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Original Article

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The Contribution of Occupation-Specific Factors to the Deaths of Despair, Massachusetts, 2005–2015

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Abstract

Objectives: In the USA, deaths from poisonings (especially opioids), suicides, and alcoholic liver disease, collectively referred to as 'deaths of despair', have been increasing rapidly over the past two decades. The risk of deaths from these causes is known to be higher among certain occupations. It may be that specific exposures and experiences of workers in these occupations explain these differences in risk. This study sought to determine whether differences in the risk of deaths of despair were associated with rate of occupational injuries and illnesses, job insecurity, and temporal changes in employment in non-standard work arrangements.

Methods: Usual occupation information was collected from death certificates of Massachusetts residents aged 16–64 with relevant causes of death between 2005 and 2015. These data were combined with occupation-level data about occupational injuries and illnesses, job insecurity, and non-standard work arrangements. We calculated occupation-specific mortality rates for deaths of despair, categorized by occupational injury and illnesses rates and job insecurity. We calculated trends in mortality according to changes in non-standard work arrangements.

Results: Workers in occupations with higher injury and illnesses rates and more job insecurity had higher rates of deaths of despair, especially opioid-related deaths. Rates of deaths of despair increased most rapidly for occupations with increasing prevalence of workers employed in non-standard work arrangements.

Conclusions: The findings suggest occupational factors that may contribute to the risk of deaths of despair. Future studies should examine these factors with individual-level data. In the meantime, efforts should be made to address these factors, which also represent known or suspected hazards for other adverse health outcomes.

What's important about this paper

This work highlights occupational factors that may be contributing to differences for the risk for deaths of despair. At the same time that drug overdoses, suicides, and alcoholic liver disease deaths have been increasing, the nature of work has been changing. This work suggests that these factors may be related to each other. Workers with more occupational injuries, job insecurity, and non-standard work arrangements are at an elevated risk for the deaths of despair.

Keywords: alcoholic liver disease; deaths of despair; job insecurity; non-standard work arrangements; occupation; opioids; suicide; work injuries

Introduction

Deaths of despair

Beginning in 2015, the USA has experienced annual declines in life expectancy every year except 2018, which have primarily been attributed to drug and alcohol poisonings, predominately those related to opioids, and suicides (Xu *et al.*, 2016, 2020; Kochanek *et al.*, 2017; Hedegaard *et al.*, 2018a,b; Murphy *et al.*, 2018). The effects of deaths from these causes and also alcoholic liver disease and cirrhosis have been most acute among non-Hispanic whites between the ages of 45 and 54, among whom mortality has been increasing since 1999. Together, deaths from drug and alcohol poisonings, suicides, and alcoholic liver disease or cirrhosis have been referred to as 'deaths of despair' (Case and Deaton, 2015, 2017). This increase in mortality has been most apparent among those with education below a college level, which may be due to changes in labour market opportunities among this group (Case and Deaton, 2017). Counties with declines in manufacturing and natural resources jobs (e.g. mining) had greater increases in the deaths of despair than other counties (Monnat, 2017). Previous work in Massachusetts (MA) has found substantial differences in both the overall mortality rates from the deaths of despair and trends in mortality for these deaths according to occupation (Hawkins *et al.*, 2020). Because of these differences, occupational factors that may be contributing to risk deserve further attention.

Occupational injuries

Occupational injuries may be a risk factor for some or all of the deaths of despair (Shaw *et al.*, 2020). With respect to opioid and other drug deaths, Kowalski-McGraw *et al.* (2017) proposed several conceptual models, suggesting that occupational injuries and musculoskeletal disorders could lead to the use of opioids and benzodiazepines for pain control. Opioids are commonly prescribed within the workers' compensation system following occupational injury, and more often than for injuries not covered through that system (Webster *et al.*, 2007; Cifuentes *et al.*, 2010; Dembe *et al.*, 2012; Franklin *et al.*, 2012; Thumula and Liu, 2018). It has been demonstrated that the majority of those who died from causes related to opioids had experienced an occupational injury at some point in their life (Cheng *et al.*, 2013); that there is a positive relationship between occupational injury and illness rates and opioid-related mortality (Hawkins *et al.*, 2019); and that workers with occupational injuries resulting in more than seven lost calendar days covered by workers' compensation in two different US states [New Mexico (NM) and West Virginia (WV)] had higher risk of drug-related mortality than workers with injuries resulting in fewer lost workdays (Applebaum *et al.*, 2019; Martin *et al.*, 2020). Some occupations are also prescribed more opioids at higher doses, which may contribute to different risks among workers in different occupations (Cifuentes *et al.*, 2010; Dembe *et al.*, 2012; Franklin *et al.*, 2012).

