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RESEARCH ARTICLE

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Health conditions among male workers in mining and other industries reliant on manual labor occupations: National Health Interview Survey, 2007–2018

Tashina Robinson MS[1] | Aaron Sussell PhD[1] | Kenneth Scott PhD[2] | Gerald Poplin PhD[1]

[1]Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Spokane, Washington, USA

[2]Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Denver, Colorado, USA

Correspondence
Tashina Robinson, MS, 315 E Montgomery Ave, Spokane, WA 99207, USA.
Email: ngg9@cdc.gov

Funding information
Centers for Disease Control and Prevention

Abstract

Introduction: Mining is an industry with diverse, demanding occupational exposures. Understanding the prevalence of chronic health conditions in working miners is an area of active research. Of particular interest is how the health of miners compares to that of workers in other industry sectors with a high proportion of manual labor occupations. By comparing similar industries, we can learn what health conditions may be associated with manual labor and with individual industries. This study analyzes the prevalence of health conditions in miners compared to workers employed in other manual-labor-reliant industries.

Methods: National Health Interview Survey public data were analyzed for the years 2007–2018. Mining and five other industry groups with a high proportion of manual labor occupations were identified. Female workers were excluded because of small sample sizes. The prevalence of chronic health outcomes was calculated for each industry group and compared to that of nonmanual labor industries.

Results: Currently-working male miners showed increased prevalence of hypertension (in those age <55 years), hearing loss, lower back pain, leg pain progressing from lower back pain, and joint pain, compared to nonmanual labor industries workers. Construction workers also demonstrated a high prevalence of pain.

Conclusion: Miners demonstrated increased prevalence of several health conditions, even when compared to other manual labor industries. Given previous research on chronic pain and opioid misuse, the high pain prevalence found among miners suggests mining employers should reduce work factors that cause injury while also providing an environment where workers can address pain management and substance use.

KEYWORDS
chronic disease, epidemiology, illness, manual labor, mining, occupational health, workers

1 | INTRODUCTION

Mining is an industry with unique, demanding occupational exposures compared with the general working population. Well-studied health-related exposures in mining include respirable particulates (e.g., coal, silica- and metals-containing dust, diesel particulate matter) and noise.[1–4] These exposures have been linked to chronic occupational diseases in miners, including pneumoconioses, silicosis, lung cancer, and noise-induced hearing loss. However, much less is known about the prevalence of other chronic health conditions in miners.

Compared to the general working population, the mining industry has a high proportion of workers in manual labor occupations, indicating different occupational exposures while working than those who may work in office-based positions. Prior research with National Health Interview Survey (NHIS) data has shown that morbidity and mortality differ significantly between occupational groups within single industry sectors.[5,6] Of particular interest is how the prevalence of health conditions in currently employed miners compares to that of workers employed in other industry sectors with a high proportion of manual labor occupations. By comparing similar industries, we can learn what health conditions may be associated with manual labor as well as with individual industries.

Our previous research has indicated that retired miners have significantly higher rates of certain health conditions (hypertension, hearing loss, functionally limiting lung problems, and fair or poor health) than other retired workers.[7] Additionally, when oil and gas extraction (OGE) workers were used as a separate comparison group (OGE being the other industry subsector within the overall mining sector), miners still generally had a higher prevalence of these health conditions than OGE workers.

Other industry sectors that have high proportions of manual labor workers are construction; manufacturing; transportation and warehousing (T&W); and agriculture, forestry, fishing, and hunting (AFF). In this study, we used the NHIS, a nationally representative survey of civilian, noninstitutionalized adults that collects information on job, health status, and chronic diseases. We hypothesized that, after adjusting for potential confounders, miners would have an increased prevalence of selected chronic health disorders compared to workers in other manual-labor-reliant industries.

2 | MATERIALS AND METHODS

2.1 | Study population

The NHIS is an annual cross-sectional survey that collects information on a broad range of health topics, developed by the National Center for Health Statistics (NCHS) and administered by the US Census Bureau. Each month of the year, the NHIS uses geographically clustered sampling techniques to identify a nationally representative sample of households. Households are recruited to participate in face-to-face interviews. Data collected during interviews are later assigned statistical weights to generalize to the civilian, noninstitutionalized population. NHIS datasets for the years 2007–2018 were aggregated to ensure an adequate sample size for the mining industry. Our study was exempt from institutional review board approval because the data were de-identified, publicly available, and we had no interaction with human subjects. During the years examined, the NHIS included four core modules. The Family and Sample Adult core modules were used in this study. The Family core module collected health and sociodemographic information on each member of each family residing within the sample household. The Sample Adult core module collected health and industry and occupation information for the randomly chosen sample adult from each household interviewed.

We used the Integrated Public Use Microdata Series (IPUMS) tool, funded by the National Institutes of Health (NIH), to aggregate the NHIS data and harmonize variables to create the 12-year dataset.[8] We followed guidelines for pooling data across multiple years as recommended by the NCHS and made adjustments for variance calculations and sample weights.[9,10] Weights were adjusted for the 12-year pooling of observations by multiplying individual Sample Adult weights by the fraction of the sample year's observations to the total number of observations in the pooled sample (number of observations in sample year/number of observations in pooled sample). IPUMS automatically accounts for strata and cluster adjustment in the dataset output.

2.2 | Industry subpopulations of interest

The NHIS asks sample adults if they worked in the week before the interview. Current workers ages 18–64 years were asked about the job they last held; those age 65 years or older were only asked what job they had held the longest. Current workers age 65+ years whose longest-held job was not their current job (from the question, “Is this the job you have held for the longest?”) comprised only approximately 2% (weighted) of the sample and so were not excluded. Verbatim responses to the industry and occupation questions were obtained from each eligible sample adult. The industry and occupation text data were reviewed by Census Bureau computer-assisted coding specialists, who assigned the appropriate 4-digit Census Bureau codes. Census industry and occupation codes were based on the North American Industry Classification System (NAICS) and US Bureau of Labor Statistics Standard Occupational Classification (SOC) systems, respectively.[11] We used the publicly available NHIS 2-digit recodes of the 4-digit Census codes.

This analysis included only nonmilitary, currently-working sample adults with coded industry information. A sample adult was considered a currently-working adult if they held a job within the last week or if they were unemployed but were looking for work and had worked within the last 12 months.

Workers in mining, except oil and gas extraction (OGE), were the primary subpopulation of interest for our study. Therefore, it was necessary to split the mining sector into its two subsectors. "Miners" were those in NHIS detailed industry code 07 (“mining, except oil and gas”), and OGE workers were those in either industry code 06 (“oil and gas extraction”) or 08 (“support activities for mining”). Workers in the NHIS detailed industry recode 08 are mostly OGE workers.[11]

Manual labor occupations were defined as those with NHIS simple occupation recodes 18–22, comprising the following occupation groups: farming, fishing, and forestry; construction and extraction; installation, maintenance, and repair; production; and transportation and material moving.[5] Sixty-two percent of workers in the mining sector (including both OGE workers and miners) were in “manual labor” occupations (weighted). Due to the small sample size for the miner

subpopulation ($n = 377$, unweighted), there was insufficient sample size to analyze manual labor occupations separately. Four industry groups with over 50% of workers in manual labor occupations were selected for comparison: construction (76% manual labor occupation workers); manufacturing (61%); T&W (59%); and AFF (58%; NHIS industry simple recodes 04, 05, 08, and 02, respectively).

