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ORIGINAL ARTICLE

Opioid use disorder, job strain, and high physical job demands in US workers

BongKyoo Choi[1,2]

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Abstract

Purpose Little is known about the work environmental risk factors for opioid use disorder (OUD) in working populations. The purpose of this study is to examine whether adverse physical and psychosocial working conditions are associated with OUD in a working population of the United States (US).

Methods Among the participants of the National Survey of Midlife Development in the United States (MIDUS) II Study (2004–2006), 2134 workers (1059 men and 1075 women; mean age, 51 years) were chosen for this study. OUD was measured with self-administered questions in line with the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSD-5). Physical demands (physical efforts, heavy lifting, and crouching/stooping/kneeling) and psychosocial work stressors (skill discretion, decision authority, job control, psychological job demands, supervisor and coworker support at work, job insecurity, and work hours) were measured with a standard questionnaire.

Results The prevalence of OUD was 3.8%. In multivariate analyses, low skill discretion, high psychological job demands, job strain (a combination of low control and high demands), and high physical job demands were significantly associated with OUD. The multivariate prevalence ratios for OUD by job strain and frequent heavy lifting were 1.98 (1.27–3.10) and 2.23 (1.22–4.10), respectively. Job strain was more strongly associated with OUD in men, while high physical job demands were more strongly associated with OUD in women.

Conclusion This study implies that adverse physical and psychosocial working conditions may be important risk factors for OUD in US working populations. Future longitudinal and mechanistic studies are urgently warranted.

Keywords Opioid · Physical demands · Job strain · Psychosocial · MIDUS · United States

Introduction

There were 47,600 opioid overdose deaths in 2017 in the United States (US), which is equivalent to 130 deaths per day (Hedegaard et al. 2018). During the recent 2 decades, the rate of opioid overdose deaths has quadrupled in the US: 2.9 per 100,000 standard population in 1999 to 14.9 in 2017. In particular, the rate of increase in opioid overdose deaths has been greatest among the working-age population (Hedegaard et al. 2018). In addition, the economic costs due to opioid overdose, abuse, and dependence were estimated to be 78.5 billion dollars (Florence et al. 2016). In addition, the workplace costs due to lost and reduced productivity were greater than the healthcare care costs (Birnbaum et al. 2006; Florence et al. 2016; Goplerud et al. 2017).

To establish effective strategies for the primary prevention of opioid overdose deaths in working populations, it is essential to identify important work environmental risk factors for opioid overdose, abuse, and dependence. Several researchers (Miller 2009; Moore and Dietze 2005; Rhodes 2002) have emphasized the importance of understanding the risk environment, "the space – whether social or physical - in which a variety of factors interact to increase the chances of drug-related harm." (Rhodes 2009, p. 88). However, our current understanding of the work environmental risk factors is very limited (Harduar Morano et al. 2018). Although low occupation-specific median income and high job insecurity were correlated with opioid overdose deaths in bivariate analyses in a recent study (MDPH 2018), it remains to

✉ BongKyoo Choi
b.choi@uci.edu

[1] Department of Medicine and Program in Public Health, University of California Irvine, 100 Theory, Suite 100, Irvine, CA 92617, USA

[2] Center for Work and Health Research, Irvine, CA, USA

be further tested using multivariate analyses. In addition, no epidemiological studies have examined the associations between adverse working conditions and opioid use disorder (OUD), a problematic pattern of opioid use that leads to serious impairment or distress (APA 2013) which is a strong predictor for opioid overdose death (Degenhardt et al. 2011; Hser et al. 2017). One case–control study (Muntaner et al. 1995) investigated physical and psychosocial working conditions in relation to drug abuse/dependence using data from households in five US metropolitan areas in the 1980s. In the study, high physical job demands and low skill discretion were positively associated with drug abuse/dependence. However, unexpectedly, high decision authority appeared to be positively associated with drug abuse/dependence. Moreover, the previous study did not address specifically OUD.

The supply for opioids in the US has substantially increased since the mid-1990s mainly due to more liberal use of prescription opioids for chronic pain (FDA 2018; Franklin et al. 2015; Sullivan and Howe 2013), coupled with aggressive promotion and marketing of opioid products by pharmaceutical companies (Griffin and Miller 2011; Hadland et al. 2017; Van Zee 2009). Given the circumstances, some adverse physical and psychosocial working conditions may increase the risk of OUD in US working populations. Here are three possible etiological mechanisms from adverse working conditions to OUD, although they are neither exhaustive nor mutually exclusive:

