Accepted: 3 July 2019

DOI: 10.1002/ajim.23029

RESEARCH ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Opioid-related overdose deaths by industry and occupation—Massachusetts, 2011-2015

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Funding information
Centers for Disease Control and Prevention, Grant/Award Number: 1UI7CE002724

Abstract

Background: Thousands of people in the United States continue to die from opioid overdoses every year. Work-related injuries and other factors associated with work may increase exposure to opioids and, subsequently, opioid-related overdose deaths (OROD). This study sought to determine whether OROD rates differed by industry and occupation and explored work-related factors that might contribute to these differences.

Methods: We coded industry and occupation information on death certificates for all OROD among Massachusetts residents from 2011 to 2015. We estimated rates of OROD by industry and occupation using Massachusetts employment data. National survey data were used to explore whether work-related factors known to vary by occupation (occupational injury and illness, job insecurity, and paid sick leave) correlate to observed differences in OROD.

Results: Several industries and occupation groups had rates of OROD that were significantly higher than the rates for other workers. Construction workers and fishing workers stood out for having OROD rates many times higher than the average for all workers. Occupation groups with high rates of occupational injuries and illnesses, high job insecurity, and low availability of paid sick leave had higher rates of OROD.

Conclusions: These findings underscore the need for policy and educational interventions to reduce OROD tailored to the needs of high rate worker populations. Interventions should address workplace hazards that cause injuries for which opioids are prescribed, as well as best practices in medical management and return to work following injury, safer prescribing, enhanced access to treatment for opioid use disorders, and overdose prevention education.

KEYWORDS
construction, fishing, job insecurity, occupational injuries, opioids, paid sick leave, poisoning

1 | INTRODUCTION

Since the beginning of the opioid epidemic in the late 1990s, 630 000 people are estimated to have died from opioid-related overdoses (OROD) in the United States.[1] The increase in OROD has been precipitous, and has, until recently, closely tracked with the rise in opioid prescriptions.[1,2] In response to the awareness of the crisis, updated medical practice guidelines and insurance industry and

The institution at which the work was performed: Occupational Health Surveillance Program, Massachusetts Department of Public Health.

[Late author's correction updated after publication dated 08 August 2019: in Section 4, Conclusions, para 3, new reference 50 has been included]

public policy interventions, including Prescription Drug Monitoring Programs, have led to changes in prescribing practices. Providers are writing fewer and less potent prescriptions.[3]

While the rates and numbers of OROD have continued to rise nationally, Massachusetts began to show signs that the crisis was abating in 2017.[4] Despite this recent stabilization, Massachusetts has a higher rate of OROD compared with the United States overall. In 2016, Massachusetts' rate of OROD was 31.3/100 000 residents compared with the US rate of 19.8/100 000.[4] In 2017, there were an estimated 2061 OROD in Massachusetts. Currently, most OROD in Massachusetts are attributed to synthetic opioids such as illicitly manufactured fentanyl, although prescription opioids, such as hydrocodone, hydromorphone, oxycodone, oxymorphone, and tramadol, continue to contribute to OROD.[5]

The etiology of the opioid epidemic is multifactorial, with contributing factors arrayed along with every level of the socioecological model of health—from individual biopsychosocial characteristics including childhood adversity and smoking status to global economic phenomena such as income inequality and job insecurity wrought by fading rural economies.[6,7] Injuries in the workplace have been identified as a factor in the rise of opioid dependence and OROD.[8-11] Musculoskeletal injuries, whether resulting from chronic exposures to ergonomic risk factors or from acute incidents such as slips, trips, and falls, are the leading cause of work-related injury and disability.[12] Demanding physical work, high psychosocial work demands, excessive repetition of tasks, awkward postures, and heavy lifting are all known workplace risk factors for musculoskeletal pain in prospective studies.[13] Such injuries are routinely treated with high doses and long-term prescriptions for opioids despite the publication of clinical practice guidelines that caution against routine use.[14-16] Prescribing rates and doses of opioids are higher in workers compensation insurance claims that they are in private insurance claims.[17,18] Workers may be prescribed higher doses of opioids to allow them to continue working and to return to work following an injury.[19,20] Use of opioids for work-related injuries is also linked to long term disability which may, in turn, contribute to opioid use disorder.[21-23]

The Massachusetts Department of Public Health (MDPH) supports data-driven opioid overdose prevention activities in a number of communities throughout the state (https://www.mass.gov/massachusetts-responds-to-the-opioid-epidemic). Two Massachusetts communities reviewed death certificate data and found that risk of fatal opioid overdoses varied by occupation, with significantly higher rates among workers in manual trades including construction and fishing.[24,25] Other states have documented a potential causal link between occupations, workplace physical demands, work-related pain and injuries, prescription opioids for chronic pain, and nonmedical opioid use.[19,26,27] These findings prompted MDPH to undertake a statewide study to determine whether rates of OROD varied by industry and occupation and to assess if work-related factors might contribute to observed differences. The aim was to generate information that can be used to target policy and program interventions to worker populations that are most impacted by the epidemic.

