 661 614	121 754	83.5 (83.1-83.8)	23 187 612	24 116	86.8 (86.2-87.3)	87 474 002	97 638	82.6 (82.2-83.0)
	65+	4 910 617	6382	3.7 (3.6-3.8)	780 815	942	2.9 (2.7-3.2)	4 129 802	5440	3.9 (3.8-4.0)
Ethnicity	Non-hispanic	113 646 860	116 458	85.7 (85.3-86.1)	22 864 722	22 341	85.5 (84.9-86.1)	90 782 139	94 117	85.7 (85.3-86.2)
	Hispanic	18 963 966	26 888	14.3 (13.9-14.7)	3 868 927	5091	14.5 (13.9-15.1)	15 095 039	21 797	14.3 (13.8-14.7)
Highest educational attainment	Greater than high school	83 526 926	89 386	63.4 (62.9-63.9)	15 253 225	15 619	57.3 (56.4-58.1)	68 273 701	73 767	64.9 (64.4-65.4)
	High school	34 281 715	36 036	26.0 (25.6-26.4)	8 231 072	8 163	30.9 (30.2-31.6)	26 050 643	27 873	24.8 (24.4-25.2)
	Less than high school	13 975 562	17 049	10.6 (10.3-10.9)	3 140 517	3539	11.8 (11.3-12.3)	10 835 045	13 510	10.3 (10.0-10.6)
Health insurance	Insured	108 910 019	115 259	82.4 (82.1-82.8)	22 374 618	22 554	83.9 (83.3-84.5)	86 535 401	92 705	82.0 (81.7-82.4)
	Uninsured	23 232 022	27 653	17.6 (17.2-17.9)	4 288 639	4822	16.1 (15.5-16.7)	18 943 383	22 831	18.0 (17.6-18.3)
Region of the United States	Northeast	23 884 597	23 762	18.0 (17.4-18.6)	443 545	4159	16.6 (15.8-17.4)	19 449 144	19 603	18.4 (17.8-19.0)
	Midwest	32 191 978	32 538	24.3 (23.5-25.1)	6 888 764	6663	25.8 (24.6-27.0)	25 303 215	25 875	23.9 (23.2-24.6)

(Continues)

TABLE 1 (Continued)

		Total employed population			Green collar			Non-green collar		
	Characteristics	US estimated population[b]	NHIS sample size[c] (*n*)	Percent of population[d] (95% CI)	US estimated population[a]	*n*	Percent of population[e] (95% CI)	US estimated population[a]	*n*	Percent of population[e] (95% CI)
	South	47 417 490	52,096	35.8 (35.0-36.5)	9 663 434	9983	36.1 (35.0-37.3)	37 754 056	42 113	35.6 (34.9-36.4)
	West	29 116 760	34 950	21.9 (21.3-22.6)	5 745 997	6627	21.5 (20.7-22.3)	23 370 763	28 323	22.1 (21.4-22.7)
Use of special equipment	Yes	2 030 212	2227	1.5 (1.5-1.6)	396 398	399	1.5 (1.3-1.7)	1 633 814	1828	1.5 (1.5-1.6)
	No	130 340 696	140 867	98.5 (98.4-98.5)	26 303 781	27 001	98.5 (98.3-98.7)	104 036 915	113 866	98.5 (98.4-98.5)
Any functional limitations	Yes	29 125 676	31 869	22.0 (21.7-22.4)	5 612 138	5743	21.0 (20.4-21.6)	23 513 538	26 126	22.3 (21.9-22.6)
	No	103 069 471	111 056	78.0 (77.6-78.3)	21 056 075	21 624	79.0 (78.4-79.6)	82 013 396	89 432	77.7 (77.4-78.1)
Any hearing impairment	Yes	14 859 979	15 353	11.2 (11.0-11.5)	3 530 509	3425	13.2 (12.7-13.7)	11 329 470	11 928	10.7 (10.4-11.0)
	No	117 712 190	127 946	88.8 (88.5-89.0)	23 196 846	24 000	86.8 (86.3-87.3)	94 515 344	103 946	89.3 (89.0-89.6)
Any visual impairment	Yes	8 912 813	9674	6.7 (6.5-6.9)	1 685 807	1695	6.3 (5.9-6.7)	7 227 006	7979	6.8 (6.6-7.0)
	No	123 621 885	133 590	93.3 (93.1-93.5)	25 040 806	25 727	93.7 (93.3-94.1)	98 581 078	107 863	93.2 (93.0-93.4)
Body mass index	Normal weight (18.5-25)	47 605 980	51 316	37.3 (36.8-37.7)	8 215 771	8536	31.5 (30.6-32.3)	39 390 209	42 780	38.7 (38.2-39.2)
	Overweight (25.01-30)	46 563 860	50 024	36.4 (36.1-36.8)	10 396 195	10 678	39.8 (39.1-40.6)	36 167 665	39 346	35.6 (35.2-35.9)
	Obese (>30.00)	33 630 200	36 680	26.3 (26.0-26.7)	7 500 754	7535	28.7 (28.0-29.4)	26 129 446	29 145	25.7 (25.3-26.1)
Works more than one job	Yes	11 477 735	12 316	8.7 (8.5-8.9)	1 840 718	1884	6.9 (6.5-7.3)	9 637 016	10 432	9.1 (8.9-9.4)
	No	120 576 612	130 455	91.3 (91.1-91.5)	24 857 452	25 511	93.1 (92.7-93.5)	95 719 161	104 944	90.9 (90.6-91.1)