- First, high physical (biomechanical) job demands may increase the risk of OUD via work-related injuries. For example, frequent heavy lifting is a well-established risk factor for occupational injuries (Barcenilla et al. 2012; Harris-Adamson et al. 2015; NIOSH 1997). Occupational injuries and pain were treated more often with opioids as analgesics and for longer periods, compared to non-occupational injuries (Asfaw et al. 2018). Chronic opioid therapy for non-cancer pain was associated with incident OUD (Edlund et al. 2014; Fishbain et al. 2008).
- Second, psychosocial work stressors [e.g., job strain, a combination of low job control and high psychological job demands (Karasek 1979)] may increase the risk of OUD via common mental disorders (depression and anxiety disorders). Psychosocial work stressors raise chances of common mental disorders in working populations (Madsen et al. 2017; Stansfeld and Candy 2006; Theorell et al. 2015). Depression and anxiety disorders increase the risk of higher dose and longer term opioid treatment, and OUD (Halbert et al. 2016; Martins et al. 2012; Seal et al. 2012; Wasan et al. 2005). There is also a reciprocal relationship between depression and pain (Kroenke et al. 2011). Workers under stressful working conditions may self-medicate their negative emotions (emotional pain) with opioids (Cheng et al. 2013; Khantzian 1997; Merlo et al. 2013a, b; Rigg and Ibañez 2010), which if frequently repeated, may lead to OUD.
- Third, workers may use opioids to get high (Davey et al. 2007; Merlo et al. 2013a; Rigg and Ibañez 2010). For example, about 20–30% of opioid overdose fatality cases used prescription painkillers for "fun, good feeling, getting high" (Cheng et al. 2013). In addition, workers may use opioids to meet their high physical and emotional job demands (Davey et al. 2007; Walter et al. 2018). Working under the influence of opioids can increase the risk for work-related injuries (Gomes et al. 2013; Kowalski-McGraw et al. 2017; Li et al. 2013). More than half of the people who reported that they misused pain relievers obtained the drugs from a friend or relative in 2017 (SAMHSA 2018).

The purpose of this cross-sectional study is to examine the associations between adverse working conditions (physical job demands, job control, psychological job demands, social support at work, job insecurity, and work hours) and OUD in a working population from the National Survey of Midlife Development in the United States (MIDUS) II Study during 2004–2006.

Methods

The MIDUS II study

For this cross-sectional study, the MIDUS II study data were chosen over the MIDUS I study data in consideration of the fact that the current opioid epidemic in US general and working populations started in the late 1990s. The MIDUS II study was conducted in 2004–2006 as a follow-up survey of the MIDUS I study (1994–1995) that had been originally designed to investigate the roles of behavioral, psychological, and social factors in understanding age-related differences in physical and mental health (Ryff et al. 2007). Initially, 6329 persons (men, 48% and women, 52%) completed interview and self-administered questionnaires of the MIDUS I study. All of the participants were non-institutionalized, English-speaking adults, aged 25 to 74 in the US. They were drawn from four subsamples: (1) a main national random-digit-dial (RDD) sample ($N = 3034$); (2) oversamples from five metropolitan areas ($N = 658$); (3) siblings of individuals from the RDD sample ($N = 869$); and (4) a national RDD sample of twin pairs ($N = 1764$). The response rates of the four subsamples ranged from 60 to 70%. The socio-demographic characteristics of the main RDD subsample were comparable to those of a US population representative sample, the October 1995 Current Population Survey. However, the main RDD subsample relatively underrepresented those who were African-Americans, young (e.g.,

aged 25–34), or had less formal education (i.e., ≤ 12 years of formal education) (Ryff et al. 2007).

In total, 4032 persons completed interview and self-administered questionnaires of the MIDUS II study: (1) the main RDD sample ($N = 1805$); (2) the city oversamples ($N = 386$); (3) the sibling sample ($N = 637$); and (4) the twin RDD sample ($N = 1204$). The longitudinal retention rates among the four subsamples ranged from 59 to 73% (on average, 64%). There were no significant ($p < 0.01$) differences in age and gender between the follow-up participants and non-participants. However, during the follow-up, less-educated persons and non-whites were more likely to have dropped out of the study (Choi et al. 2010a).

Study subjects ($N = 2134$)

For the current study, among those ($N = 4032$) who participated in the MIDUS II study, study subjects were first restricted to those who reported to work as a full-timer or part-timer in 2003 and also work for pay at the time of the MIDUS II study during 2004–2006 ($N = 2237$). Then the workers who did not have valid information on the exposure or outcome variables ($N = 103$) were excluded. Thus, finally 2134 workers were chosen for analyses in this study.

Opioid use disorder (OUD)

Substance use was assessed with the following question: "By "on your own" we mean either without a doctor's prescription, in larger amounts than prescribed, or for a longer period than prescribed. With this definition in mind, did you ever use any of the following substances on your own during the past 12 months?" There was a response option (Yes/No) for narcotic painkillers: "Analgesics or other prescription painkillers on your own (NOTE: this does not include normal use of aspirin, Tylenol without codeine, etc., but does include use of Tylenol with codeine and other prescribed painkillers like Demerol, Darvon, and Percodan)." In addition, there was a separate response option for heroin. Among those who reported the use of narcotic painkillers or heroin on their own, OUD cases were defined with those who additionally agreed to two or more of the following seven questions about substances use behaviors or experiences, which is in line with the definition of OUD according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (APA 2013): (1) used much larger amounts or for a longer period than intended, (2) under the effects or suffering aftereffects while at work or school, or while taking care of children, (3) under the effects or feeling aftereffects in a situation which increased your chances of getting hurt, (4) any emotional or psychological problems from using substances, (5) a strong irresistible desire or urge to use substances, (6) spent a great deal of time using substances or getting over aftereffects, and (7) used more than usual to get the same effect or the same amount had less effect on you than before.