Additionally, the subpopulation of employed workers was restricted to males, due to the high proportion of males in the industries of interest (71%–91% male). Sex is associated with several health conditions, but subpopulation analyses of females could not be performed because of their small numbers in the sample.

For regression analyses, a comparison group was created containing working adults across all other industries (i.e., workers whose NHIS simple industry recodes were not in 04, 05, 08, 02 or detailed recodes were not in 06, 07, 08). Unconditional subpopulation analysis methods were used for all defined subpopulations to ensure that the full complex sample design of the NHIS was accounted for in all variance estimation procedures.[12]

2.3 | Selected health conditions

Health conditions were selected for analysis if there was a large enough sample of miners to produce reliable prevalence estimates (those with a coefficient of variation [CV] <50%). All health conditions were self-reported. Other than pain frequency and hearing quality, reported conditions were based on health professional diagnoses (i.e., "ever told by a doctor or health professional you had…"). From the Sample Adult core module, these included: cancer (any kind); cardiovascular disease (one or more: heart attack, coronary heart disease, heart condition, or angina); diabetes or prediabetes; hypertension (on 2+ separate visits); hearing quality without hearing aid; any lung condition (one or more: emphysema, current asthma, or chronic bronchitis [in past 12 months]); current asthma; vision problems (even with corrective lenses); lower back pain (within past 3 months); leg pain (spreading from lower back pain, within the past 3 months); neck pain (within past 3 months); and joint pain (within past 30 days). Hearing quality was reported in five categories, and the answers "a lot of trouble" and "deaf" were lumped together. From the Family core module, we abstracted data on self-reported functional or activity limitation from a lung/breathing problem or hypertension.

2.4 | Covariates

Demographic variables included age, race/ethnicity, geographic region of residence (based on Census regions: Northeast, North Central/Midwest, South, and West), educational attainment, body mass index (BMI), heavy alcohol use (defined for males as consuming at least five drinks on at least 5 days a month over the past year[13]), current or former smoking status, health insurance status, and interval since last healthcare visit. Age was categorized into 18–34, 35–44, 44–54, and 65+ years based on the age distribution of current workers. Race and ethnicity were separate variables that were collapsed into a four-category variable: "white, non-Hispanic," "black, non-Hispanic," "other race, non-Hispanic," and "Hispanic." Collapsing categories was necessary due to the relatively low racial/ethnic diversity and small sample sizes in some of the industry groups of interest. Education was categorized by "less than high school," "high school graduate or GED," "some college or technical school," and "college graduate or more." Smoking status was categorized as "current or former" and "never." BMI was collapsed into the three standard categories <25 (normal), 25–29.9 (overweight), and 30+ (obese). Time since last healthcare visit was dichotomized as "less than 12 months" or "more than 12 months."

2.5 | Statistical analyses

Analyses were performed using Stata 16.1 (StataCorp LLC). We calculated prevalence ratios (PRs) for the health conditions by industry group with "nonmanual labor industries workers" as the comparison group. A design-based Poisson regression model (to account for the complex survey design) obtained by backward selection for main effects and forward selection for interaction terms was used to calculate adjusted PRs (APRs). Prevalence patterns for a given condition may differ between subgroups of workers, and we included interaction terms to test for this possibility. Covariates were assessed for use in the Poisson regression model if they made epidemiologic sense and were independently associated with the industry (exposure) and the health outcome variables in bivariate analyses using design-adjusted Rao-Scott F tests. Those confounders significant at the $p < 0.25$ level were particularly considered for inclusion in the model, but all variables were considered potential interaction term predictors. Standard errors were calculated using Taylor Series linearization to account for the complex sample design features. We then evaluated the importance of each of the covariates using design-adjusted Wald tests. Main effects were retained in the full model if they were statistically significant ($p < 0.05$). We then evaluated relevant interaction terms between all potential predictors and tested for significance using design-adjusted Wald tests—interaction terms were tested using forward selection and retained at the $p < 0.005$ level so as to not overfit the model. Statistical techniques for goodness-of-fit tests of design-based Poisson regression models do not exist. Thus, the Poisson regression model was assessed for goodness-of-fit using a design-based logistic model and the Archer-Lemeshow goodness-of-fit test (design-adjusted Hosmer–Lemeshow test, with the same predictors); the model was kept if it did not reject the null hypothesis (no significant difference between the observed and expected values).

Due to the small sample size for the mining industry and to ensure a better model fit, all nonbinary modeling covariates (except BMI) described above were dichotomized. Where appropriate, the modeling covariates were dichotomized as: age <55 or 55+ years; race/ethnicity (white, non-Hispanic vs. all others); education (less or more than high school/GED); and region (West vs. all others). The age binary of 55 years was chosen due to the onset of some chronic

conditions (as has been done in previous NHIS analyses[14]) and the distribution of the age in miners (who are generally older). In instances where the model was still not a good fit, age was recategorized and the modeling methodology reiterated; this occurred with neck pain (age modeled continuously) and functional limitation from hypertension (age modeled as a binary <65 and 65+ years; Supporting Information: Table S1).

3 | RESULTS

For the years 2007–2018, 357,714 adults participated in the Sample Adult core module. Of those, 212,885 (59.5%) were currently working in a nonmilitary industry, 49.5% (105,409) of which were male. Among these male workers, 337 miners (0.3%, unweighted), 795 OGE workers (0.8%), 12,494 construction workers (11.9%), 13,934 manufacturing workers (13.2%), 6426 T&W workers (6.1%), 2564 AFF workers (2.4%), and 68,859 nonmanual labor industries workers (65.3%) were identified (Table 1 and Figure 1, unweighted).

The seven industry groups in the current male workers population differed in sociodemographic composition (Table 1). Miners had the lowest proportion of workers aged 18–34 years (27.4%) and the highest proportion of workers aged 45–54 years (29.2%). Most miners were white and non-Hispanic. Additionally, the majority of miners lived in the US South (44.7%) and West (31.0%); OGE, construction, and nonmanual labor industries workers were also concentrated in these regions. Fewer than 50% of miners, construction workers, and AFF workers had more than a high school degree or equivalent. Miners had a high proportion of obesity (39.3%) and the highest proportion of health insurance coverage (92.4%), while construction workers were the least insured (64.9%). Miners also had the highest proportion of having a healthcare visit in the last 12 months (78.1%), while construction workers reported the lowest (63.4%).