With respect to suicide and deaths from chronic liver disease and cirrhosis, occupational injuries may be a risk factor for negative mental health outcomes like anxiety and depression (Helliwell *et al.*, 1992; Pransky *et al.*, 2000). Additionally, occupational injuries are a known risk factor for involuntary job loss (Keogh *et al.*, 2000; Brewer *et al.*, 2012; Okechukwu *et al.*, 2016) and related financial losses (Boden and Galizzi, 2003; Galizzi and Zagorsky, 2009). Job loss in turn is associated with alcohol and drug use (Henkel, 2011), negative mental health effects (Paul and Moser, 2009), and suicide (Blakely *et al.*, 2003). These impacts may contribute to elevated rates of deaths of despair in counties that

have experienced declines in manufacturing and natural resources employment (Monnat, 2017). The same NM and WV studies referenced above also reported elevated rates of suicides following occupational injuries (Applebaum *et al.*, 2019; Martin *et al.*, 2020).

Perceived job insecurity

Job insecurity has been defined in a variety of ways. Fundamentally, it refers to concern about whether one will have a job in the future. It can also refer to concern about losing specific aspects of a job, such as benefits or consistent hours (Witte, 1999). Associations have been found between job insecurity and drug use (Frone, 2006). In a meta-analysis, job insecurity was associated with common mental disorders (Stansfeld and Candy, 2006). Other studies have linked job insecurity to depression and suicidal ideation (Ferrie *et al.*, 2002; Rugulies *et al.*, 2006; Stansfeld and Candy, 2006; Dalglish *et al.*, 2015; Milner *et al.*, 2016, 2018), while job security improvements led to better mental health in a large, 14-year population sample (LaMontagne *et al.*, 2020). Additionally, workers in occupations with a high prevalence of job insecurity (Hawkins *et al.*, 2019) have higher opioid-related mortality, and construction workers with higher levels of perceived job insecurity (Evanoff *et al.*, 2020) have higher rates of pain medication use.

Non-standard work arrangements

Non-standard, alternative, or contingent work arrangements are defined by the U.S. Bureau of Labor Statistics (BLS) as 'any job in which an individual does not have an explicit or implicit contract for long-term employment' (Polivka and Nardone, 1989). Such arrangements include independent contractors, on-call workers, workers employed through contract firms and temporary help agencies, involuntary part-time workers, app-based or 'gig' workers, and freelancers (Stone, 2004; Katz and Krueger, 2019). Fundamentally, what unifies these workers is that 'they have no expectation of permanence, even if the work is performed well' (Stone, 2004; Howard, 2017).

One study found that since 2005 the percentage of US workers employed in non-standard work has increased by about 6% (Katz and Krueger, 2019). On the other hand, the 2017 Bureau of Labor Statistics (BLS) Contingent Worker Survey reported no increase in the prevalence of non-standard work arrangements since 2005 (BLS, 2018). These contradictory findings may be due to a focus on respondents' main jobs, while excluding secondary, non-standard work (Novello and Stettner, 2018). However, even if the overall prevalence of non-standard work arrangements has not increased, there are several specific occupational categories in which these arrangements are more common (BLS, 2005, 2018).

While there is less literature to date on the specific health effects of non-standard work arrangements, documented impacts include lower job satisfaction (Wilkin, 2013), higher psychological morbidity (Virtanen *et al.*, 2005), and higher alcohol-related mortality compared to other workers (Kivimäki *et al.*, 2003). A number of studies have identified non-standard workers as having a higher risk of both fatal and non-fatal occupational injuries compared to other workers (Virtanen *et al.*, 2005; Benavides *et al.*, 2006; Smith *et al.*, 2010; Boden *et al.*, 2016). Thus, contingent work may impact the risk of deaths of despair through similar mechanisms to those described above for occupational injuries and/or perceived job insecurity.

Objectives

This study sought to determine whether mortality due to the deaths of despair differed by occupational injury and illness rate and prevalence of perceived job insecurity. Additionally, it sought to determine whether trends in the deaths of despair differed according to changes in the prevalence of non-standard work arrangements within an occupation.