Physical and psychosocial working conditions

Physical job demands were assessed and analyzed with each of the following three questions ("How often does your job require…"): (1) a lot of physical effort, (2) lifting loads weighing 50 lbs or greater, and (3) crouching, stooping, or kneeling. For analyses, the five responses to the questions were simplified into three groups: all of the time/most, some, and little/never.

Several psychosocial working conditions (job control, psychological job demands, supervisor, and coworker support at work, job insecurity, and working hours) were measured with a self-administered questionnaire. The questions for job control (five questions: two skill discretion items about variety of work and learning opportunities on the job and three decision authority items about on-the-job decision-making opportunities), psychological job demands (three questions; time pressure and workload), and immediate supervisor (two questions) and coworker support (two questions) were similar to the ones of the Job Content Questionnaire (JCQ) (Karasek et al. 1985). More detailed information about the items is available elsewhere (Choi et al. 2010a, b). The items had a five-point Likert type of response set: all of the time to never and the responses were summed up for scaling–scoring. The scores of the aforementioned scales were dichotomized at their medians for analyses. There was one additional response option for the immediate supervisor and coworker support items: does not apply. Thus, those who responded with the option were categorized into no immediate supervisor and no coworker groups, respectively (Choi 2018).

Job strain, a combination of low job control and high psychological job demands based on the Demand-Control Model (Karasek 1979), was operationalized using the medians of job control and psychological job demands. Job insecurity was measured with one question ("If you wanted to stay in your present job, what are the chances that you could keep it for the next two years?"). Those with the response options (fair or poor vs. good, very good, or excellent) were considered to be the high job insecurity group. Work hours per week at a main job and other paid jobs were added up for analysis.

Covariates

Several potential confounders were considered in analysis: data sources, socio-demographic characteristics (age, sex, marital status, race, annual household income, and education), and cancer ("Have you ever had cancer?"). In addition, a history of non-work period due to alcohol or substance

abuse problems during the whole working life ("Alcohol or substance abuse problems kept you from working") was considered in analyses. Two self-reported health conditions were included in analysis as potential confounders: experience of or treatment for sciatica, lumbago, or recurring backache (hereafter called backache), and experience or treatment for anxiety, depression, or some other emotional disorder (hereafter called common mental disorders) in the past 12 months. However, the two health conditions could be considered potential mediators under the assumption that adverse working conditions affect OUD via work-related injuries/musculoskeletal disorders or common mental disorders and some of the backaches and common mental disorders are work related. Thus, their impacts on the results were examined separately from other confounders (see below).

Statistical analyses

Descriptive statistics of OUD by data source, sociodemographic variables, and health conditions were conducted. The bivariate association between each working condition and OUD was examined by χ^2 test. When a working condition was at least marginally ($p < 0.20$) associated with OUD in the bivariate analysis, it was further investigated through a series of multivariate Cox's proportional hazards models (Lee and Chia 1993) after controlling for sociodemographic variables (Model 1); additionally controlling for the other working conditions (Model 2); additionally controlling for backache (Model 3); and additionally controlled for common mental disorders (Model 4). The prevalence ratios (PRs) and their 95% confidence intervals (CIs) for OUD by working conditions were presented. Statistical significance testing was based on a two-sided test. The above analyses were replicated in men and women to examine potential gender differences in the results (Muntaner et al. 1995). As a sensitivity analysis, the above analyses were replicated in the workers without a history of non-work period due to alcohol or substance abuse problems.

Results

Prevalence of OUD by sociodemographic characteristics and health conditions

Among the 2131 workers, 91 workers (4.3%) reported that they used narcotic prescription painkillers on their own in the past 12 months. Eighty of the 91 workers met the definition of OUD. Although 2 of the 91 workers reported that they also used heroin on their own, they did not meet the definition of OUD. Thus, among the 2131 workers, the prevalence of OUD was 3.8% (80 workers; 44 men and 36 women). The distributions of OUD did not significantly change by data source, sex, marital status, education, and cancer experience (Table 1). However, OUD was more prevalent in younger workers and African-Americans. It was also more prevalent in workers with medium annual household incomes ($ 60,000–$ 99,999) than in workers with low or high annual household incomes. OUD was significantly and positively associated with experiences or treatment for backache or common mental disorders in the past 12 months (Table 1). Ten workers reported a history of non-work period due to alcohol or substance abuse problems during their working lives. Among the ten workers, one worker had OUD at the time of the MIDUS II study.