[a]Mixed workers (ie, not pure green or non-green collar workers) are not included in this table.
[b]Estimated from the NHIS for the years 2004-2012.
[c]Sample size from the NHIS for the years 2004-2012.
[d]Percent of total employed population (*N* = 132 610 826).
[e]Percent of green collar (*N* = 26 733 648) or non-green collar workers (*N* = 105 877 178), except for the "Total" row, which displays the percentage of the total employed population (*N* = 132 610 826) represented by green and non-green collar workers.

TABLE 2 Prevalence of any anatomic joint pain (excluding neck and back) in the past 30 days[c] estimated for green and non-greena collar US workers 18 years and older participating in the NHIS, 2004-2012

		Total employed population			Green collar			Non-green collar		
	Characteristics	US estimated population[b]	Yes, joint pain (*n*)	Yes, joint pain percent[c] (95% CI)	US estimated Population[a]	Yes, joint pain (*n*)	Yes, joint pain percent[d] (95% CI)	US estimated population[a]	Yes, joint pain (*n*)	Yes, joint pain percent[d] (95% CI)
	Total[c]	34 285 108	36 763	25.9 (25.5-26.2)	7 076 143	7079	26.5 (25.8-27.1)*	27 208 965	29 684	25.7 (25.3-26.1)*
Gender	Male	17 735 955	17 298	24.9 (24.4-25.3)	5 313 631	5052	26.3 (25.5-27.0)*	12 422 324	12 246	24.3 (23.8-24.8)*
	Female	16 549 153	19 465	27.0 (26.6-27.5)	1 762 512	2027	27.2 (26.0-28.4)	14 786 641	17 438	27.0 (26.5-27.5)
Race	White	29 441 626	29 984	27.0 (26.7-27.4)	6 197 204	5945	28.0 (27.1-28.5)*	23 244 423	24 039	26.8 (26.4-27.3)*
	Black	3 439 033	5055	22.1 (21.4-22.9)	621 316	847	21.6 (20.0-23.3)	2 817 717	4208	22.3 (21.5-23.1)
	Other	1 404 449	1724	17.4 (16.4-18.3)	257 624	287	16.6 (14.6-18.6)	1 146 825	1437	17.5 (16.5-18.6)
Age	18-24	2 355 439	2118	13.8 (13.0-14.6)	412 737	349	14.9 (13.1-16.7)	1 942 702	1769	13.6 (12.7-14.5)
	25-64	29 871 179	32 002	27.0 (26.7-27.4)	6 364 531	6385	27.5 (26.8-28.2)	23 506 648	25 617	26.9 (26.5-27.3)
	65+	2 058 490	2643	41.9 (40.3-43.6)	298 876	345	38.3 (34.3-42.2)*	1 759 614	2298	42.6 (40.9-44.3)*
Ethnicity	Non-hispanic	31 052 952	32 081	27.3 (27.0-27.7)	6 407 538	6202	28.0 (27.3-28.8)*	24 645 414	25 879	27.2 (26.8-27.6)*
	Hispanic	3 232 156	4682	17.0 (16.5-17.6)	668 605	877	17.3 (15.9-18.7)	2 563 551	3805	17.0 (16.3-17.6)
Highest educational attainment	Greater than high school	21 846 672	23 379	26.2 (25.8-26.6)	4 116 351	4166	27.0 (26.1-27.9)*	17 730 321	19 213	26.0 (25.6-26.4)*
	High school	9 137 207	9527	26.7 (26.1-27.3)	2 194 051	2121	26.7 (25.5-27.8)	6 943 156	7406	26.7 (26.0-27.4)
	Less than high school	3 164 233	3714	22.7 (21.8-23.5)	750 493	774	23.9 (22.1-25.8)	2 413 740	2940	22.3 [21.3-23.3)
Health insurance	Insured	29 051 134	30 620	26.7 (26.3-27.0)	6 100 030	6010	27.3 (26.6-28.0)	22 951 104	24 610	26.5 (26.1-26.9)
	Uninsured	5 138 865	6058	22.1 (21.5-22.8)	958 202	1057	22.4 (20.8-23.9)	4 180 663	5001	22.1 (21.4-22.8)
Region of the United States	Northeast	5 806 880	5783	24.3 (23.6-25.1)	1 105 126	1022	24.9 (23.5-26.4)	4 701 754	4761	24.2 (23.4-25.0)
	Midwest	9 382 624	9559	29.2 (28.5-29.9)	2 078 980	1981	30.2 (28.8-31.6)	7 303 644	7578	28.9 (28.1-29.7)
	South	11 724 610	12 828	24.7 (24.2-25.3)	2 426 744	2444	25.1 (24.0-26.2)	9 297 866	10 384	24.6 (24.0-25.3)
	West	7 370 995	8593	25.3 (24.6-26.1)	1 465 294	1632	25.5 (24.3-26.7)	5 905 701	6961	25.3 (24.4-26.1)
Use of special equipment	Yes, special equipment	1 200 343	1361	59.2 (56.7-61.7)	228 440	237	57.7 (51.4-64.0]	971 904	1124	59.6 (56.7-62.4)
	No, special equipment	32 990 818	35 310	25.3 (25.0-25.7)	6 834 160	6830	26.0 (25.3-26.6)*	26 156 658	28 480	25.2 (24.825.5)*
Any functional limitations	Yes, any functional limitations	17 135 767	18 749	58.8 (58.2-59.5)	3 285 137	3353	58.6 (57.0-60.2)	13 850 630	15 396	58.9 (58.2-59.6)
	No, any functional limitations	17 006 537	17 868	16.5 (16.2-16.8)	3 766 555	3703	17.9 (17.3-18.5)*	13 239 982	14 165	16.2 (15.8-16.5)*