Miners had similar prevalence of cancer, cardiovascular disease, high cholesterol, diabetes/prediabetes, asthma, and vision problems as nonmanual labor industries workers (Tables 2 and 3, Supporting Information: Table S1). None of the other five industry groups had a significantly elevated prevalence of cancer, cardiovascular disease, high cholesterol, diabetes/prediabetes, asthma, and vision problems compared to nonmanual labor industries workers after adjustment for confounders (Table 3). Some industry groups, particularly construction, demonstrated significantly lower prevalence of certain health conditions than nonmanual labor industries workers after adjustment for confounders.

Miners had the highest point prevalence of hypertension (27.9%) across all workers. In adjusted analyses, including an interaction term for industry and age, miners were significantly more likely to report hypertension in those aged <55 years than non-manual-labor industries workers (APR: 1.59, 95% CI: 1.21–2.09; Figure 2, Table 3). Manufacturing and T&W workers were also significantly more likely to have hypertension in those aged <55 years compared to nonmanual labor industries workers but to a lesser degree than miners. Hypertension was the only health condition with a significant industry interaction term in the model.

Miners had the highest point prevalence of moderate-to-deaf hearing loss (10.6%) across all industry groups. In adjusted analyses, almost all industry groups (except for T&W) showed significantly higher moderate-to-deaf hearing loss compared to nonmanual labor industries workers, but miners had the highest degree of hearing loss with greater than a 2-fold higher prevalence (APR: 2.27, 95% CI: 1.51–3.43).

Miners (vs. nonmanual industry workers) had the highest point prevalence of all the pain variables of any of the manual labor industries examined. In adjusted analyses, miners had significantly higher lower back pain in the past 3 months (APR: 1.24, 95% CI: 1.01–1.52), leg pain progressing from lower back pain within 3 months (APR: 1.99, 95% CI: 1.39–2.86), and joint pain in the past 30 days (APR: 1.26, 95% CI: 1.03–1.54) than nonmanual labor industries workers. Construction workers also had higher adjusted prevalence of these conditions than nonmanual industry workers, but lower point prevalence than miners; the adjusted prevalence of neck pain among miners was not statistically significantly elevated. Manufacturing and AFF workers also had higher adjusted prevalence of joint pain in the past 30 days, but less than miners.

4 | DISCUSSION

This analysis revealed that compared to six other groups of manual labor workers based on industry, currently working male miners had high crude prevalence of hypertension, moderate-to-deaf hearing loss, lower back pain, leg pain (from lower back pain), neck pain, and joint pain. Miners also had a high proportion of having health insurance and healthcare visits within the past 12 months.

In the adjusted analyses of health conditions, currently working male miners had the highest prevalence of hypertension (in those age <55 years), moderate-to-deaf hearing loss, lower back pain, leg pain (from lower back pain), and joint pain among any of the six industries of interest.

These results are largely consistent with previous research. It is well-documented that miners have high exposure to noise, and hearing protection and engineering controls for noise are priority research areas for mining.[15,16] Compared to all other industry sectors, mining, construction, and manufacturing all rank high in the prevalence of current workers reporting hearing difficulty[2,17,18]; some AFF subsectors also have higher prevalence of hearing loss, specifically those with a high proportion of males.[19]

We found a significant interaction between age, hypertension, and industry group, with miners (and also workers in manufacturing and T&W industries) aged <55 years having significantly higher prevalence of hypertension than nonmanual industry workers age <55. Hypertension is associated with higher risk of incident cardiovascular disease (CVD) as well as all-cause mortality. Some research suggests a higher risk of CVD due to hypertension in those with new onset hypertension at age <45

TABLE 1 Distribution of currently working male adults by selected characteristics and industry group for most recent (age 18–64 years) or longest-held (age 65+ years)[a] job—From the National Health Interview Survey (NHIS), 2007–2018.