Bivariate associations of adverse working conditions with OUD

Low skill discretion, high psychological job demands, job strain, high physical efforts, frequent heavy lifting, and frequent crouching/stooping/kneeling were all significantly associated with OUD in bivariate analyses (Table 2). The prevalence of OUD was 6.4% in the job strain group and 9.0% in the frequent heavy lifting group. OUD was more prevalent in the low job control group than in the high job control group, although the difference was only marginally significant ($p < 0.20$). OUD did not significantly vary by decision authority, supervisor support, coworker support, job insecurity, and work hours.

Multivariate associations of adverse working conditions with OUD

The multivariate results were very similar to those in the bivariate analyses. After controlling for sociodemographic variables (age, race, and annual household income) (Model 1), low skill discretion, high psychological job demands, job strain, high physical efforts, frequent heavy lifting, and frequent crouching/stooping/kneeling were all significantly associated with OUD (Table 3). There was minor attenuation in the associations by backache (Model 3). In the final multivariate model (Model 4) after controlling for other working conditions, backache, and common mental disorders, low skill discretion, high psychological job demands, job strain, and frequent heavy lifting were significantly associated with OUD. Their PRs for OUD were 1.70 (1.09–2.66), 1.86 (1.12–3.09), 1.98 (1.26–3.10), and 2.23 (1.22–4.10), respectively (Table 3).

Multivariate associations of adverse working conditions with OUD in men and women

The prevalence of OUD in the job strain group was higher in men (8.1%) than in women (4.9%). By contrast, the prevalence of OUD in the frequent heavy lifting group was higher

Table 1 Distributions of study variables and the prevalence of opioid use disorder (OUD) in 2,131 workers

Study variables	Category	Subcategory	*N* (%)	OUD: *N* (%)
Data source	Subsamples	Main RDD	902 (42.3)	37 (4.1)
		City	210 (9.9)	7 (3.3)
		Sibling	347 (16.3)	10 (2.9)
		Twin RDD	672 (31.5)	26 (3.9)
Sociodemographic	Age	< 39	254 (11.9)	14 (5.5)*
		40–49	731 (34.3)	31 (4.2)*
		50–59	748 (35.1)	26 (3.5)*
		≥ 60	398 (18.7)	9 (2.3)*
	Sex	Men	1,057 (49.6)	44 (4.2)
		Women	1,074 (50.4)	36 (3.4)
	Race	Non-Hispanic white	1,973 (92.6)	70 (3.5)*
		African-Americans	68 (3.2)	6 (8.8)*
		Pacific Islanders/Asians/others	90 (4.2)	4 (4.4)*
	Marital status	Married	1571 (73.7)	61 (3.9)
		Separated	37 (1.7)	3 (8.1)
		Divorced	283 (13.3)	12 (4.2)
		Widowed	56 (2.6)	1 (1.8)
		Never married	184 (8.6)	3 (1.6)
	Education	High school or less	558 (26.2)	27 (4.8)
		Some college	607 (28.5)	20 (3.3)
		University or more	964 (45.3)	33 (3.4)
	Household income ($)	< 60,000	682 (32.0)	20 (2.9)**
		60,000–99,999	709 (33.3)	37 (5.2)**
		≥ 100,000	740 (34.7)	23 (3.1)**
Health conditions	Cancer ever	No	1926 (90.4)	70 (3.6)
		Yes	205 (9.6)	10 (4.9)
	Sciatica, lumbago, or recurring backache in the past 12 months	No	1835(86.1)	60 (3.3)***
		Yes	296 (13.9)	20 (6.8)***
	Anxiety or depression in the past 12 months	No	1791 (84.0)	59 (3.3)**
		Yes	340 (16.0)	21 (6.2)**
	Alcohol or substance abuse problem kept you from working	No	2121 (99.5)	79 (3.7)
		Yes	10 (0.5)	1 (10.0)

*$p < 0.20$, **$p < 0.05$, and ***$p < 0.01$ at χ^2 test

[a]Two persons refused to answer

in women (11.5%) than in men (8.9%) (for details, see a note of Table 2). However, none of the gender differences were statistically significant ($p > 0.10$). The multivariate associations of job strain and its components (low skill discretion, low job control, and high psychological job demands) with OUD were stronger in men than in women, while the associations between high physical job demands with OUD were stronger in women than in men (Tables 4 and 5; Fig. 1). The PRs for OUD by job strain were 2.74 (1.50–5.00, $p = 0.001$) in men and 1.58 (0.81–3.09, $p = 0.180$) in women in the multivariate model (Model 2) after controlling for age, race, household income, and other working conditions. The PRs for OUD by frequent heavy lifting were 1.96 (0.86–4.47, $p = 0.084$) in men and 3.21 (1.26–8.14, $p = 0.008$) in women in Model 2. The associations of job strain and frequent heavy lifting with OUD were not affected by backache and common mental disorders in men (Models 3 and 4, Table 4). However, the associations were attenuated to some extent particularly by backache in women (Model 3, Table 5).