(Continues)

TABLE 2 (Continued)

		Total employed population			Green collar			Non-green collar		
	Characteristics	US estimated population[b]	Yes, joint pain (*n*)	Yes, joint pain percent[c] (95% CI)	US estimated Population[a]	Yes, joint pain (*n*)	Yes, joint pain percent[d] (95% CI)	US estimated population[a]	Yes, joint pain (*n*)	Yes, joint pain percent[d] (95% CI)
Any hearing impairment	Yes, hearing impairment	7 049 477	7375	47.5 (46.5-48.4)	1 658 927	1622	47.0 (45.2-48.8)	5 390 550	5753	47.6 (46.4-48.8)
	No, hearing impairment	27 223 421	29 373	23.1 (22.8-23.5)	5 416 790	5456	23.4 (22.7-24.0)	21 806 632	23 917	23.1 (22.7-23.5)
Any visual impairment	Yes, visual impairment	4 330 569	4752	48.6 (47.3-49.9)	796 515	816	47.3 (44.0-50.5)	3 534 054	3936	48.9 (47.5-50.3)
	No, visual impairment	29 927 810	31 980	24.2 (23.9-24.6)	6 277 582	6260	25.1 (24.4-25.7)*	23 650 228	25 720	24.0 (23.6-24.4)*
Body mass index	Normal weight (18.50-25.00)	9 540 017	10 283	20.0 (19.620.5)	1 638 831	1701	20.0 (19.0-21.0)	7 901 187	8582	20.1 (19.6-20.6)
	Overweight (25.01-30.00)	12 016 447	12 655	25.8 (25.3-26.3)	2 724 801	2699	26.2 (25.2-27.2)	9 291 646	9956	25.7 (25.1-26.3)
	Obese (>30.00)	11 548 709	12 579	34.4 (33.7-35.0)	2 574 517	2536	34.3 (33.0-35.7)	8 974 193	10 043	34.4 (33.7-35.0)
Works more than one job	Yes, have more than one job	3 609 441	3881	31.5 (20.4-32.5)	590 728	604	32.1 (29.4-34.8)	3 018 713	3277	31.3 (30.2-32.5)
	No, have more than one job	30 607 398	32 809	25.4 (25.1-25.7)	6 477 267	6469	26.1 (25.4-26.7)*	24 130 132	26 340	25.2 (24.8-25.6)*

*Statistically significant difference in prevalence of acute joint pain between Green and Non-green collar workers ($P < 0.050$).