2 | MATERIALS AND METHODS

We analyzed data from death certificates provided by the Massachusetts Registry of Vital Records for persons who died of OROD from 2011 to 2015. The Massachusetts Registry of Vital Records manages the death registration system and receives death certificate information electronically via the Vitals Information Partnership. OROD were identified by the causes of death listed on the death certificate. ICD-10 codes for the underlying cause of death due to accidental poisoning (X40-X49), unintentional poisoning (X60-X69), assaults by drugs (X85-X90, Y35.2), or poisonings with undetermined intents (Y10-Y19) were used to identify deaths. Multiple causes of deaths fields were searched to identify poisonings in which the substance involved was an opioid: T40.0 (opium), T40.1 (Heroin), T40.2 (other opioids), T40.3 (Methadone), T40.4 (synthetic narcotics), and T40.6 (other unspecified narcotics).[28] For deaths occurring in 2014 and 2015 that had not yet received ICD-10 codes, some OROD were identified by searching the cause of death text fields for opioid-related terms. All OROD, including those with intentional, unintentional, and undetermined motivation, were included in the analysis. Less than 5% of the deaths were identified as intentional or undetermined.

The National Institute for Occupational Safety and Health (NIOSH) Industry and Occupation Computerized Coding System was used to code decedents' usual industry and occupation reported on death certificates to the North American Industry Classification System and the Standard Occupational Classification System, respectively, followed by manual review.[29] The data were used to describe the distribution and rates of OROD among Massachusetts residents by industry and occupation, overall, and within sex, age, and racial/ethnic groups. Five-year average annual OROD rates among workers were calculated as the number of deaths per 100 000 workers with corresponding 95% confidence intervals. Denominator data on average annual numbers of workers employed in Massachusetts during the study period by industry and occupation were obtained from the American Community Survey (ACS), from 2011 to 2015 to calculate these rates, 95% confidence intervals were calculated for all rates presented. To determine whether rates were statistically different from each other, rate ratios (RRs) were calculated using Poisson regression with a log link in SAS Version 9.3 (SAS Institute In, NC). In these models, the dependent variable was the count of the number of deaths with the log of the number of workers treated as the offset and industry or occupation group as the independent variable. Separate models were run with for each industry or occupation group with all other workers treated as the reference group. RRs were considered statistically significant at the level of $P \leq .05$.

There were a total of 5580 OROD in Massachusetts from 2011 through 2015. One hundred and ninety-one deaths of out-of-state residents were excluded from the analysis. Eight hundred and eighty eight deaths were excluded because the death certificates for these individuals indicated that they were not in the workforce either

because they were homemakers (319), were unemployed, or had never been employed (208), were unable to work due to disability or another reason (199), were students (160), or were a child (2). An additional 199 individuals were excluded because their death certificates contained no information or not enough information to code either industry or occupation. If the only industry or only occupation was coded, they were included in the analysis. Ultimately, 4302 deaths with usable industry and/or occupation information were included in the analysis representing 77% of total OROD in the time period. Those excluded due to missing industry and occupation information were similar to those in the final study group with respect to sex and age but were less likely to be white, non-Hispanic. This missing information may have resulted in underestimates of rates for racial/ethnic groups other than white, non-Hispanic.

To gain insight into how work-related factors may be contributing to high OROD rates, several national surveys were used to categorize occupation groups by work-related factors. Data from the Bureau of Labor Statistics' 2015 Massachusetts Survey of Occupational Injuries and Illnesses were used to categorize occupation groups according to injury rates.*,[30] Categories were based on the number of injuries and illnesses per 10 000 full-time equivalents in Massachusetts in 2015 (Table 4). The four categories were: 0 to 49, 50 to 99, 100 to 199, or 200 and more. We also examined OROD rates in relation to three other factors that vary by occupation: job insecurity, availability of paid sick leave, and income. These factors may influence a worker's decision to work while in pain and may increase reliance on pain medication. Occupation groups were categorized according to their levels of job insecurity using data from the National Health Interview Survey, 2011 to 2015.[31] An occupation group was considered to have high job insecurity if 30% or more of workers within that occupation group reported being worried about losing their job. All other occupation groups were categorized as having low job insecurity. In addition, occupation groups were categorized according to the availability of paid sick leave using data from the 2017 Bureau of Labor Statistics' Employee Benefits Survey.[32] An occupation group was considered to have low availability of paid sick leave if 70% or more workers within that occupation reported not having access to paid sick leave. All other occupation groups were categorized as having a high availability of paid sick leave. For the job insecurity and paid sick leave analysis, national data were used because no Massachusetts specific data were available. Finally, occupations were classified according to their median income in Massachusetts using data from the ACS, 2011 to 2015.[33] Occupation groups were categorized into the following five annual income categories: less than $20 000, $20 000 to $29 999, $30 000 to $39 999, $40 000 to $49 999 and $50 000 or more. To determine whether the rates for these different grouping were statistically different from each other, RRs were calculated using Poisson regression with the same parameters as those described above. In these models, the grouping with the lowest rate was treated as the reference category. RRs were considered statistically significant at the level of $P \leq .05$

This study was performed at the MDPH (federal-wide assurance number 786) and was conducted within the scope of existing reviewed and approved surveillance activities, including the use of death certificate data from the electronic death registration system. For this study, the MDPH was not engaged in human subjects research and no additional Institutional Review Board (IRB) review was required.