Sensitivity analysis

A sensitivity analysis was conducted after excluding ten workers who reported a history of non-work period due to alcohol or substance abuse problem during their

Table 2 Distributions of adverse working conditions and the prevalence of opioid use disorder (OUD) in 2131 workers

Category	Subcategory	*N* (%)	OUD: *N* (%)
Skill discretion	Low	834 (39.1)	43 (5.2)***
	High	1297 (60.9)	37 (2.8)***
Decision authority	Low	984 (46.2)	40 (4.1)
	High	1147 (53.8)	40 (3.5)
Job control	Low	1057 (49.6)	47 (4.4)*
	High	1074 (50.4)	33 (3.1)*
Psychological job demands	Low	908 (42.6)	21 (2.3)***
	High	1223 (57.4)	59 (4.8)***
Job strain	No	1533 (71.9)	42 (2.7)***[a]
	Yes	598 (28.1)	38 (6.4)***[b]
Supervisor support	Low	891 (41.8)	36 (4.0)
	High	915 (42.9)	33 (3.6)
	No immediate supervisors	325 (15.3)	11 (3.4)
Coworker support	Low	1012 (47.5)	43 (4.2)
	High	922 (43.3)	33 (3.6)
	No immediate coworkers	197 (9.2)	4 (2.0)
Job insecurity	Low	2018 (94.8)	75 (3.7)
	High	110 (5.2)	5 (4.5)
Work hours per week	≤40	1207 (56.6)	43 (3.6)
	41–48	323 (15.2)	13 (4.0)
	49–56	368 (17.3)	18 (4.9)
	≥57	233 (10.9)	6 (2.6)
Physical efforts	Never/little	1217 (57.1)	34 (2.8)**
	Some	495 (23.2)	24 (4.8)**
	Most/all of the time	419 (19.6)	22 (5.3)**
Lifting loads weighing 50 lbs or greater	Never/little	1644 (77.1)	55 (3.3)***[c]
	Some	345 (16.2)	11 (3.2)***[d]
	Most/all of the time	142 (6.7)	14 (9.9)***[e]
Crouching/stooping/kneeling	Never/little	958 (45.0)	28 (2.9)**
	Some	663 (31.1)	23 (3.5)**
	Most/all of the time	510 (23.9)	29 (5.7)**

*$p < 0.20$, **$p < 0.05$, and ***$p < 0.01$ at χ^2 test. [a]2.8% (22/787) in men and 2.7% (20/746) in women. [b]8.1% (22/270) in men and 4.9% (16/328) in women. [c]3.9% (28/722) in men and 2.9% (27/922) in women. [d]3.3% (8/245) in men and 3.0% (3/100) in women. [e]8.9% (8/90) in men and 11.5% (6/52) in women

working lives. The results of the sensitivity analysis were very similar.

Discussion

To my knowledge, this is the first epidemiological study that examined and demonstrated a significant association between adverse working conditions and opioid use disorder (OUD) in a working population. The prevalence of OUD was 3.8% in the whole study participants, while it was the highest (11.5%) in female workers who reported frequent heavy lifting on their jobs. Job strain and its components (low skill discretion and high psychological job demands) and high physical job demands (particularly, frequent heavy lifting) significantly increased the risk for OUD after controlling for sociodemographic variables, health conditions, and other working conditions. This study implies that adverse psychosocial and physical (biomechanical) working conditions may be important risk factors for OUD in US working populations.

The findings of the current study on OUD are similar to those of the previous case–control study on drug abuse/dependence (Muntaner et al. 1995) in that in both studies, high physical job demands and low skill discretion were identified as significant risk factors, while low social support at work and job insecurity were not significant risk factors. However, in contrast with the previous study, high psychological job demands and job strain significantly increased the risk for OUD in the current study. In addition, while decision

Table 3 The prevalence ratios (PRs) and their 95% confidence intervals for opioid use disorder (OUD) by psychosocial and physical (biomechanical) working conditions in the 2131 workers after controlling for potential confounders