[a]Mixed workers (ie, not pure green or non-green collar workers) are not included in this table.

[b]The estimates from this table are based on questions from the NHIS that asked respondents "Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?" for the years 2004-2012.

[c]Percent of total employed population ($N = 132\,610\,826$) reporting acute anatomic joint pain in the past 30 days estimated from the NHIS for the years 2004-2012.

[d]Percent of Green collar ($N = 26\,733\,648$) or Non-green collar workers ($N = 105\,877\,178$) reporting acute anatomic joint pain in the past 30 days estimated from the NHIS for the years 2004-2012.

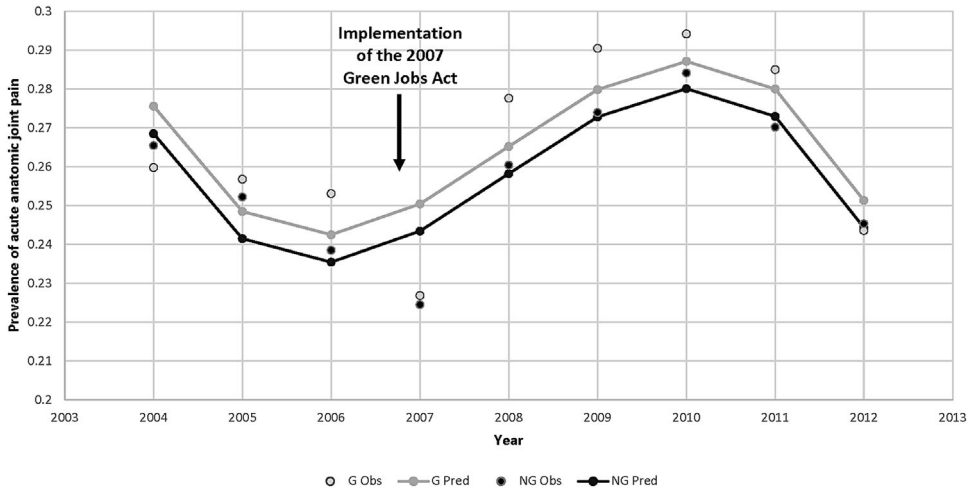

FIGURE 1 Observed and predicted annual prevalence of any anatomic joint pain (excluding neck and back) in the past 30 days estimated for green and non-green collar US workers 18 years and olderparticipating in the NHIS, 2004-2012

the right hip (14.9% vs 12.2%), right ankle (15.1% vs 13.9%), right toes (6.2% vs 5.2%), left hip (14.1% vs 12.0%), left knee (47.4% vs 46.0%), and left toes (5.8% vs 5.0%).

4 | DISCUSSION

This study is the first to describe the acute musculoskeletal pain experience of the emerging US green collar workforce. It is well documented that musculoskeletal pain is influenced by a complex mixture of genetic factors, socio-economic factors, lifestyle, and individual perceptions. However, high physical work demands are generally considered to be one of the primary causes of musculoskeletal pain among workers.[24–32] When compared to all workers, those employed in jobs with high physical work demands (eg, blue collar workers) have the highest prevalence of musculoskeletal pain.[33–37] Most often, physical work demands that predispose workers to develop musculoskeletal disorders and joint pain include monotonous and repetitive arm movements, awkward body postures, prolonged standing, work with arms above shoulder height, and heavy lifting. In our study, a significantly greater proportion of green collar workers were found to self-report acute joint pain as compared to their non-green counterparts. While the new and changing occupational physical demands associated with green work could be associated with the observed differences in acute joint pain,