Characteristic	Miners *N*[b], %[c] (95% CI)	OGE *N*[b], %[c] (95% CI)	Construction *N*[b], %[c] (95% CI)	Manufacturing *N*[b], %[c] (95% CI)	T&W *N*[b], %[c] (95% CI)	AFF *N*[b], %[c] (95% CI)	Nonmanual labor industries workers *N*[b], %[c] (95% CI)
Age group (years)							
18–34	95, 27.4 (21.1–34.7)	330, 41.1 (36.3–46.1)	3994, 34.1 (32.9–35.3)	3867, 29.0 (27.9–30.1)	1639, 28.7 (27.2–30.2)	733, 32.3 (29.6–35.1)	24,657, 38.0 (37.4–38.7)
35–44, compared to	62, 19.7 (14.8–25.7)	168, 20.6 (17–24.9)	3210, 25.4 (24.5–26.4)	3292, 23.3 (22.4–24.3)	1469, 22.8 (21.5–24.1)	494, 19.3 (17.5–21.3)	14,949, 21.3 (20.9–21.7)
45–54	96, 29.2 (23.6–35.4)	158, 20.0 (16.5–24)	2852, 23.2 (22.2–24.3)	3576, 27.0 (25.9–28.0)	1650, 25.5 (24.2–26.9)	514, 21.4 (19.4–23.5)	13,922, 20.6 (20.2–21.1)
≥55	84, 23.8 (17.9–30.9)	139, 18.3 (15.7–21.3)	2438, 17.3 (16.5–18.1)	3199, 20.7 (19.8–21.6)	1668, 23.0 (21.7–24.4)	823, 27.0 (24.5–29.7)	15,331, 20.3 (19.6–20.5)
Race/ethnicity							
White, non-Hispanic	291, 87.2 (82.7–90.6)	526, 63.5 (55.1–71.1)	7605, 64.0 (62.6–65.4)	9205, 69.7 (68.4–70.9)	3590, 57.8 (56.1–59.5)	1653, 64.7 (59.6–69.6)	43,740, 66.3 (65.6–67)
Black, non-Hispanic	11.0, 3.7 (2.0–6.8)	39, 5.8 (3.4–9.8)	742, 5.0 (4.5–5.5)	1458, 9.1 (8.4–9.8)	1258, 18.0 (16.8–19.3)	86, 3.2 (2.3–4.4)	8123, 11.0 (10.6–11.5)
Other, non-Hispanic	8,[e]	49, 6.4 (4.4–9.0)	415, 2.7 (2.3–3.2)	1012, 6.6 (6.0–7.2)	418, 6.2 (5.5–7.1)	65, 2.1(1.4–3.1)	5931, 7.3 (7.0–7.7)
Hispanic	27.0, 8.5[d] (5.8–12.3)	181, 24.3 (15.5–36.1)	3732, 28.2 (26.9–29.6)	2259, 14.7 (13.7–15.8)	1160, 17.9 (16.6–19.3)	760, 30.0 (25.1–35.5)	11,065, 15.3 (14.8–15.9)
Region of residence							
Northeast	14, 8.0[d] (3.6–16.9)	18, 3.2[d] (1.5–6.7)	1829, 16.4 (15.3–17.6)	2076, 15.9 (14.8–17.0)	1049, 18.3 (16.9–19.9)	207, 9.2 (6.9–12.3)	11,310, 17.8 (17.1–18.6)
North Central/ Midwest	41, 16.3 (10.2–25.1)	62, 6.0 (3.9–9.0)	2511, 20.3 (19.1–21.5)	4559, 33.5 (31.8–35.1)	1503, 23.5 (21.9–25.1)	848, 30.1 (25.4–35.3)	14,705, 22.1 (21.4–22.9)
South	125, 44.7 (34.3–55.6)	497, 78.0 (70.2–84.2)	4785, 39.0 (37.4–40.5)	4366, 31.9 (30.4–33.5)	2265, 36.4 (34.6–38.2)	561, 26.3 (22.6–30.3)	23,811, 35.4 (34.4–36.3)
West	157, 31.0 (21.0–43.1)	218, 12.9 (8.1–19.9)	3369, 24.3 (23.1–25.6)	2933, 18.7 (17.6–19.9)	1609, 21.8 (20.4–23.3)	948, 34.4 (28.9–40.4)	19,033, 24.7 (23.9–25.5)
Education							
Less than high school	43, 16.1 (11.8–21.6)	115, 14.1 (9.8–20.0)	2997, 23.1 (22.0–24.2)	1733, 11.3 (10.5–12.1)	739, 10.9 (9.9–11.9)	786, 32.1 (28.0–36.5)	5769, 8.1 (7.8–8.5)
High school graduate or GED	148, 41.7 (34.1–49.6)	281, 35.2 (31.4–39.3)	4515, 37.2 (36.0–38.3)	4508, 32.7 (31.7–33.8)	2319, 37.2 (35.6–38.8)	856, 33.9 (30.9–37)	13,920, 20.7 (20.2–21.2)
Some college, no degree	57, 16.2 (11.0–23.4)	147, 15.3 (12.0–19.2)	2147, 17.3 (16.5–18.2)	2412, 17.5 (16.6–18.3)	1477, 23.0 (21.6–24.4)	346, 13.8 (12.0–15.8)	13,209, 19.4 (19.0–19.9)
College graduate or more	89, 26.0 (18.8–34.8)	251, 35.4 (28.2–43.2)	2760, 22.4 (21.4–23.4)	5237, 38.5 (37.3–39.8)	1862, 28.9 (27.5–30.4)	562, 20.2 (17.7–22.9)	35,770, 51.8 (51.1–52.4)
BMI category							
<25	75, 25.1 (19.1–32.3)	186, 24.2 (19.9–29.2)	3205, 25.9 (24.9–27)	3597, 25.9 (25.0–26.9)	1409, 22.3 (20.9–23.7)	609, 24.5 (22.1–27.1)	20,571, 30.1 (29.6–30.6)
25–30	126, 35.6 (28.3–43.7)	288, 36.9 (32.3–41.8)	5559, 44.7 (43.7–45.8)	5887, 42.5 (41.5–43.6)	2691, 42.8 (41.2–44.4)	1116, 44.3 (41.7–47)	28,674, 41.7 (41.3–42.2)
30+	131, 39.3 (31.4–47.7)	304, 38.9 (34.1–43.9)	3482, 29.4 (28.4–30.4)	4260, 31.6 (30.6–32.6)	2238, 34.9 (33.4–36.5)	778, 31.1 (28.9–33.5)	18,576, 28.1 (27.7–28.6)

TABLE 1 (Continued)

Characteristic	Miners N[b], %[c] (95% CI)	OGE N[b], %[c] (95% CI)	Construction N[b], %[c] (95% CI)	Manufacturing N[b], %[c] (95% CI)	T&W N[b], %[c] (95% CI)	AFF N[b], %[c] (95% CI)	Nonmanual labor industries workers N[b], %[c] (95% CI)
Heavy alcohol use							
Yes	14, 4.3[d] (2.3–7.7)	56, 6.7 (4.7–9.3)	928, 7.0 (6.5–7.6)	781, 5.4 (4.9–6.0)	291, 4.5 (3.9–5.2)	127, 4.3 (3.4–5.5)	3264, 4.3 (4.1–4.6)
Current/former smoker							
Yes	161, 47.3 (40.6–54.1)	388, 49.8 (44.1–55.4)	6494, 50.9 (49.8–52.1)	6414, 45.8 (44.6–46.9)	2978, 45.6 (43.9–47.2)	1034, 38.8 (36.0–41.8)	26,855, 37.8 (37.3–38.3)
Health insurance							
Yes	316, 92.4 (87.2–95.6)	667, 84.9 (80.8–88.2)	7764, 64.9 (63.7–66.1)	12,124, 88.5 (87.7–89.2)	5100, 80.9 (79.6–82.2)	1710, 67.8 (63.8–71.6)	56,768, 84.1 (83.7–84.5)
Healthcare visit in last 12 months							
Yes	267, 78.1(69.9–84.6)	587, 76.7(71.8–81.0)	7595, 63.4(62.2–64.6)	10,112, 74.6(73.5–75.6)	4701, 74.8(73.3–76.2)	1641, 64.9(61.8–67.9)	50,100, 74.8(74.3–75.3)
Total	337	795	12,494	13,934	6426	2564	68,859
Weighted total	164,867	542,451	9,304,791	10,739,889	4,791,142	1,623,347	51,866,320

Abbreviations: AFF, agriculture, forestry, fishing and hunting; CI, confidence interval (weighted); GED, general educational development; OGE, oil and gas extraction; TW, transportation and warehousing.

[a]Weighted percentage of industry group age 65+ ranges from 3.1% (miners) to 11.2% (AFF); weighted percentage of industry group age 65+ whose longest held job is different from their current job ranges from 1.1% (miners) to 3.0% (AFF).

[b]Unweighted.

[c]Weighted.

[d]Coefficient of variation >30%; interpret with caution.

[e]Coefficient of variation >50%; cannot be reported.