Methods

Data collection and management

The methods for data collection and coding have been described previously (Hawkins *et al.*, 2020). Briefly, death certificates in MA from 2005 to 2015 were screened for underlying cause of death and categorized using ICD-10 codes as unintentional or undetermined poisonings, suicides, and alcoholic liver disease and cirrhosis deaths. Deaths were categorized as opioid related if the multiple cause of death field included codes indicative of opioids; thus opioid-related deaths are a subset of any of the deaths of despair, not only poisonings. Deaths among residents of other states, those younger than 16 or older than 64, those with missing occupation or indication that the decedent was not working, and those who lacked corresponding denominators were excluded. Because of the disproportionately high number and rate of deaths of despair among construction workers (Hawkins *et al.*, 2020), we performed separate analyses with construction workers included and excluded.

Occupation, year of death, age, sex, race/ethnicity, and educational attainment were collected from death certificates. Age was categorized into five groups: 16–24, 25–34, 35–44, 45–54, and 55–64. Sex was coded as male or female. Race and ethnicity data were used to assign decedents into five categories: white, non-Hispanic; black, non-Hispanic; Asian, non-Hispanic; Hispanics of all races; and all others. Educational attainment was dichotomized as high school education or less and some college education or more. The National Institute for Occupational Safety and Health Industry and Occupation Computerized Coding System (NIOSH, 2018) was used to code occupation into 23 major census categories.

Denominator data for calculating mortality rates were obtained from the annual, nationally representative American Community Survey (ACS) files for 2005–2015 (US Census Bureau, 2020). Denominators were produced for MA residents employed during the survey year and stratified by occupation, age group, sex, race/ethnicity, and educational attainment using cut-off values corresponding to those used with the death data.

Occupational injuries

Occupations were categorized according to the occupational injury and illness rate for 2011–2015, obtained from the annual BLS Survey of Occupational Injuries and Illnesses (SOII) of US private sector and local or state government establishments (BLS, 2018). A stratified sample of establishments by industry, ownership, and size is generated to 'represent all in-scope private industries, state government, and local government'. A sample of injury or illness cases involving days away from work, job transfer, or work restriction is then taken from these establishments. For incidents involving at least one lost workday, characteristics of the injury and injured worker, including occupation, are extracted.

Using data on all injuries and illnesses, occupations were placed into one of four categories (less than 40; 40–99; 100–199; or 200 or more injuries per 10 000 full-time workers) depending on their annual rate for the majority of years from 2011 to 2015. If an occupation's injury and illness rate was in two categories for an equal number of years, then we calculated the average occupational injury and illness rates for all years with available data and categorized the occupation according to that average. Occupational injury and illness data were available for 20 of 23 occupations to which death certificate data were coded. Extraction workers had their injury data combined with construction workers so these rates were used for both occupations. Similarly, business operations and financial specialists also had their data combined and the same rates were used for both.

Perceived job insecurity

Occupations were categorized according to the self-reported job insecurity of workers within the occupation using data from the 2015 National Health Interview Survey (CDC, 2015). In 2015, the NHIS included a supplement to the core questionnaire with items relevant to occupational health, including the question, 'Are you worried about losing your job?' Those who answered 'yes' to this question were classified as considering their employment status as insecure, and the percentage of those answering yes was calculated for each occupation. If the unadjusted prevalence of perceived job insecurity was 12.0% or higher, then the occupation was categorized as having a high level of job insecurity. Occupations with between 9.0% and 11.9% of workers reporting job insecurity were categorized as having a medium level, and those with less than 9.0% of workers reporting job insecurity were categorized as having a low level (NIOSH, 2016). Perceived job insecurity data were available for 20 of 23 occupations to which death certificate data were coded. As with the occupational injury data, the same job insecurity data were used for extraction and construction workers as well as for the combination of business operations and financial specialists.

Non-standard work arrangements

Occupations were categorized according to the prevalence of workers employed in non-standard work arrangements using estimates generated by Katz and Krueger (2019) from the 2005 BLS Contingent Work Survey (CWS) and the 2015 RAND-Princeton (RP) CWS. In each survey, workers were asked two questions about their employment in non-standard work arrangements, based on their responses to these questions they were classified as being employed in non-standard work arrangements.