Category	Subcategory	Model 1	Model 2	Model 3	Model 4
Skill discretion	High	1.00	1.00	1.00	1.00
	Low	1.77 (1.13–2.76)	1.82 (1.17–2.84)	1.74 (1.11–2.72)	1.70 (1.09–2.66)
Job control	High	1.00	1.00	1.00	1.00
	Low	1.42 (0.91–2.23)	1.42 (0.91–2.23)	1.35 (0.86–2.12)	1.33 (0.85–2.10)
Psychological job demands	Low	1.00	1.00	1.00	1.00
	High	1.95 (1.18–3.22)	1.88 (1.13–3.12)	1.89 (1.14–3.14)	1.86 (1.12–3.09)
Job strain	No	1.00	1.00	1.00	1.00
	Yes	2.19 (1.41–3.41)	2.09 (1.34–3.27)	2.02 (1.29–3.15)	1.98 (1.26–3.10)
Physical efforts	Never/little	1.00	1.00	1.00	1.00
	Some	1.75 (1.03–2.98)	1.74 (1.02–2.97)	1.74 (1.02–2.97)	1.77 (1.04–3.02)
	Most/all of the time	1.82 (1.05–3.17)	1.67 (0.95–2.91)	1.62 (0.92–2.84)	1.64 (0.94–2.88)[a]
Lifting loads weighing 50 lbs or greater	Never/little	1.00	1.00	1.00	1.00
	Some	0.88 (0.46–1.70)	0.86 (0.45–1.66)	0.85 (0.44–1.64)	0.89 (0.46–1.71)
	Most/all of the time	2.53 (1.39–4.63)	2.29 (1.25–4.20)	2.22 (1.21–4.09)	2.23 (1.22–4.10)
Crouching/stooping/kneeling	Never/little	1.00	1.00	1.00	1.00
	Some	1.18 (0.68–2.05)	1.15 (0.66–2.01)	1.14 (0.65–1.99)	1.17 (0.67–2.04)
	Most/all of the time	1.81 (1.06–3.09)	1.73 (1.01–2.95)	1.68 (0.98–2.86)	1.68 (0.98–2.86)[b]

Model 1: after controlling for age, race, and household income

Model 2: after controlling for age, race, household income, and other working conditions (e.g., psychological job demands and lifting 50 lbs or more for skill discretion; skill discretion and psychological job demands for lifting 50 lbs or more)

Model 3: after controlling for age, race, household income, other working conditions, and backache

Model 4: after controlling for age, race, household income, other working conditions, backache, and common mental disorders

[a]$P=0.082$. [b]$P=0.058$

authority was positively associated with drug abuse/dependence in the previous study, there was a negative, albeit non-significant, association between decision authority and OUD in the current study. It is not clear what made the differences in the results between the two studies for decision authority, psychological job demands, and job strain, particularly given their different study time periods and main health-related outcomes. Nonetheless, for future studies, it would be worthwhile to note the following two methodological weaknesses in the previous study. First, the information on working conditions in the previous study was not reported by the study participants, but imputed via job titles from other data source (i.e., the Quality of Employment Surveys in the 1970s). Second, more than 30% of the study participants in the previous study were not working for pay at the time of the assessment of drug abuse/dependence. Thus, the likelihood of exposure misclassification was greater in the previous study than in the current study.

This study suggests that the associations between some adverse working conditions and OUD may differ by gender. High physical job demands were more strongly associated with OUD in women than in men. Muntaner et al. (1995) also reported that compared to male workers, female workers were at a higher risk of drug abuse/dependence by the combination of high physical job demands and high decision authority. In addition, the association between high physical job demands and OUD in women in the current study was attenuated to some extent particularly by backache. All these imply that high physical job demands may play a more important role in the etiology of OUD in female workers via work-related injuries/musculoskeletal disorders and entailing chronic opioid therapy. Women may be at a greater risk of back injury from heavy lifting tasks than men (Barim et al. 2019; Marras et al. 2003). In addition, incidence of long-term opioid analgesic use for non-cancer pain treatment was greater in women than in men in a study using data from two large health plans (Campbell et al. 2010). Furthermore, some investigators have reported a significant gender difference in reasons for using drugs, including opioids (e.g., therapeutic uses (relieving pain) in women vs. social/recreational uses in men) (Airagnes et al. 2018; Carrasco-Garrido et al. 2008; Johnston and O'Malley 1986; McHugh et al. 2013). On the other hand, in the current study, job strain was more strongly associated with OUD in men and the association was not affected by backache or common mental disorders. These may indicate that there are other important etiological pathways from job strain to OUD in men, for instance, although remains to be tested in the future, use of

Table 4 The prevalence ratios (PRs) and their 95% confidence intervals for opioid use disorder (OUD) by psychosocial and physical (biomechanical) working conditions in men (44 OUD cases out of 1059 workers) after controlling for potential confounders