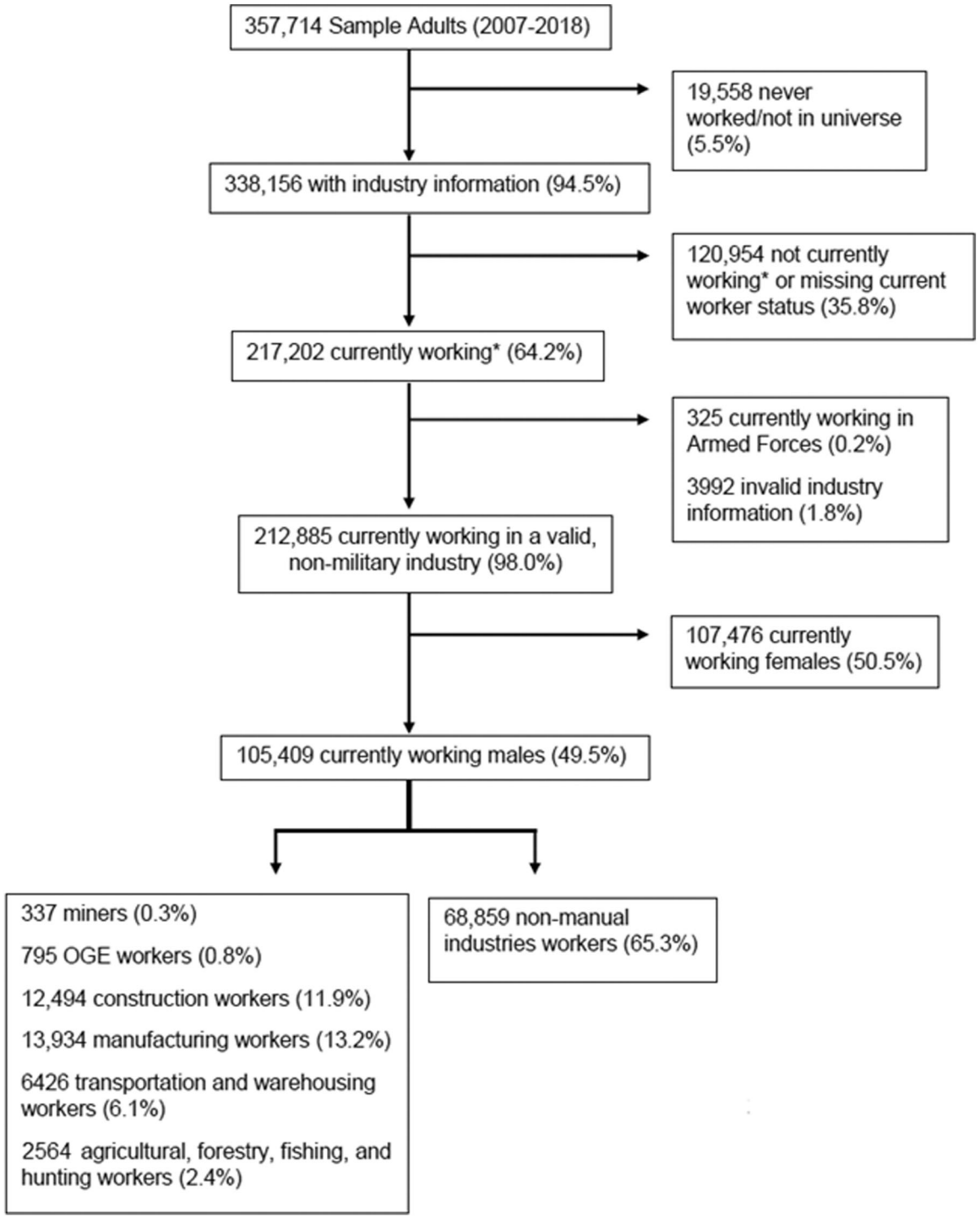

FIGURE 1 Flow diagram of the distribution of the National Health Interview Survey (NHIS 2007–2018) Sample Adult sample. *currently working: in a job within the past week of the survey, or unemployed but looking for work and had worked within the last 12 months.

years.[20] Our previous study using NHIS found that retired miners had a significantly higher prevalence of hypertension than all other retirees.[7] Several workplace factors can influence blood pressure. Job stressors such as high noise exposure, shift work, and production occupations (all highly prevalent in the mining industry) have all been linked to hypertension.[2,21–24] Further study is needed to determine if miners have a higher prevalence of hypertension than other workers in the early working years, and, if so, the contributing factors.

Miners reported the highest prevalence of pain among all workers. In the adjusted analyses, only neck pain was not significantly associated with mining. Construction workers also had high reported prevalence of all pain variables, including neck pain. Musculoskeletal pain is a known problem in both the construction and mining industries.[3,25,26] The high

TABLE 2 Crude, weighted prevalence estimates of selected outcomes for currently working male adults by industry group—From the National Health Interview Survey (NHIS), 2007–2018.

Outcome	Miners % (95% CI)	OGE % (95% CI)	Construction % (95% CI)	Manufacturing % (95% CI)	T&W % (95% CI)	AFF % (95% CI)	Nonmanual labor industries workers % (95% CI)
Any cancer	5.0[a] (2.0–8.0)	4.7 (2.9–6.5)	3.2 (2.8–3.6)	3.9 (3.4–4.4)	3.6 (3.1–4.1)	5.0 (3.9–6.0)	4.4 (4.2–4.6)
Cardiovascular disease[b]	6.8[a] (2.3–11.3)	8.1 (5.4–10.8)	5.9 (5.4–6.5)	7.4 (6.8–8.0)	7.4 (6.6–8.2)	8.7 (7.3–10.1)	7.2 (6.9–7.5)
Diabetes/prediabetes	6.6[a] (2.1–11.0)	8.7 (5.2–12.2)	5.9 (5.4–6.4)	7.8 (7.3–8.4)	9.3 (8.5–10.2)	7.9 (6.7–9.1)	7.0 (6.8–7.3)
Hypertension in 2+ visits	27.9 (21.5–34.3)	21.6 (17.7–25.6)	17.0 (16.2–17.9)	21.2 (20.4–22.1)	22.7 (21.4–24.0)	19.5 (17.5–21.5)	18.7 (18.3–19.2)
Hearing							
Excellent	32.5 (25.4–39.6)	49.1 (43.9–54.3)	49.2 (48.0–50.3)	44.6 (43.5–45.7)	50.6 (48.9–52.3)	43.4 (40.2–46.6)	53.4 (52.8–54.0)
Good	43.5 (35.9–51.1)	33.2 (29.5–37.0)	36.4 (35.3–37.4)	39.1 (38.1–40.1)	36.6 (35.1–38.1)	36.4 (33.9–38.9)	34.7 (34.2–35.2)
A little trouble	13.4 (9.7–17.1)	11.7 (8.0–15.5)	10.0 (9.3–10.6)	11.9 (11.0–12.8)	9.1 (8.2–10.0)	12.8 (11.0–14.5)	8.5 (8.2–8.8)
Moderate trouble	9.8 (5.4–14.1)	4.9 (3.3–6.5)	3.4 (3.0–3.8)	3.4 (3.0–3.8)	2.7 (2.2–3.1)	4.9 (3.8–6.0)	2.6 (2.4–2.7)
A lot of trouble/deaf	0.8[a] (0.1–1.4)	1.0 (0.5–1.6)	1.2 (0.9–1.4)	1.1 (0.8–1.3)	1.1 (0.8–1.4)	2.5 (1.7–3.4)	0.9 (0.8–1.0)
Any lung condition[c]	9.7 (5.7–13.7)	6.6 (4.5–8.7)	6.4 (5.9–7.0)	6.0 (5.6–6.5)	7.4 (6.5–8.2)	5.9 (4.8–7.1)	7.1 (6.9–7.3)
Functional limitation from hypertension	1.0[a] (0.4–1.7)	[d]	0.3 (0.2–0.4)	0.4 (0.3–0.5)	0.4 (0.2–0.5)	0.6 (0.3–2.0)	0.3 (0.3–0.4)
Current asthma	3.9[a] (1.4–6.4)	5.4 (3.5–7.3)	4.3 (3.9–4.8)	4.2 (3.8–4.6)	4.6 (3.9–5.3)	4.0 (3.0–5.0)	5.2 (5.0–5.4)
Has vision problems	5.4 (2.7–8.1)	6.7 (4.0–9.4)	6.9 (6.3–7.4)	6.5 (5.9–7.1)	5.2 (4.5–5.9)	6.1 (4.9–7.2)	5.8 (5.6–6.1)
Lower back pain (3 months)	33.3 (26.4–40.3)	26.0 (21.9–30.1)	29.2 (28.3–30.2)	24.5 (23.6–25.5)	25.2 (23.8–26.5)	25.4 (23.3–27.6)	23.1 (22.6–23.5)
Leg pain from lower back pain (3 months)	14.8 (9.2–20.5)	6.6 (4.4–8.9)	9.0 (8.3–9.6)	6.6 (6.1–7.1)	7.4 (6.5–8.2)	7.4 (6.1–8.7)	5.8 (5.6–6.1)
Neck pain (3 months)	16.4 (11.2–21.5)	9.5 (6.8–12.1)	12.4 (11.7–13.2)	11.1 (10.5–11.8)	11.2 (10.3–12.2)	11.4 (9.7–13.1)	10.7 (10.4–11.0)
Joint pain (30 days)	38.1 (31.2–45.0)	26.7 (21.9–31.6)	29.7 (28.7–30.8)	28.5 (27.5–29.6)	26.7 (25.4–28.1)	29.3 (26.7–31.8)	25.5 (25.0–25.9)