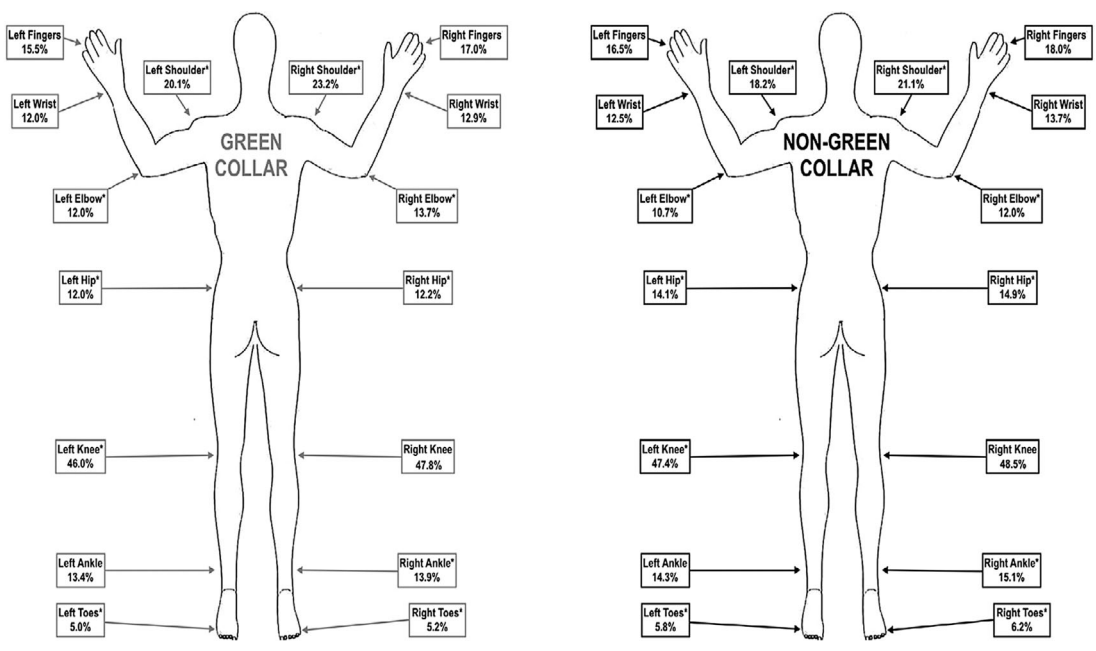

FIGURE 2 Site-specific prevalence of self-reported anatomic joint pain (excluding neck and back) in the past30 days† estimated for green and non-green collar US workers 18 years and older participating in theNational Health Interview Survey, 2004-2012

further exploration is needed to identify which green collar occupations and specific physical stressors predispose workers to more frequently self-report more musculoskeletal pain.

The stereotypical green collar worker who experiences acute joint pain based on our study data would be a white race, non-Hispanic, female, older than 65 years of age with greater than a high school education. This demographic can be considered a priority worker subgroup for targeted workplace interventions that aim to reduce the burden of acute musculoskeletal pain among green collar workers. However, it is difficult to compare findings from the present study to past evidence, as past studies have largely focused on the chronic pain experience (ie, lasting 3 months or longer) rather than the acute. Using 2012 NHIS data, Blackwell et al. found 22.3% of employed Americans to self-report chronic joint pain symptoms.[38] The present study found the overall prevalence of acute joint pain to be 25.9%, with workforce specific prevalence of 26.5% among green collar workers and 25.7% among non-green collar workers. Although the prevalence of acute joint pain in our study was found to be higher than national estimates of chronic joint pain, the lack of past scientific evidence differentiating these two pain experiences highlights a void in the understanding of occupational physical exposures and joint pain. Chronic pain can often develop as a result of joint degeneration, possibly attributable to years of repetitive movements or poor implementation of ergonomic tools, while acute joint pain may better reflect the daily wear and tear of the joints, possibly representing workers who sustain workplace injuries that are too minor to seek medical attention or miss work. In addition to examining the changing workplace physical demands among green collar workers that may explain the observed disparity in self-reported acute musculoskeletal pain, characterizing the differences in temporality and etiology of acute versus chronic musculoskeletal pain may allow researchers to better understand of the burden of joint pain among US workers and devise public health interventions to address this burden.