Category	Subcategory	Model 1	Model 2	Model 3	Model 4
Skill discretion	High	1.00	1.00	1.00	1.00
	Low	1.83 (1.00–3.35)	1.86 (1.01–3.40)	1.85 (1.01–3.39)	1.88 (1.02–3.46)
Job control	High	1.00	1.00	1.00	1.00
	Low	1.82 (0.98–3.37)	1.88 (1.01–3.48)	1.86 (1.00–3.46)	1.88 (1.01–3.49)
Psychological job demands	Low	1.00	1.00	1.00	1.00
	High	2.47 (1.21–5.03)	2.36 (1.16–4.84)	2.36 (1.16–4.84)	2.36 (1.15–4.84)
Job strain	No	1.00	1.00	1.00	1.00
	Yes	2.79 (1.53–5.08)	2.74 (1.50–5.00)	2.73 (1.49–4.98)	2.74 (1.50–5.00)
Physical efforts	Never/little	1.00	1.00	1.00	1.00
	Some	1.75 (0.87–3.50)	1.74 (0.86–3.51)	1.75 (0.87–3.53)	1.74 (0.87–3.51)
	Most/all of the time	1.40 (0.64–3.09)	1.26 (0.57–2.79)	1.25 (0.57–2.78)	1.25 (0.56–2.78)
Lifting loads weighing 50 lbs or greater	Never/little	1.00	1.00	1.00	1.00
	Some	0.85 (0.38–1.89)	0.84 (0.38–1.89)	0.84 (0.38–1.89)	0.83 (0.37–1.87)
	Most/all of the time	2.08 (0.91–4.75)	1.96 (0.86–4.47)	1.96 (0.86–4.48)	1.99 (0.87–4.56)
Crouching/stooping/kneeling	Never/little	1.00	1.00	1.00	1.00
	Some	1.10 (0.53–2.29)	1.06 (0.51–2.21)	1.07 (0.51–2.22)	1.06 (0.51–2.21)
	Most/all of the time	1.39 (0.66–2.91)	1.33 (0.64–2.79)	1.34 (0.64–2.80)	1.34 (0.64–2.80)

Model 1: after controlling for age, race, and household income

Model 2: after controlling for age, race, household income, and other working conditions (e.g., psychological job demands and lifting 50 lbs or more for skill discretion; skill discretion and psychological job demands for lifting 50 lbs or more)

Model 3: after controlling for age, race, household income, other working conditions, and backache

Model 4: after controlling for age, race, household income, other working conditions, backache, and common mental disorders

opioids to self-medicate negative emotions (Khantzian 1997; Merlo et al. 2013a, b; Rigg and Ibañez 2010), to deal with high workload (Davey et al. 2007; Walter et al. 2018), or to get high (Davey et al. 2007; Merlo et al. 2013a; Rigg and Ibañez 2010). More future studies are needed on the gender differences in the associations between adverse working conditions and OUD and their etiological mechanisms.

The national prevention efforts for OUD in US general and working populations have been heavily focused on the secondary (e.g., national guideline for prescription opioids for chronic pain) and tertiary (e.g., buprenorphine or methadone in combination with behavioral therapies) preventions (Dowell et al. 2016). Although as a result of the national efforts, opioid prescribing in the US has declined since 2011, the level of opioid prescribing in 2015 was still three times higher, compared to the level in 1999 (Guy et al. 2017). Opioid overdose deaths in US general and working populations also remain on a high level. This study implies that addressing adverse working conditions as the sources of workers' demands for opioids—biomechanical hazards (frequent heavy lifting, and frequent awkward postures) and psychosocial work hazards (lack of variety and learning opportunities on the job, high time pressure and workload)—may significantly contribute to the prevention of OUD and opioid overdose deaths in US working populations. For example, despite the maximum weight to be lifted with two hands (51 lbs) recommended by the National Institute for Occupational Safety and Health (NIOSH 1994), about 7% of the workers in the current study reported that they were required to lift loads weighing 50 or greater most or all of their work time. Vacuum lift assisting device, automatic baggage moving system, and mechanical lift aids have been recommended to reduce work-related injuries from frequent heavy lifting (NIOSH 2015). On the other hand, the prevalence of job strain in US working population has significantly increased since 2002 (Myers et al. 2019). Several workplace intervention studies targeting monotonous tasks and low job control (Bond and Bunce 2001; Orpen 1979) and high workload (Evans et al. 1999) have demonstrated that changing psychosocial working conditions is beneficial for workers' mental health and job satisfaction.

There are three main limitations to the current study. First, the current study is a cross-sectional study. Thus, it cannot tell the temporal relationship between adverse working conditions and OUD. There is a possibility of reverse causality because some workers particularly in safety sensitive occupations (e.g., transportation workers and health care professionals) (Merlo et al. 2013a, b; GAO 2008) can lose their job due to OUD and later land a job with physically and psychosocially worse working conditions. However,

Table 5 The prevalence ratios (PRs) and their 95% confidence intervals for opioid use disorder (OUD) by psychosocial and physical (biomechanical) working conditions in women (36 OUD cases out of 1075 workers) after controlling for potential confounders