Using the BLS CWS and RP CWS, Katz and Krueger (2019) estimated the prevalence of workers in non-standard work arrangements according to major occupations in 2005 and 2015. For this paper, we utilize their non-standard weight system designed to match as closely as possible the BLS CWS. Occupations were categorized according to whether or not their prevalence of non-standard work arrangements increased more than the average for all workers between 2005 and 2015. Because the prevalence of non-standard work

arrangements for all workers increased from 10.7% to 15.8%, or a 5.1% absolute increase, the cut-off value of 5.1% was used. Non-standard work arrangement data were available for 20 of 23 occupations to which death certificate data were coded.

Statistical analysis

For occupational injury and illness, perceived job insecurity categories, the average annual mortality rates, and corresponding 95% confidence intervals were calculated for the period from 2011 to 2015. For non-standard work arrangements, these same calculations were performed for the period 2005–2015. Rates were calculated for all deaths of despair and for opioid-related deaths, suicides, and alcoholic liver disease and cirrhosis deaths separately.

In order to examine the impact of potential confounders on the relationship between occupational injury and illness/perceived job insecurity and deaths of despair we also created multivariate models that examined how the relationship between these factors and deaths of despair change when controlling for age, sex, race ethnicity, and education. Three models were constructed. The first controlled for occupational injury and illness rate *or* job insecurity, the second added age, sex, and race/ethnicity, and the third added education. Mortality rate ratios were modelled with Poisson regression using generalized mixed models with a log link in SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA). The independent variable was the annual number of deaths, with the log of the annual number of workers treated as the offset. We also applied the same Poisson regression approach to model trends in mortality rates for non-standard work arrangements.

Trends in mortality rate were estimated by fitting separate models for each category (prevalence of non-standard work arrangements increasing less than or more than the average for all workers), with year as the independent variable. The exponent of the parameter estimate for year represents the average annual percent changes (AAPCs) in mortality rates for these categories. These AAPCs with corresponding 95% confidence intervals were calculated for each category. To examine the possible influence of workers' demographic and socioeconomic characteristics on these trends, we ran three separate models to calculate these AAPCs: (i) a simple model with year only; (ii) a model with age, gender, and race/ethnicity included; and (iii) a model with age, gender, race/ethnicity, and educational attainment. These analyses were performed on all deaths of despair, as well as opioid-related deaths, suicides, and alcoholic liver disease and cirrhosis deaths. Trend analyses only were performed for non-standard work arrangements, because we hypothesize that changes in the prevalence of these work arrangements are a major factor accounting for trends in deaths of despair.

Results

The study examined deaths of MA residents between the ages of 16 and 64 presumed to be working, with usable occupation information. For the occupational injury and illness analysis and perceived job insecurity analysis, which covered the period from 2011 to 2015, there were 6214 deaths. For the non-standard work arrangements analysis, which covered 2005–2015, there were 11 851 deaths. Table 1 shows how the occupations were categorized according to occupational injuries, perceived job insecurity, and non-standard work arrangements.

Occupational injury rates

The highest number of all deaths of despair occurred in occupations with injury rates of at least 100 per 10 000 full-time workers, while the lowest number of deaths occurred in the group with the lowest injury and illness rate. A similar pattern was observed for opioid-related deaths. The highest number of deaths due to suicides and alcoholic liver disease and cirrhosis occurred among in occupations with injury rates between 40 and 199 injuries and illnesses per 10 000 full-time workers (Table 2 and Supplementary Table S1, available at *Annals of Work Exposures and Health* online).

There was a generally positive association between occupational injury and illness rate and an occupation's rate of deaths of despair (Fig. 1). The mortality rate in the highest injury rate category was nearly four times higher than that in occupations with the lowest injury rates. A similar pattern was generally observed for the specific causes of death. The most extreme difference was observed for opioid-related deaths, where the mortality rate in the highest injury and illness rate category was over six times higher than that in the lowest injury rate category.

Models controlling for age, gender, and race/ethnicity (Model 2), generally resulted in RRs slightly elevated compared to the Model 1, which did not control for these factors. However, in Model 3, which controlled for education, estimates were closer to the null than in Model 1. Additionally, Model 3 tended to bring the RRs for the two higher categories closer to each other. However, in all models the RRs for the two highest

Table 1. Occupation categorized according to rate of occupational injuries and illnesses, prevalence of job insecurity, change in the prevalence of non-standard work arrangements between 2005 and 2015.