*Nationwide in 2015, injuries accounted for 95.2% of all injuries and illnesses monitored by the Bureau of Labor Statistics (BLS) SOII.

3 | RESULTS

OROD in Massachusetts workers occurred mostly among males and among non-Hispanic, whites (see Table 1). The OROD rate for all workers was 25.1 deaths per 100 000 workers which compares to the unweighted average annual OROD rate in the general Massachusetts population of 16.1/100 000 residents during the same time period.[34]

As shown in Table 2, there were six industry sectors in which the OROD rates were significantly higher than the rate for all other workers: construction; agriculture, forestry, fishing, and hunting; transportation and warehousing; administrative and support and waste management services; accommodation and food services; and other services, except public administration. There were nine occupation categories in which the OROD rate was significantly higher than the

TABLE 1 Distribution of opioid-related overdose deaths by demographic characteristics, Massachusetts workers, 2011-2015

Characteristic	Number	Percent
Sex		
Male	3324	77.3
Female	978	22.7
Age groups		
16-24	334	7.8
25-34	1308	30.4
35-44	1060	24.6
45-54	1031	24.0
55-64	477	11.1
65+	69	1.6
Unknown	23	0.5
Race/ethnicity		
White, non-Hispanic	3795	88.2
Hispanic	292	6.8
Black, non-Hispanic	159	3.7
Other	36	0.8
Asian or Pacific Islander, non-Hispanic	20	0.5
Total	4302	100

TABLE 2 Average annual rate and number of opioid-related overdose deaths by industry sector and occupation group, overall and by sex, Massachusetts workers, 2011-2015

	Opioid-related overdose deaths N (%)			Overall rates		Males		Females	
	Total	Males	Females	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)
Industry									
Construction	1155 (26.8)	1142 (34.4)	13 (1.3)	124.9 (108.8-141.0)	6.51 (6.08-6.96)[a]	135.0 (117.5-152.5)	4.90 (4.56-5.26)[a]	16.5 (0.0-36.5)	1.45 (0.84-2.50)
Agriculture, forestry, fishing, and hunting	67 (1.4)	…[b]	…[b]	107.5 (49.9-165.1)	4.37 (3.43-5.56)[a]	158.8 (71.8-245.8)	4.23 (3.31-5.42)[a]	…[b]	…[b]
Transportation and warehousing	246 (5.7)	211 (6.3)	35 (3.6)	48.3 (34.8-61.8)	2.00 (1.75-2.27)[a]	55.3 (38.6-72.0)	1.48 (1.29-1.71)[a]	27.4 (7.1-47.7)	2.45 (1.75-3.43)[a]
Administrative and support and waste management services	275 (6.4)	240 (7.2)	35 (3.6)	43.1 (31.7-54.5)	1.78 (1.57-2.01)[a]	60.4 (43.3-77.4)	1.63 (1.43-1.86)[a]	14.5 (3.8-25.3)	1.28 (0.91-1.79)
Accommodation and food services	424 (9.9)	255 (7.7)	169 (17.3)	36.5 (28.7-44.2)	1.51 (1.37-1.67)[a]	46.7 (33.9-59.6)	1.25 (1.10-1.42)[a]	27.4 (18.2-36.6)	2.69 (2.28-3.18)[a]
Other services, except public administration	259 (6.0)	196 (5.9)	63 (6.4)	34.3 (24.9-43.6)	1.40 (1.23-1.59)[a]	61.8 (42.4-81.1)	1.66 (1.44-1.92)[a]	14.4 (6.4-22.3)	1.27 (0.99-1.64)
Mining, quarrying, and oil and gas extraction	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]
Arts, entertainment, and recreation	85 (2.0)	67 (2.0)	18 (1.8)	25.4 (13.3-37.5)	1.02 (0.82-1.26)	39.4 (18.3-60.5)	1.04 (0.81-1.32)	10.9 (0.0-22.2)	0.95 (0.60-1.52)
Wholesale trade	95 (2.2)	87 (2.6)	8 (0.8)	23.4 (12.9-34.0)	0.94 (0.77-1.15)	31.0 (16.4-45.5)	0.80 (0.65-1.00)[a]	6.4 (0.0-16.4)	0.56 (0.28-1.12)
Utilities	24 (0.6)	…[b]	…[b]	22.3 (2.4-42.3)	0.90 (0.60-1.34)	28.5 (3.0-54.0)	0.75 (0.50-1.12)	…[b]	…[b]
Retail trade	401 (9.3)	291 (8.8)	110 (11.2)	21.8 (17.0-26.6)	0.86 (0.78-0.95)[a]	30.2 (22.5-38.0)	0.77 (0.69-0.87)[a]	12.5 (7.3-17.8)	1.11 (0.91-1.35)
Manufacturing	342 (8.0)	280 (8.4)	62 (6.3)	21.8 (16.6-27.0)	0.86 (0.77-0.97)[a]	25.8 (19.0-32.5)	0.65 (0.57-0.73)[a]	12.9 (5.7-20.0)	1.13 (0.88-1.47)
Information	79 (1.8)	54 (1.6)	25 (2.6)	20.0 (10.1-29.8)	0.80 (0.64-1.00)[a]	23.2 (9.3-37.0)	0.60 (0.46-0.79)[a]	15.4 (1.9-28.9)	1.36 (0.91-2.01)
Management of companies and enterprises	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]	…[b]
Health care and social assistance	419 (9.7)	125 (3.8)	294 (30.1)	15.0 (11.8-18.3)	0.56 (0.51-0.62)[a]	19.8 (12.0-27.5)	0.50 (0.42-0.60)[a]	13.7 (10.2-17.1)	1.28 (1.12-1.47)[a]
Real estate and rental and leasing	43 (1.0)	35 (1.1)	8 (0.8)	14.5 (4.8-24.1)	0.58 (0.43-0.78)[a]	21.5 (5.6-37.4)	0.56 (0.40-0.78)[a]	6.0 (0.0-15.2)	0.52 (0.26-1.04)