Abbreviations: CI, confidence interval (weighted); OGE, oil and gas extraction; TW, transportation and warehousing; AFF, agriculture, forestry, fishing and hunting.

[a]Coefficient of variation >30%; interpret with caution.

[b]Cardiovascular disease variable aggregated from "ever told had heart attack," "ever told had coronary heart disease," "ever told had heart condition," and "ever told had angina."

[c]Any lung condition variable aggregated from "functionally limiting lung/breathing problem," "activity limiting lung/breathing problem," "still has asthma," "ever told had emphysema," and "told had chronic bronchitis, past 12 months."

[d]Coefficient of variation >50%; cannot be reported.

TABLE 3 Crude and adjusted[a] weighted prevalence ratios of selected health conditions for currently working male adults by industry group, compared to nonmanual labor industries workers—From the National Health Interview Survey (NHIS), 2007–2018.

Outcome	Nonmanual labor industries workers PR/APR (95% CI)	Miners		OGE	
		PR (95% CI)	APR[a](95% CI)	PR (95% CI)	APR[a] (95% CI)
Any cancer	1.0 (ref)	1.14 (0.62–2.09)	1.08 (0.61–1.92)	1.07 (0.73–1.58)	1.23 (0.84–1.81)
Cardiovascular disease[c]	1.0 (ref)	0.94 (0.49–1.82)	0.81 (0.42–1.58)	1.12 (0.81–1.57)	1.10 (0.79–1.52)
Diabetes/prediabetes	1.0 (ref)	0.93 (0.47–1.84)	0.80 (0.41–1.56)	1.24 (0.83–1.85)	1.00 (0.68–1.47)
Hypertension in 2+ visits, age <55	1.0 (ref)	1.49[b] (1.18–1.87)	1.59[b] (1.21–2.09)	1.16 (0.96–1.38)	1.08 (0.88–1.33)
Hypertension in 2+ visits, age 55+	1.0 (ref)		0.83 (0.61–1.13)		1.03 (0.82–1.29)
Moderate hearing loss to deaf	1.0 (ref)	3.07[b] (2.03–4.66)	2.27[b] (1.51–3.43)	1.73[b] (1.33–2.27)	1.64[b] (1.26–2.12)
Any lung condition[d]	1.0 (ref)	1.37 (0.91–2.07)	1.19 (0.78–1.82)	0.93 (0.67–1.27)	0.86 (0.62–1.19)
Functional limitation from hypertension	1.0 (ref)	3.14[b] (1.68–5.88)	1.89 (0.43–8.28)	1.17 (0.28–4.90)	0.94 (0.22–3.98)
Current asthma	1.0 (ref)	0.74 (0.39–1.43)	0.71 (0.37–1.37)	1.03 (0.72–1.47)	1.04 (0.72–1.49)
Has vision problems	1.0 (ref)	0.92 (0.56–1.52)	0.73 (0.44–1.21)	1.14 (0.76–1.72)	1.07 (0.71–1.62)
Lower back pain (3 months)	1.0 (ref)	1.45[b] (1.17–1.78)	1.24[b] (1.01–1.52)	1.13 (0.96–1.32)	1.00 (0.85–1.19)
Leg pain from lower back pain (3 months)	1.0 (ref)	2.55[b] (1.73–3.74)	1.99[b] (1.39–2.86)	1.14 (0.81–1.60)	0.98 (0.69–1.39)
Neck pain (3 months)	1.0 (ref)	1.53[b] (1.12–2.09)	1.27 (0.93–1.73)	0.88 (0.67–1.17)	0.83 (0.62–1.11)
Joint pain (30 days)	1.0 (ref)	1.50[b] (1.25–1.79)	1.26[b] (1.03–1.54)	1.05 (0.87–1.26)	0.98 (0.82–1.17)

Abbreviations: AFF, agriculture, forestry, fishing and hunting; CI, confidence interval (weighted); OGE, oil and gas extraction; TW, transportation and warehousing.

[a]Adjusted model: See Supporting Information: Table 1 for model parameters by health condition.

[b]$p < 0.05$.

prevalence of pain reported by workers in mining and construction relative to the four other industries of interest (OGE, manufacturing, T&W, AFF) is a notable finding. The industry groups of interest are all associated with elevated risk of musculoskeletal disorders (MSDs) and with generally higher injury rates than most industries.[27,28] Mining and construction may particularly require improved pain management interventions. Chronic pain can interfere with normal activities and may lead to other adverse health outcomes such as depression and insomnia.[29] Additionally, physical injury and chronic pain from work are a major occupational pathway to chronic opioid use.[30] Mining (including OGE) and construction sector workers have the highest opioid dispensing rates of workers in any industry.[31] Furthermore, construction and extraction occupations have the highest proportional mortality (PMR) of any occupation group for prescription opioid-related deaths, with extraction occupations reporting the highest estimated difference for natural and semisynthetic opioids (PMR: 1.39).[32] Higher burden of prescription opioid use, prescription opioid-related deaths, and suicide rates[33] among workers in the mining and construction sectors may be consequences of the high prevalence of MSDs and resulting musculoskeletal pain in both sectors.