Occupation category	Occupational injuries and illnesses per 10 000 full-time workers category[a]	Perceived job insecurity[b]	Non-standard work category[c]
Architecture and Engineering	Less than 40	Medium	Below average
Arts, Design, Entertainment, Sports, and Media	Less than 40	High	Below average
Building and Grounds Cleaning and Maintenance	200 or more	High	Below average
Business Operations Specialists	Less than 40	Medium	Below average
Community and Social Service	100–199	Medium	Above average
Computer and mathematical	Less than 40	High	Above average
Education, Training, and Library	40–99	Low	Above average
Extraction workers	200 or more	High	Below average
Farming, Fishing, and Forestry	100–199	High	Above average
Financial specialists	Less than 40	Medium	Below average
Food Preparation and Serving Related	100–199	High	Above average
Healthcare Practitioners and Technical	100–199	Low	Below average
Healthcare Support	200 or more	Low	Above average
Installation, Maintenance, and Repair	200 or more	Medium	Below average
Legal	Less than 40	Low	Above average
Life, Physical, and Social Science	Less than 40	High	Below average
Management	40–99	Medium	Below average
Office and Administrative Support	40–99	High	Below average
Personal Care and Service	100–199	Medium	Above average
Production	100–199	High	Below average
Protective Service	100–199	Low	Above average
Sales and Related	40–99	Low	Above average
Transportation and Material Moving	200 or more	High	Above average

[a]Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses, MA, 2011–2015.
[b]National Health Interview Survey, 2015.
[c]Bureau of Labor Statistics, Contingent Worker Survey, 2005/RAND-Princeton, Contingent Worker Survey, 2015

injury and illness rate categories remained significantly higher than the lowest category (Table 3).

Perceived job insecurity

There were more deaths of despair, overall, among those in the high perceived job insecurity category. This was also true for each individual category of deaths of despair, with the most drastic disparity for opioid-related deaths (Table 2 and Supplementary Table S1, available at *Annals of Work Exposures and Health* online).

Occupations with higher than average perceived job insecurity had higher mortality rates than occupations with lower insecurity (Fig. 2). Most of this difference was explained by the higher rate of opioid-related deaths with high insecurity. Workers in the high perceived job insecurity occupations also had higher mortality rates due to suicides and alcoholic liver disease and cirrhosis, but these differences were smaller than the difference for opioid-related deaths.

With respect to perceived job insecurity, Models 2 and 3 resulted in attenuated RRs. Model 3 for all deaths, opioid-related overdose deaths, and alcoholic liver disease and cirrhosis deaths gave only a slightly elevated RR for perceived job insecurity higher than average. Model 3 for suicides did not show significantly elevated RRs. Most attenuation for the high category occurred after controlling for education (Table 4).

Non-standard work arrangements

There were fewer deaths but a higher average annual mortality rate in occupations with a greater increase in

Table 2. Number and rate of deaths of despair according to occupational characteristics, MA.

Exposure category	Number of workers	Number of deaths of despair (% of deaths of despair)	Average annual deaths of despair per 100 000 workers (95% CI)
Occupational injuries and illnesses per 10 000 full-time workers category (2011–2015)[a]			
Less than 40	2 782 043	632 (10.2)	22.7 (20.9, 24.5)
40–99	6 506 922	1800 (29.0)	27.7 (26.4, 28.9)
100–199	3 941 256	1951 (31.4)	49.5 (47.3, 51.7)
200 or more	2 098 473	1831 (29.5)	87.3 (83.3, 91.3)
200 or more (with construction workers)	2 798 089	3570 (—)	127.6 (123.4, 131.8)
Job insecurity category (2011–2015)[b]			
Low	4 780 105	1520 (24.5)	31.8 (30.2, 33.4)
Medium	4 396 425	1515 (24.4)	34.5 (32.7, 36.2)
High	6 152 164	3179 (51.2)	51.7 (49.9, 53.5)
High (with construction workers)	6 851 780	4918 (—)	71.8 (69.8, 73.8)
Non-standard work category (2005–2015)[c]			
Increasing less than average	18 340 069	6186 (52.2)	33.7 (32.9, 34.6)
Increasing more than average	14 794 913	5665 (47.8)	38.3 (37.3, 39.3)
Increasing less than average (with construction workers)	19 955 154	9457 (—)	47.4 (46.4, 48.3)

CI, confidence interval.

[a]Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses, MA, 2011–2015.

[b]National Health Interview Survey, 2015.

[c]Bureau of Labor Statistics, Contingent Worker Survey, 2005/RAND-Princeton, Contingent Worker Survey, 2015.