(Continues)

TABLE 2 (Continued)

	Opioid-related overdose deaths N (%)			Overall rates		Males		Females	
	Total	Males	Females	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)
Public administration	84 (2.0)	66 (2.0)	18 (1.8)	12.3 (6.4-18.3)	0.49 (0.39-0.60)[a]	16.1 (7.4-24.7)	0.41 (0.32-0.52)[a]	6.7 (0.0-13.6)	0.58 (0.36-0.92)[a]
Finance and insurance	66 (1.5)	40 (1.2)	26 (2.7)	6.6 (3.1-10.2)	0.25 (0.20-0.32)[a]	8.4 (52.6-14.2)	0.21 (0.15-0.29)[a]	5.0 (0.7-9.3)	0.42 (0.29-0.62)[a]
Professional, scientific, and technical services	103 (2.4)	68 (2.0)	35 (3.6)	6.4 (3.6-9.2)	0.24 (0.20-0.29)[a]	7.3 (3.4-11.2)	0.18 (0.14-0.22)[a]	3.9 (1.3-9.0)	0.43 (0.31-0.61)[a]
Educational services	85 (2.0)	46 (1.4)	39 (4.0)	4.3 (2.2-6.3)	0.16 (0.13-0.19)[a]	6.8 (2.4-11.1)	0.17 (0.12-0.22)[a]	2.1 (0.9-5.1)	0.23 (0.17-0.32)[a]
Military	16 (0.4)	…[b]	…[b]	…[c]		…[c]		…[c]	
Unknown	29 (0.7)	15 (0.5)	14 (1.4)	…[c]		…[c]		…[c]	
Occupation									
Construction and extraction	1096 (24.8)	1084 (32.6)	12 (1.2)	150.6 (146.0-155.1)	7.75 (7.24-8.30)[a]	152.3 (132.1-172.6)	5.47 (5.08, 5.88)[a]	73.5 (0-166.6)	6.24 (3.53-11.03)[a]
Farming, fishing, and forestry	61 (1.4)	…[b]	…[b]	143.9 (125.4-162.3)	5.82 (4.52-7.50)[a]	205.9 (89.4-322.5)	5.49 (4.25-7.08)[a]	…[b]	…[b]
Material moving	167 (3.9)	158 (4.8)	9 (0.9)	59.1 (54.5-63.7)	2.43 (2.09-2.84)[a]	71.9 (46.7-97.0)	1.99 (1.66-2.28)[a]	14.4 (0-35.5)	1.21 (0.63-2.34)
Installation, maintenance, & repair	221 (5.1)	213 (6.4)	8 (0.8)	54.0 (50.4-57.6)	2.22 (1.94-2.55)[a]	54.3 (38.0-70.6)	1.45 (1.26-1.67)[a]	47.8 (0-121.9)	4.03 (2.01-8.10)[a]
Transportation	203 (4.7)	187 (5.6)	16 (1.6)	42.6 (39.6-45.6)	1.74 (1.51-2.00)[a]	46.1 (31.3-60.9)	1.22 (1.06-1.42)[a]	22.4 (0-47.0)	1.90 (1.16-3.11)[a]
Production	312 (7.3)	274 (8.2)	38 (3.9)	42.1 (39.7-44.5)	1.74 (1.55-1.96)[a]	53.1 (39.0-67.2)	1.43 (1.27-1.62)[a]	17.0 (4.9-29.0)	1.44 (1.04-1.99)[a]
Food preparation and serving related	372 (8.6)	227 (6.8)	145 (14.8)	39.5 (37.5-41.6)	1.64 (1.47-1.82)[a]	51.6 (36.6-66.6)	1.38 (1.21-1.58)[a]	28.9 (18.4-39.4)	2.68 (2.25-3.19)[a]
Building/grounds cleaning & maintenance	230 (5.3)	207 (6.2)	23 (2.4)	38.3 (35.8-40.9)	1.57 (1.38-1.79)[a]	54.2 (37.7-70.7)	1.45 (1.25-1.67)[a]	10.2 (0.7-19.8)	0.90 (0.59-1.35)
Healthcare support	146 (3.4)	27 (0.8)	119 (12.2)	31.8 (29.2-34.5)	1.28 (1.09-1.51)[a]	43.1 (6.7-79.5)	1.13 (0.78-1.65)	30.1 (18-42.1)	2.74 (2.26-3.32)[a]
Personal care and service	153 (3.6)	67 (2.0)	86 (8.8)	23.7 (21.8-25.6)	0.95 (0.80-1.11)	43.1 (20.0-66.2)	1.13 (0.89-1.45)	17.5 (9.2-25.8)	1.52 (1.22-1.89)[a]
Sales and related	342 (7.9)	230 (6.9)	112 (11.5)	20.0 (18.9-21.1)		26.2 (18.6-33.8)		13.5 (7.9-19.1)	