Employer programs that comprehensively respond to employee health and safety concerns, help reduce ergonomic problems, provide access to nonpharmacologic and alternative pain management information, and encourage wellness and substance use treatment could reduce pain and opioid use.[30] Training programs and resource pages on pain management and opioid use have been developed for the construction industry and could be translated to the mining industry.[34,35] Mining employers should continue to identify and reduce work factors that cause injury and ergonomic hazard, but also provide an environment where workers can discuss pain management and substance use. A holistic approach to worker well-being, such as the approach implemented by the NIOSH Total Worker Health Program®,[36] can improve both the health and safety of workers. Future studies should explore further what factors related to working in the mining and construction industries contribute to chronic pain and opioid use and what interventions are most effective at reducing these outcomes.

5 | LIMITATIONS

Several limitations are inherent to self-reported population health survey data. NHIS data are cross-sectional, and thus causal inferences are not possible. Self-reporting outcomes or reporting a health professional's diagnosis may be subject to both recall and social desirability bias. Furthermore, some misclassification of industry or occupation may occur based on the respondents' descriptions of their type of work.

Construction		Manufacturing		T&W		AFF	
PR(95% CI)	APR[a] (95% CI)	PR(95% CI)	APR[a](95% CI)	PR (95% CI)	APR[a] (95% CI)	PR (95% CI)	APR[a] (95% CI)
0.72[b] (0.63–0.82)	0.85[b] (0.74–0.96)	0.89 (0.78–1.02)	0.91 (0.79–1.05)	0.82[b] (0.71–0.96)	0.86[b] (0.74–1.00)	1.13 (0.91–1.40)	1.06 (0.88–1.28)
0.82[b] (0.75–0.90)	0.82[b] (0.74–0.89)	1.03 (0.94–1.12)	0.97 (0.89–1.06)	1.02 (0.91–1.14)	0.95 (0.85–1.06)	1.20[b] (1.02–1.41)	1.09 (0.94–1.26)
0.84[b] (0.77–0.92)	0.81[b] (0.74–0.89)	1.11[b] (1.02–1.21)	1.03 (0.95–1.12)	1.33[b] (1.20–1.47)	1.07 (0.97–1.18)	1.12 (0.95–1.31)	0.90 (0.77–1.05)
0.91[b] (0.86–0.96)	0.94 (0.88–1.01)	1.13[b] (1.08–1.19)	1.13† (1.06–1.20)	1.21[b] (1.14–1.29)	1.11[b] (1.02–1.21)	1.04 (0.94–1.15)	0.90 (0.76–1.07)
	0.88[b] (0.82–0.94)		0.96 (0.91–1.01)		1.00 (0.92–1.08)		0.94 (0.84–1.05)
1.32[b] (1.17–1.48)	1.22[b] (1.09–1.38)	1.29[b] (1.15–1.45)	1.14[b] (1.02–1.28)	1.09 (0.94–1.26)	0.99 (0.85–1.15)	2.17[b] (1.74–2.69)	1.75[b] (1.45–2.10)
0.90[b] (0.82–0.99)	0.88[b] (0.80–0.96)	0.85[b] (0.78–0.92)	0.81[b] (0.74–0.88)	1.04 (0.92–1.17)	1.02 (0.90–1.14)	0.83 (0.69–1.01)	0.83 (0.68–1.01)
0.92 (0.62–1.38)	0.75 (0.50–1.13)	1.27 (0.92–1.74)	1.09 (0.78–1.52)	1.15 (0.77–1.71)	0.94 (0.62–1.41)	1.93[b] (1.08–3.45)	1.37 (0.75–2.52)
0.83[b] (0.74–0.93)	0.86[b] (0.77–0.97)	0.81[b] (0.73–0.90)	0.81[b] (0.74–0.90)	0.88 (0.75–1.03)	0.91 (0.77–1.06)	0.77 (0.60–0.98)	0.79 (0.61–1.01)
1.18[b] (1.07–1.29)	1.08 (0.99–1.19)	1.12[b] (1.01–1.23)	1.04 (0.94–1.14)	0.89 (0.78–1.03)	0.81[b] (0.70–0.93)	1.04 (0.86–1.27)	0.95 (0.78–1.16)
1.27[b] (1.22–1.32)	1.17[b] (1.13–1.22)	1.06[b] (1.02–1.11)	1.00 (0.96–1.04)	1.09[b] (1.03–1.16)	1.04 (0.99–1.10)	1.10[b] (1.01–1.20)	1.04 (0.95–1.14)
1.54[b] (1.41–1.67)	1.34[b] (1.22–1.47)	1.13[b] (1.03–1.23)	1.01 (0.93–1.11)	1.27[b] (1.12–1.43)	1.11 (0.98–1.25)	1.27[b] (1.06–1.52)	1.11 (0.93–1.34)
1.16[b] (1.09–1.24)	1.12[b] (1.04–1.19)	1.04 (0.97–1.11)	0.98 (0.92–1.05)	1.05 (0.96–1.15)	1.00 (0.91–1.10)	1.06 (0.91–1.24)	1.02 (0.87–1.19)
1.17[b] (1.12–1.21)	1.13[b] (1.09–1.18)	1.12[b] (1.08–1.17)	1.06[b] (1.02–1.11)	1.05 (1.00–1.10)	1.01 (0.96–1.06)	1.15[b] (1.05–1.25)	1.11[b] (1.03–1.20)

[c]Cardiovascular disease variable aggregated from "ever told had heart attack," "ever told had coronary heart disease," "ever told had heart condition," and "ever told had angina."

[d]Any lung condition variable aggregated from "functionally limiting lung/breathing problem," "activity limiting lung/breathing problem," "still has asthma," "ever told has emphysema," and "told had chronic bronchitis, past 12 months."

Sample size was the biggest limitation of this study. Miners composed only 0.2% of current male workers. This limited statistical power and yielded large confidence intervals for prevalence estimates and ratios, particularly for less common conditions. The NHIS sampling design does not consider industry and occupation, so while the NHIS is representative of the US population as a whole, small industrial sectors such as mining may have few participants overall. Throughout the 12 years of the NHIS survey captured in the sample, miners composed less than 0.1%–0.2% of the US workforce.

Finally, this study included only current workers, who generally must have a certain level of health to conduct their daily work, especially in physically demanding industries. Moreover, conditions were based on diagnosis by a healthcare provider. The prevalence estimates reported in this study could be biased downward by the healthy worker effect and lack of healthcare access. We minimized the healthy worker effect in our study by comparing workers in the industry groups of interest to other current workers (not the general population) and comparing current workers across similar industry groups. Lack of healthcare access may have had a particularly strong effect on the construction industry estimates. When we stratified data by healthcare access variables, several health conditions (cancer, lung conditions, asthma, hypertension, and diabetes/prediabetes) no longer had a statistically significantly lower prevalence in construction workers compared to nonmanual labor industries (Supporting Information: Table S2).