We found significant differences in the proportion of green collar workers reporting upper extremity acute joint pain at the shoulders and elbows when compared to non-green collar workers. It is possible that individuals employed in green collar occupations are using more upper body muscle strength to meet their evolving or new job demands. These demands are exemplified by green jobs that focus on construction and maintenance of environmentally friendly systems, with common job tasks such as overhead installation of insulation panels, energy-efficient windows, and solar panels.[2,3] In contrast, a higher proportion of non-green collar workers reported lower extremity joint pain at the hips, knees, ankles, and toes as compared to green collar workers, suggesting that green collar jobs may require fewer or less severe physical demands in the legs (eg, carrying heavy materials, bending at the hips, squatting). Reme et al. found that adults employed as hospital patient care workers, a non-green service occupation reported higher lower body pain in the last 3 months (64.5%), while 45.7% of them reported upper body pain.[39] The site-specific acute joint pain estimates in our study were higher for both green and non-green collar workers in almost all joints, except for the hips. Their results are similar to our finding that non-green collar workers self-report a significantly higher prevalence of lower body joint pain compared to green collar workers. Despite the differences in site-specific acute joint pain observed in our study, the heterogeneity in physical demands and job tasks for both the green and non-green collar workforces suggest that further research is needed to characterize which occupational demands, ergonomic hazards, and other environmental exposures specific to green collar workers predispose them to develop musculoskeletal pain in upper body versus lower body locations.

Sociodemographic and health characteristics were also different between green and non-green collar workers. We found that green collar workers had greater hearing impairment and were more obese (BMI ≥ 30.0 kg/m^2) than the non-green collar counterparts (13.2% vs 10.7% and 28.7% vs 25.7%, respectively). Occupational exposure to elevated levels of noise at construction sites remains a major hazard in modern construction sites such as sustainable building options (ie, LEED) green standards.[40,41] It may be possible new "green equipment" and worksite flow processes emits high noise levels or limit opportunities for hearing conservation. Along the same vein, we found slightly less functional limitations (21.0% vs 22.3%) and visual impairment (6.3% vs 6.8%) in green versus non-green collar workers. Non-green collar workers usually worked more than one job (9.1% vs 6.9%) as compared to green collar workers. As the type and quantity of green collar jobs evolve in the US, it is likely that full-time dedicated positions for green collar workers will be available, limiting availability for part-time green collar work.[42] Approximately 22 different sectors of the US economy currently provide workers with full-time green collar jobs.[43] These new and evolving green jobs represent a growing component of workforce opportunities especially given the relatively high quality jobs, with relatively low barriers to entry. There was a small increased trend in self-reported acute joint during the 2004-2012 study period, where significant differences were noted in the prevalence of the joint pain between green and non-green collar workers in the 2006 and 2009-2011 time periods. The lowest reported prevalence of anatomic joint pain for both workforces was observed in 2007, the same year the Green Collar Jobs Act was passed into US law. During the same time frame, the global financial crisis in 2007-2008 was marked with increased unemployment which may have led to employed workers, particularly blue collar workers engaging in additional physical demands, hire paced jobs, cutting of safety coupled with a fear of reporting injury or pain as not to lose their job.[44] Future studies should further examine the reporting of health conditions and pain during economic downturns.

Limitations of this study included the self-report and cross-sectional nature of the NHIS. Additionally, we were unable to determine green-collar job status of 9% of the NHIS participants (ie, mixed green/non-green collar workers) because we linked jobs by top level O*NET codes, not the sub-level O*NET codes. However, due to the relatively small proportion of missing data, we do not believe differential selection bias exists. The major strengths of this study lie in the use of the NHIS, a nationally representative sample of the US population, which yielded a large and representative sample of US adults with their musculoskeletal pain experience and a unique opportunity to collect information on occupational hazards that are rarely included in national surveys.

5 | CONCLUSIONS

Green collar jobs include a large number and variety of industries with myriad occupational exposures, and our study found a higher prevalence of acute joint pain among employees in these environmentally friendly professions, particularly upper extremity pain. Further research is necessary to examine longitudinally the musculoskeletal pain experience of this evolving workforce and differentiate the evolving mixture of traditional and new workplace hazards in any job, but especially those specific to green collar occupations and workplaces.

AUTHORS' CONTRIBUTIONS

AJCM, DJL, and SRH conceived the study, participated in its design, coordination, performed statistical analyses, and co-drafted the manuscript. WGL and KLA participated in the design of the study, performed statistical analysis, and helped with the manuscript draft. All authors read and approved the final manuscript.

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ETHICS APPROVAL AND INFORMED CONSENT

The University of Miami Institutional Review Board reviewed and approved the research protocol for this study (ID: 20120714).

DISCLOSUER (AUTHORS)

All authors express there are no known conflicts of interest in this study or in the writing of the manuscript. The findings and conclusions in this report are those of the authors and do not necessarily represent the views of NIOSH.

DISCLOSUER BY AJIM EDITOR OF RECORD

Steven Markowitz declares that he has no conflict of interest in the review and publication decision regarding this article.

DISCLAIMER

None.

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