(Continues)

TABLE 2 (Continued)

	Opioid-related overdose deaths N (%)			Overall rates		Males		Females	
	Total	Males	Females	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)	Opioid-related overdose deaths/100 000 workers (95% CI)	Rate ratio (95% CI)
					0.78 (0.70-0.88)[a]		0.67 (0.58-0.76)[a]		1.15 (0.94-1.40)
Arts, design, entertainment, sports, & media	74 (1.7)	57 (1.7)	17 (1.7)	19.5 (17.2-21.8)	0.78 (0.62-0.98)[a]	31.5 (13.2-49.8)	0.82 (0.63-1.07)	8.6 (0-17.7)	0.71 (0.44-1.15)
Community and social services	56 (1.3)	29 (0.9)	27 (2.8)	16.6 (14.3-18.8)	0.66 (0.51-0.86)[a]	28.5 (5.3-51.7)	0.75 (0.52-1.08)	11.4 (1.8-21.0)	0.96 (0.65-1.40)
Protective service	58 (1.3)	50 (1.5)	8 (0.8)	15.4 (13.3-17.4)	0.62 (0.48-0.80)[a]	16.1 (6.0-26.2)	0.42 (0.32-0.56)[a]	12.1 (0-30.8)	1.01 (0.51-2.03)
Architecture and engineering	47 (1.1)	38 (1.1)	9 (0.9)	12.5 (10.6-14.3)	0.49 (0.37-0.66)[a]	12 (3.5-20.5)	0.31 (0.22-0.42)[a]	15.1 (0-37.1)	1.27 (0.66-2.44)
Office & administrative support	248 (5.8)	98 (2.9)	150 (15.3)	11.7 (10.9-12.4)	0.43 (0.38-0.49)[a]	15.9 (8.9-22.9)	0.40 (0.33-0.49)[a]	9.9 (6.4-13.5)	0.80 (0.67-0.96)[a]
Healthcare practitioner and technical	122 (2.8)	29 (0.9)	93 (9.5)	11.1 (10.1-12.1)	0.43 (0.36-0.51)[a]	11.5 (2.1-20.8)	0.30 (0.21-0.43)[a]	11.0 (6.0-16.0)	0.91 (0.74-1.13)
Management	164 (3.8)	135 (4.1)	29 (3)	8.6 (7.9-9.3)	0.32 (0.27-0.37)[a]	12.5 (7.8-17.2)	0.30 (0.25-0.36)[a]	3.5 (0.7-6.4)	0.27 (0.19-0.40)[a]
Legal	19 (0.4)	11 (0.3)	8 (0.8)	7.9 (6.1-9.8)	0.31 (0.20-0.49)[a]	8.9 (0-20.7)	0.23 (0.13-0.42)[a]	6.9 (0-17.6)	0.58 (0.29-1.16)
Business and financial operations	76 (1.8)	55 (1.7)	21 (2.1)	7.4 (6.6-8.3)	0.29 (0.23-0.36)[a]	11.2 (4.6-17.9)	0.28 (0.22-0.37)[a]	4.0 (0.2-7.7)	0.32 (0.21-0.49)[a]
Life, physical, and social science	20 (0.5)	…[b]	…[b]	6.5 (5.0-7.9)	0.26 (0.16, 0.40)[a]	9.8 (0-20.9)	0.25 (0.15-0.42)[a]	…[b]	…[b]
Computer and mathematical	36 (0.8)	…[b]	…[b]	5.6 (4.6-6.5)	0.22 (0.16, 0.30)[a]	6.5 (1.4-11.6)	0.16 (0.11-0.23)[a]	…[b]	…[b]
Education, training, and library	49 (1.1)	16 (0.5)	33 (3.4)	4.0 (3.4-4.5)	0.15 (0.11, 0.20)[a]	4.4 (0-9.2)	0.11 (0.07-0.18)[a]	3.8 (0.9-6.7)	0.29 (0.21-0.42)[a]
Military specific	12 (0.3)	…[b]	…[b]	…[c]	…[c]	…[c]		…[c]	
Unknown	18 (0.4)	…[b]	…[b]	…[c]	…[c]	…[c]		…[c]	
All industries/occupations	4302 (100)	3324 (100)	978 (100)	25.1 (23.8-26.8)		38.2 (35.3-41.2)		11.6 (10.0-13.2)	

Note: Rate ratios derived from Poisson regression using the overall dataset as contrast.

Abbreviation: CI, confidence interval.