6 | CONCLUSION

To our knowledge, this is the first study examining the health of currently-working male miners compared to other manual-labor-focused industries within the United States.

Miners, even when compared to workers in industries with similar proportions of manual labor occupations, have an increased prevalence of several health conditions. Specifically, currently working male miners show the highest elevated prevalence of hypertension (in those age <55 years), hearing loss, lower back pain, leg pain progressing from lower back pain, and joint pain. Of note, construction workers show similarly increased prevalence of physical pain but less of health professional-diagnosed health conditions, and this is likely in part due to lower access to healthcare. These industry groups vary greatly by demographics and healthcare access.

Noise overexposure and ergonomic hazards are well-known in the mining industry, but the findings also point to a need to focus on preventing and managing hypertension and chronic pain. Work exposures that could contribute to hypertension include stress and high noise.

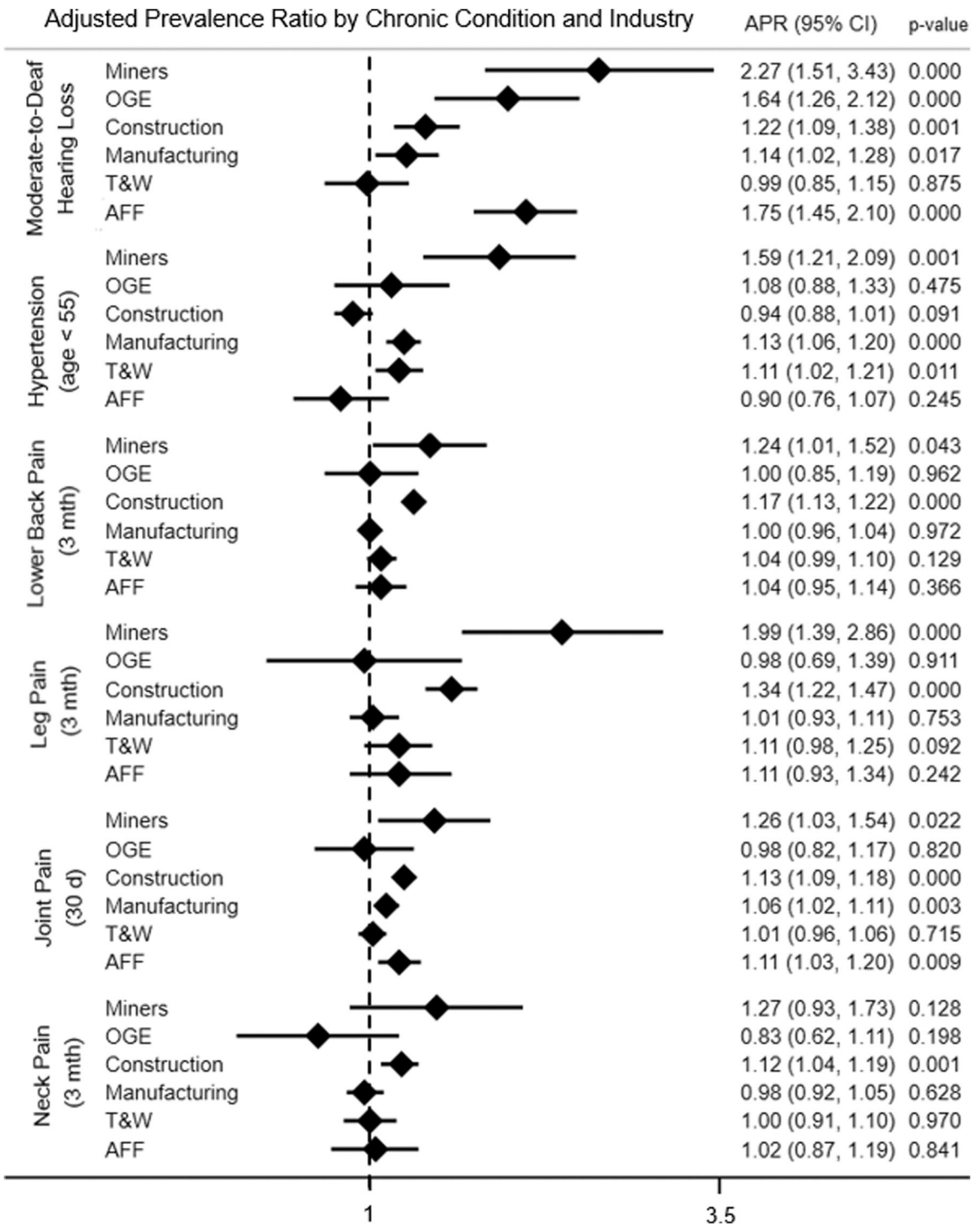

FIGURE 2 Forest plot of adjusted prevalence ratios (APR) comparing selected health conditions by industry group using nonmanual labor industries as the reference group—from the National Health Interview Survey (NHIS), 2007–2018. AFF, agriculture, forestry, fishing and hunting; CI, confidence interval (weighted); OGE, oil and gas extraction; TW, transportation and warehousing.

Chronic pain is damaging and can also lead to other health conditions, including opioid use, a crisis in both the mining and construction sectors. Additional information on workplace exposures relevant to hypertension and chronic pain is also needed. These studies will help build understanding on the commonalities and differences between workers in manual-labor-reliant industries and inform interventions.

AUTHOR CONTRIBUTIONS

Tashina Robinson designed and executed the study, performed and interpreted analyses, drafted the work as primary and corresponding author and agrees 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 are appropriately investigated and resolved. Aaron

Sussell is the principal investigator of the project encompassing the present study and provided input on study design and analyses, critically revised the work, provided final approval for publication and agrees to be accountable for all aspects of the work. Kenneth Scott provided input on study design and analyses, critically revised the work, provided final approval for publication and agrees to be accountable for all aspects of the work. Gerald Poplin provided input on study design and analyses, critically revised the work, provided final approval for publication and agrees to be accountable for all aspects of the work.

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CONFLICTS OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Paul A. Landsbergis declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

DISCLAIMER

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC). Mention of any company or product does not constitute endorsement by NIOSH, CDC.

ETHICS APPROVAL AND INFORMED CONSENT

This work was completed at the Centers for Disease Control and Prevention, National Institute for Occupational Health and Safety. Institutional review board approval was not needed because the National Health Interview Survey data were deidentified and publicly available.

ORCID

Tashina Robinson http://orcid.org/0000-0001-8705-1107
Aaron Sussell http://orcid.org/0000-0002-0976-4133
Kenneth Scott http://orcid.org/0000-0002-2192-5526

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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