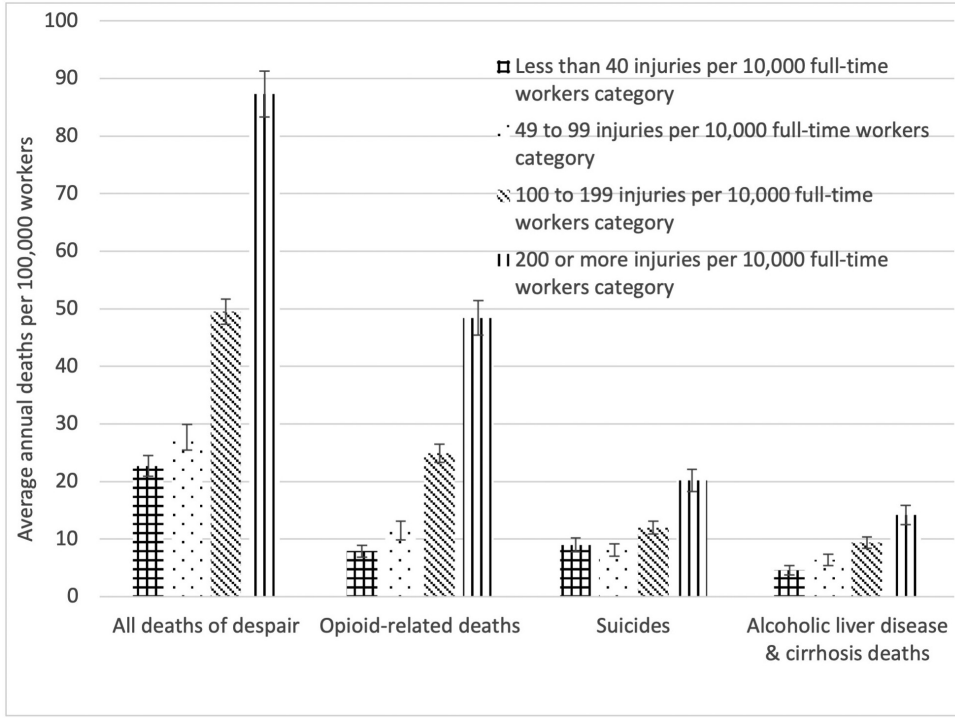

Figure 1. Average annual mortality rates for deaths of despair by category of occupational injury and illness rate (Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses), MA, 2011–2015, $n = 6214$ deaths. Note: Construction workers were not included in this analysis.

Table 3. Rate ratios for mortality rates for all deaths of despair and individual categories of deaths of despair by occupational injury and illness category, MA, 2011–2015, *n* = 6214 deaths.

Occupational injuries and illnesses per 10 000 full-time workers category (2011–2015)[a]	Model 1 rate ratio (95% CI)	Model 2 rate ratio (95% CI)	Model 3 rate ratio (95% CI)
All deaths of despair			
Less than 40	1 (ref)	1 (ref)	1 (ref)
40–99	1.22 (1.11, 1.33)	1.36 (1.24, 1.48)	1.00 (0.92, 1.10)
100–199	2.18 (1.99, 2.38)	2.75 (2.51, 3.01)	1.61 (1.46, 1.76)
200 or more	3.84 (3.51, 4.20)	3.89 (3.55, 4.26)	1.67 (1.51, 1.84)
Opioid-related deaths			
Less than 40	1 (ref)	1 (ref)	1 (ref)
40–99	1.45 (1.25, 1.69)	1.67 (1.44, 1.94)	1.14 (0.98, 1.33)
100–199	3.13 (2.71, 3.63)	3.95 (3.41, 4.57)	2.02 (1.74, 2.36)
200 or more	6.09 (5.27, 7.05)	6.51 (5.63, 7.54)	2.37 (2.02, 2.76)
Suicides			
Less than 40	1 (ref)	1 (ref)	1 (ref)
40–99	0.90 (0.78, 1.05)	1.02 (0.88, 1.19)	0.85 (0.73, 1.00)
100–199	1.34 (1.15, 1.56)	1.74 (1.49, 2.03)	1.23 (1.04, 1.44)
200 or more	2.26 (1.93, 2.64)	2.29 (1.96, 2.68)	1.29 (1.09, 1.54)
Alcoholic liver disease and cirrhosis deaths			
Less than 40	1 (ref)	1 (ref)	1 (ref)
40–99	1.39 (1.14, 1.70)	1.40 (1.14, 1.71)	1.04 (0.85, 1.27)
100–199	2.06 (1.68, 2.52)	2.51 (2.05, 3.07)	1.49 (1.21, 1.84)
200 or more	3.10 (2.52, 3.82)	2.82 (2.29, 3.48)	1.21 (0.97, 1.51)

Model 1: occupational injury and illness category only. Model 2: occupational injury and illness category, age group, gender, and race/ethnicity. Model 3: occupational injury and illness category, age group, gender, race/ethnicity, and educational attainment. Note: Construction workers were not included in this analysis. CI, confidence interval.