[a]Rate ratio significantly different than the rate for all other industry or occupation categories.

[b]Suppressed due to cell size restriction.

[c]Unable to calculate rate due to lack of denominator.

TABLE 3 Average annual rate and number of opioid-related overdose deaths by work-related factors, Massachusetts workers, 2011-2015

Work-related factors	Opioid-related overdose deaths N (%)[a]	Opioid-related overdose deaths/ 100 000 workers	Rate ratio (95% CI)
Rate of occupational injury and illness per 10 000 full-time workers[b]			
0-49 (Reference)	417 (10.7)	9.0 (7.1-10.9)	1.00
50-99	700 (18.0)	13.7 (11.4-16.0)	1.52 (1.35-1.72)[c]
100-199	761 (19.6)	22.4 (18.8-26.0)	2.49 (2.21-2.80)[c]
200+	2005 (51.6)	68.4 (61.7-75.1)	7.60 (6.84-8.45)[c]
Job insecurity[d]			
Low (reference)	899 (21.0)	10.9 (7.3-14.4)	1.00
High	3373 (79.0)	38.3 (31.8-44.8)	3.51 (3.26-3.78)[c]
Percent with paid sick leave[e]			
High (reference)	1132 (34.6)	11.2 (9.8-12.7)	1.00
Low	3137 (65.4)	44.9 (41.4-48.4)	4.01 (3.75-4.29)[c]
Income range[f]			
>$49 999 (Reference)	542 (12.7)	9.1 (7.4-10.8)	1.00
<$20 000	586 (13.7)	36.0 (29.4-42.5)	3.96 (3.52-4.45)[c]
$20 000-$29 999	543 (12.7)	40.6 (33.0-48.3)	4.46 (3.96-5.03)[c]
$30 000-$39 999	1105 (25.9)	21.9 (19.0-24.8)	2.41 (2.17-2.67)[c]
$40 000-$49 999	1496 (35.0)	48.4 (42.9-53.9)	5.32 (4.82-5.87)[c]

Abbreviation: CI, confidence interval.

[a]Some totals do not add up to 4302 because deaths were excluded if the occupation of the decedent could not be linked to the work-related factor being examined.

[b]Work-related injury and illness rates by occupation: BLS Massachusetts Survey of Occupational Injuries and Illnesses, 2015.

[c]Rate ratio significantly different than the reference group.

[d]Percent of workers reporting job insecurity by occupation: National Health Interview Survey, 2011-2015.

[e]Percent of workers reporting access to paid sick leave by occupation: BLS Employee Benefits Survey, 2017.

[f]Median income by occupation: American Community Survey, 2011-2015.

rate for all other workers: construction and extraction; farming, fishing, and forestry; material moving occupations; installation, maintenance, and repair; transportation; production; food preparation and serving related; building and grounds cleaning and maintenance; and healthcare support occupations. The construction and extraction group stood out as having both a high OROD rate—over seven times that for all other workers—and a high number of OROD, accounting for more than 24% of all OROD in this study. At least 97% of those within this occupation group were employed in construction occupations. Workers in the farming, fishing, and forestry occupation group also had a very high rate. While there were fewer deaths in this group than in construction, the OROD rate was more than five and a half times that for all workers. Most (74%) of deaths in this occupation group were of individuals employed in fishing occupations.

As in the general population, the OROD number and rate were significantly higher among male workers compared with female workers. Industries and occupations with significantly higher rates of OROD also differed by sex (Table 2). The industries and occupations with the highest overall OROD rates were also those that were the highest for men. Among females, the health care support and food preparation and serving-related occupation groups had elevated OROD rates. The installation, maintenance, and repair occupation group had the highest OROD rate among females, but this was based on only eight deaths. It was not possible to generate detailed findings of the OROD rates by industry and occupation within race/ethnicity categories because of the low sample size of OROD among those other than white, non-Hispanics. There were, however, differences in broad occupation groups with the highest percentages of deaths across race/ethnicity categories. For Hispanics, natural resources, construction, and maintenance occupations were the most common, followed closely by service occupations. For Black, non-Hispanic workers in the study, service occupations were the most common (data not shown).

As shown in Figure 1, workers in occupation groups with the highest occupational injury and illness rates also had the highest OROD rate and those with the lowest occupational injury and illness rates also had the lowest OROD rate. This association remained even when the construction and extraction occupation group, which had the highest OROD rate, was removed from the highest injury and illness rate category. When deceased workers were categorized according to the injury rate of their industry group, a similar relationship was found (data not shown). Occupations with high job insecurity according to national survey data had a higher OROD rate compared with occupations with lower job insecurity. The OROD rate was also higher in occupations where a lower percentage of workers had access to paid sick leave,

TABLE 4 Rate of occupational injuries and illnesses, Massachusetts workers, 2015

Occupational group	Injuries/10 000 full time workers[a]
Architecture and engineering	13.1
Arts, design, entertainment, sports, & media	36.5
Building/grounds cleaning & maintenance	232.2
Business and financial operations	9.8
Community and social services	135.7
Computer and mathematical	3.5
Construction and extraction	193.3
Education, training, and library	88.3
Farming, fishing, and forestry	73.1
Food preparation and serving related	149.4
Healthcare practitioner and technical	174.8
Healthcare support	316.2
Installation, maintenance, & repair	320.8
Legal	N/A
Life, physical, and social science	9.3
Management	37.9
Material moving	367.0
Office & administrative support	62.1
Personal care and service	147.0
Production	213.9
Protective service	107.2
Sales and related	50.7
Transportation	367.0
All occupations	121.4