Category	Subcategory	Model 1	Model 2	Model 3	Model 4
Skill discretion	High	1.00	1.00	1.00	1.00
	Low	1.71 (0.89–3.32)	1.78 (0.91–3.45)	1.60 (0.82–3.14)	1.54 (0.79–3.00)
Job control	High	1.00	1.00	1.00	1.00
	Low	1.07 (0.55–2.07)	1.05 (0.54–2.05)	0.89 (0.45–1.76)	0.91 (0.46–1.80)
Psychological job demands	Low	1.00	1.00	1.00	1.00
	High	1.52 (0.74–3.10)	1.45 (0.70–3.01)	1.47 (0.70–3.06)	1.39 (0.67–2.91)
Job strain	No	1.00	1.00	1.00	1.00
	Yes	1.72 (0.89–3.32)	1.58 (0.81–3.09)	1.41 (0.71–2.82)	1.37 (0.69–2.72)
Physical efforts	Never/little	1.00	1.00	1.00	1.00
	Some	1.71 (0.75–3.95)	1.75 (0.76–4.06)	1.69 (0.73–3.92)	1.69 (0.73–3.93)
	Most/all of the time	2.43 (1.10–5.35)	2.32 (1.05–5.15)	2.17 (0.97–4.86)	2.28 (1.01–5.13)
Lifting loads weighing 50 lbs or greater	Never/little	1.00	1.00	1.00	1.00
	Some	0.87 (0.26–2.88)	0.87 (0.26–2.91)	0.84 (0.25–2.79)	0.89 (0.27–2.98)
	Most/all of the time	3.44 (1.38–8.54)	3.21 (1.26–8.14)	2.78 (1.07–7.19)	2.83 (1.11–7.23)
Crouching/stooping/kneeling	Never/little	1.00	1.00	1.00	1.00
	Some	1.34 (0.57–3.16)	1.35 (0.57–3.19)	1.25 (0.53–2.96)	1.33 (0.56–3.16)
	Most/all of the time	2.55 (1.16–5.63)	2.53 (1.14–5.62)	2.20 (0.99–4.92)	2.17 (0.97–4.84)

Model 1: after controlling for age, race, and household income

Model 2: after controlling for age, race, household income, and other working conditions (e.g., psychological job demands and lifting 50 lbs or more for skill discretion; skill discretion and psychological job demands for lifting 50 lbs or more)

Model 3: after controlling for age, race, household income, other working conditions, and backache

Model 4: after controlling for age, race, household income, other working conditions, backache, and common mental disorders

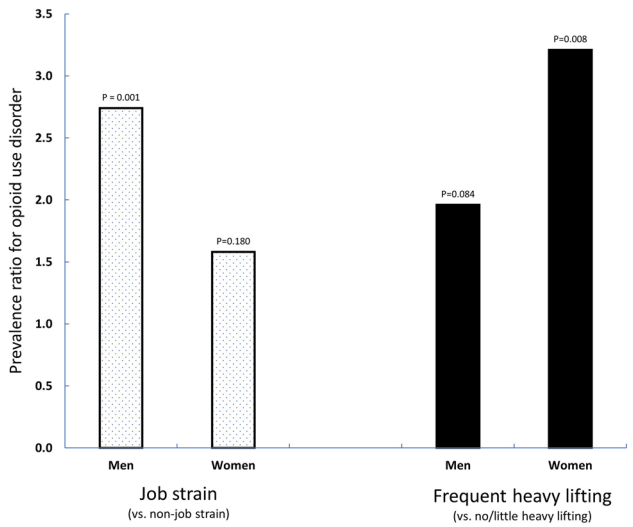

Fig. 1 The prevalence ratios for opioid use disorder by job strain (left) and frequent heavy lifting (right) in male ($N=1059$) and female ($N=1075$) workers after controlling for sociodemographic variables (age, race, and household income) and other working conditions

the main findings of the current study did not change in the sensitivity analysis after excluding those who reported a history of non-work period due to alcohol or substance abuse problem. Thus, the reverse causality is unlikely in the current study. Future longitudinal studies are warranted to confirm the findings of the current study. Second, the findings of the current study need to be cautiously interpreted due to the underrepresentation of younger workers, racial minority workers, and workers with less formal education in the MIDUS study. For example, in the current study, the prevalence of OUD appeared to be higher in African-Americans (albeit only 68 participants) than in whites, which was inconsistent with a previous study using a nationally representative sample of US workforce during 2002–2003 (Frone 2006). But, the prevalence of OUD (3.8%) in the current study was generally similar to the prevalence of psychotherapeutic drug impairment (2.2%) including analgesics in the previous study (Frone 2006). In addition, as consistent with the previous study, education was inversely, although non-significant, associated with OUD in the current study. Third, this study is very limited in exploring the mechanisms by which adverse working conditions affect OUD, although it was not the main purpose of the current study. Information on the work-relatedness of backaches and common mental disorders, and the reasons for opioid use was not available in the MIDUS II data. Future mixed-method research is needed to examine the complex relationships between adverse working conditions, work-related injuries and pain,

mental disorders, the reasons for opioid use, and OUD. All of the above limitations should be weighed against the fact that this is the first epidemiological study of supporting a significant association between adverse working conditions and OUD in working populations.

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Compliance with ethical standards

Conflict of interest I declare that I have no conflicts of interest.

Ethical approval The studies have been approved by the appropriate institutional and/or national research ethics committee and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent This study was based on de-identified data from the MIDUS II study in which informed written consent was obtained from all participants.

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