[a]Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses, MA, 2011 to 2015.

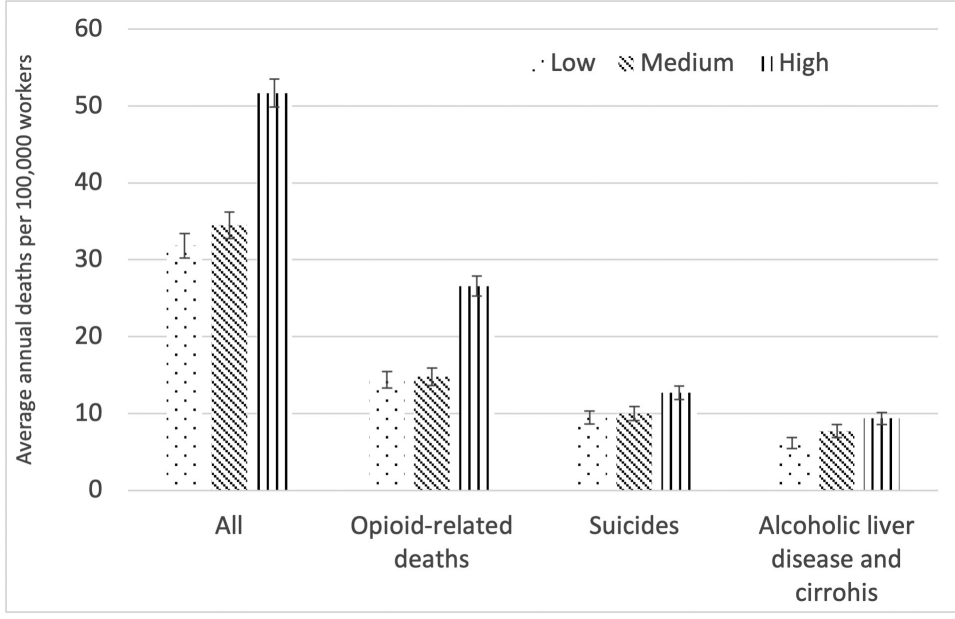

Figure 2. Average annual mortality rates for deaths of despair by perceived job insecurity category (National Health Interview Survey, 2015), MA, 2011–2015, *n* = 6214 deaths. Note: Construction workers were not included in this analysis.

Table 4. Rate ratios for mortality rates for all deaths of despair and individual categories of deaths of despair by perceived job insecurity category, MA, 2011–2015, *n* = 6214 deaths.

Perceived job insecurity[a]	Model 1 rate ratio (95% CI)	Model 2 rate ratio (95% CI)	Model 3 rate ratio (95% CI)
All deaths of despair			
Low	1 (ref)	1 (ref)	1 (ref)
Medium	1.12 (1.07, 1.17)	0.91 (0.87, 0.95)	0.87 (0.83, 0.91)
High	1.64 (1.58, 1.70)	1.58 (1.52, 1.65)	1.05 (1.00, 1.09)
Opioid-related deaths			
Low	1 (ref)	1 (ref)	1 (ref)
Medium	1.02 (0.94, 1.09)	0.85 (0.79, 0.92)	0.81 (0.75, 0.88)
High	1.83 (1.72, 1.95)	1.75 (1.65, 1.86)	1.09 (1.02, 1.16)
Suicides			
Low	1 (ref)	1 (ref)	1 (ref)
Medium	1.11 (1.02, 1.20)	0.88 (0.81, 0.95)	0.85 (0.79, 0.92)
High	1.35 (1.26, 1.45)	1.29 (1.20, 1.39)	0.96 (0.89, 1.03)
Alcoholic liver disease and cirrhosis deaths			
Low	1 (ref)	1 (ref)	1 (ref)
Medium	1.30 (1.18, 1.42)	1.04 (0.94, 1.14)	0.99 (0.90, 1.08)
High	1.71 (1.58, 1.86)	1.71 (1.57, 1.85)	1.10 (1.01, 1.20)

Model 1: perceived job insecurity category only. Model 2: perceived job insecurity category, age group, gender, and race/ethnicity. Model 3: perceived job insecurity category, age group, gender, race/ethnicity, and educational attainment. Note: Construction workers were not included in this analysis. CI, confidence interval.
[a]National Health Interview Survey, 2015.