[a]*Source:* BLS Massachusetts Survey of Occupational Injuries and Illnesses, 2015.

compared with occupations where a higher percentage of workers had access to paid sick leave. The association of OROD rates with income level was not straightforward. The highest median income occupation group (>$49 999) had the lowest OROD and the second highest median income group ($40 000-$49 999) had the highest OROD rate (Table 3).

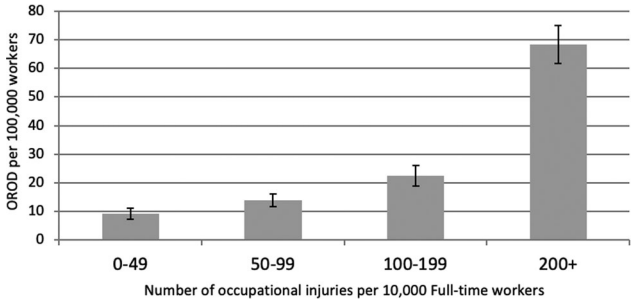

FIGURE 1 Average annual rate of opioid-related overdose deaths among Massachusetts workers by occupation-specific injury and illness rate category, 2011-2015*

4 | CONCLUSIONS

This study finds that OROD rates vary significantly by industry and occupation, supporting results from local Massachusetts communities, other states, and a recent multistate study.[24,25,35] Examination of OROD rates by factors known to vary by occupation sheds light on several factors that may contribute to the observed differences. OROD rates were significantly higher among workers employed in occupations known to be physically demanding and that have high rates of work-related injuries and illnesses. They were also higher in occupations with higher job insecurity and lower availability of paid sick leave. These findings are consistent with previous reports that opioids are widely used for pain management following work-related injuries and suggest that these injuries, and the need to work while in pain, may contribute to the use of opioids, and opioid-related morbidity and mortality.[8]

Our findings and those of Murano et al[35], which looked at OROD and occupation in 21 states, were similar. However, that study did not find elevated rates among those in farming, forestry, and fishing. Underlying variation in the opioid epidemic between states may account for differences between the studies, (Massachusetts was not among the states included), as well as differences in the composition of the workforce across states. In Massachusetts, the majority of farming, forestry, and fishing workers are in the fishing sector whereas, in other states, agricultural workers dominate that group. In addition, OROD in the NIOSH study occurred between 2007 and 2011, whereas the Massachusetts deaths occurred between 2011 and 2015.

The construction sector stands out in this study, and in other related studies, as having both a high rate and number of OROD.[28] Construction is physically demanding and dangerous work and the workers in this sector have among the highest rates of fatal and nonfatal occupational injuries.[36] In addition, construction workers are known to have a high prevalence of musculoskeletal pain—far higher than their prevalence of work-related injury. In a 2010 nationwide household survey, over one-third of constructions workers reported back pain during the previous 3 months—a prevalence rate higher than workers in other industries for all age groups.[36] It is likely that chronic back pain and subsequent opioid use increase with age. In a 2012 study, almost 40% of construction workers older than 50 years reported chronic back pain.[37] According to a recent study of opioid dispensing using workers' compensation insurance claim data from 27 states (including Massachusetts), compared with workers in other industries, workers in the construction and mining industries were more likely to receive opioids when receiving a prescription for pain medication, after controlling for multiple factors, including type of injury.[13,50] Workers in these industries were also more likely to receive high-dose opioids and opioids over a longer time period.

In Massachusetts, in 2015, according to data reported by employers to the Bureau of Labor Statistics, four out of every 100 construction workers were injured on the job, with half of these injuries resulting in time lost from work. In a recent Massachusetts study of construction workers on a large commercial construction

site, 74% reported having some kind of musculoskeletal pain in the last 3 months and about 40% reported having one or more injuries in the last month.[38] This study also found high rates of mental distress and lack of treatment, and the authors hypothesized that "stigmatization and fear of job loss may interfere with help-seeking behaviors." In interviews conducted by the Mystic Valley Public Health Commission, construction workers discussed the pressure to work in pain and the common use of opioids, both prescribed and those obtained without a prescription, to maintain employment.[25] Due to seasonal and periodic employment, construction workers may be less likely to report injuries or to take days off to recover. Numerous other factors, including access to healthcare and benefits, pay rates, working away from family, union status, and nonstandard shifts may play a role in either moderating or mediating associations between construction work and OROD. As a result of the toll of opioids in the construction industry, construction health, and safety experts have brought new attention and developed tools to address opioid use among construction workers (https://www.cpwr.com/research/opioid-resources).

Fishing workers were also found to have high rates of OROD. Commercial fishing is one of the most hazardous occupations in the United States with a work-related injury fatality rate 25 times higher than the national average.[39] Nonfatal injuries and musculoskeletal disorders among fishermen[†] are common. In one study, 35% of fishermen reported symptoms causing work interference within the last 12 months, with low back pain being the most common symptom.[40] In a recent study of lobstermen in the Northeast, the annual rate of all reported occupational injuries was 50 per 100 full-time workers with close to a third of these injuries requiring medical treatment, although many do not seek treatment.[41,42] Fishing, like construction, is physically demanding, precarious, seasonal, and sometimes well-paying. In recognition that work-related factors may play a role in both facilitating opioid use and in inhibiting treatment for opioid use disorder, efforts are now underway in Massachusetts to enhance safety training, tailor substance use treatment to the needs of the fishing community and to assure access to the overdose prophylaxis naloxone aboard vessels.[40,43]

There are some limitations to our findings. Our calculations assume that those who died and had an occupation and/or industry reported on their death certificates were employed in that industry and occupation in the years before death. We selected employment denominator data that corresponded to the year of death. Because death certificates contain information about usual, not current, industry and occupation, this assumption may not hold if the decedent's usual industry and occupation were different from the industry and the occupation he or she was working in the period before death. The rates for certain industries and occupations could be inflated if the decedent was no longer employed or employed in a different industry or occupation. In addition, the rates for other industries and occupations could be deflated if the worker was employed in that industry or occupation at the time of death, but it differed from the usual industry or occupation listed on their death certificate. However, studies have found very high rates of concordance between current and usual industry and occupation, including on death certificates.[44,45] This assumption may also not hold if the decedent has retired. To address this concern, we conducted a sensitivity analysis excluding decedents over age 55, who accounted for 11.4% of the OROD in our population. We did not see any major changes in our observed associations.

In addition, this study lacked individual-level data on the work-related factors (occupational injuries, job insecurity, paid sick leave, and income) found to be associated with OROD rates. Thus, we cannot draw conclusions about causal links between these factors and OROD. In addition, it is possible that the use of opioids by workers contributed to both occupational injuries and OROD. Finally, some occupations and industries may have higher rates of OROD because, in general, there is a higher rate of substance use within those occupations and industries. The prevalence of self-reported illicit drug use among employed adults use has been found to vary by industry. However, the ranking of industries by the prevalence of illicit drug use in a 2013 study varied markedly from the rank order of industry by OROD rates in the present analysis, and in no single industry was this prevalence more than twice that for all working adults. For construction, the prevalence of illicit drug use was 34% higher than that for all workers. Therefore, it is unlikely that this background rate of illicit drug use could account for the multifold greater OROD rate we observed among construction workers compared with other workers.[46]

Understanding the many complex factors contributing to the opioid epidemic is challenging. We continue to explore these factors and opportunities for intervention.[47] Additional research is necessary to understand the manner and extent to which work-related injuries, job insecurity, access to paid sick leave, and other occupational and socioeconomic factors impact opioid use, opioid use disorders, and OROD in the working population. However, interventions can and should be implemented before all research questions are answered. Policy and educational interventions to reduce OROD tailored to the needs of high rate worker populations are needed. These should address workplace hazards that cause injuries for which opioids are prescribed, clinician education to promote best practices in the treatment of painful work-related injuries and return to work, enhanced access to treatment for opioid use disorders, and overdose prevention education for the workplace.[48] The workplace can serve as an important venue for opioid awareness education, communication about the harms of stigma, and the availability of resources to support treatment of substance use disorders. Work is also an important source of both economic and social support. Efforts to promote the employment of those in treatment and recovery may also help prevent OROD.[49] In short, the workplace provides important opportunities for primary prevention of opioid initiation, as well as for the support of those with opioid use disorders. Our findings contribute to the growing evidence that working populations, particularly those in high-risk occupations, must be considered in strategic efforts to reverse the opioid epidemic.

[†]The term "fishermen" is used to describe both female and male workers in this occupation, according to custom.

ACKNOWLEDGMENTS

The authors would like to acknowledge the assistance of the MADPH Bureau of Substance Addiction Services, the Injury Surveillance Program and the Office of Special Analytic Projects in carrying out this work. This project was supported by a grant (1UI7CE002724) from the Centers for Disease Control and Prevention to the Massachusetts Department of Public Health (DPH).

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

DISCLOSURE BY AJIM EDITOR OF RECORD

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

AUTHORS CONTRIBUTIONS

DH and LD designed the study, conducted the analysis, drafted, and revised the manuscript. CR also drafted and revised the manuscript. JL performed data management, coded the industry and occupation, assisted with the analysis, and contributed to the writing of the manuscript. All authors approved the final version.

ETHICS STATEMENT

This work was mandated by law and conducted by a public health authority. The MADPH was not engaged in human subjects research, and no IRB review was required.

DISCLAIMER

The contents of this publication are solely the responsibility of the authors and do not represent the official views of the Centers for Disease Control and Prevention.

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How to cite this article: Hawkins D, Roelofs C, Laing J, Davis L. Opioid-related Overdose Deaths by Industry and Occupation — Massachusetts, 2011-2015. *Am J Ind Med*. 2019;62:815-825. https://doi.org/10.1002/ajim.23029