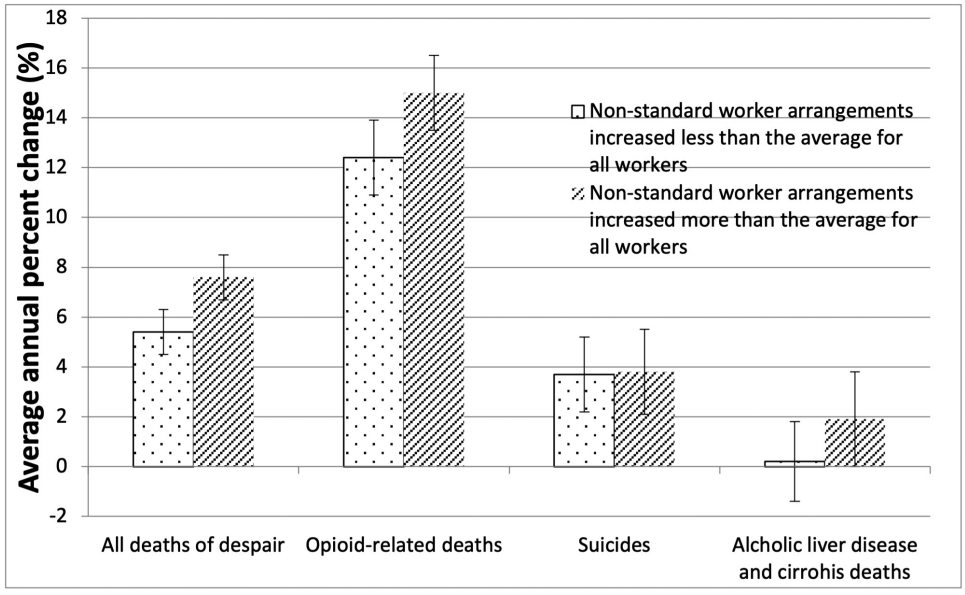

Figure 3. AAPC for deaths of despair by non-standard work arrangements category (Bureau of Labor Statistics, Contingent Worker Survey, 2005/RAND-Princeton, Contingent Worker Survey, 2015), MA, 2005–2015, *n* = 11 851 deaths. Note: Construction workers were not included in this analysis. AAPCs control for age, gender, race/ethnicity, and education.

non-standard work arrangements (Table 2). When examining the specific subtypes of deaths of despair, mortality rates for opioid-related overdose deaths were elevated in occupations with greater increases in non-standard work arrangements, while suicides and alcoholic liver disease and cirrhosis deaths were slightly elevated in jobs with

Table 5. Average annual percent trends for all deaths of despair and categories of deaths of despair by non-standard work arrangements category, MA, 2005–2015, *n* = 15 122 deaths.

Non-standard work arrangements[a]	Model 1 trend (95% CI)	Model 2 trend (95% CI)	Model 3 trend (95% CI)
All deaths of despair			
Increasing less than average	4.0 (3.2, 4.8)	4.3 (3.5, 5.2)	5.4 (4.6, 6.3)
Increasing more than average	5.9 (5.0, 6.8)	6.5 (5.7, 7.4)	7.6 (6.7, 8.5)
Increasing less than average (with construction workers included)	5.0 (4.3, 5.6)	5.4 (4.8, 5.9)	6.6 (5.9, 7.3)
Opioid-related deaths			
Increasing less than average	9.8 (8.3, 11.3)	10.6 (9.1, 12.1)	12.4 (10.9, 13.9)
Increasing more than average	12.5 (11.1, 14.0)	13.5 (12.1, 14.9)	15.0 (13.6, 16.5)
Increasing less than average (with construction workers included)	10.6 (9.5, 11.7)	11.7 (10.6, 12.8)	13.5 (12.4, 14.6)
Suicides			
Increasing less than average	2.3 (0.9, 3.8)	2.9 (1.4, 4.4)	3.7 (2.3, 5.2)
Increasing more than average	2.4 (0.8, 4.1)	3.2 (1.5, 4.9)	3.8 (2.1, 5.5)
Increasing less than average (with construction workers included)	2.0 (0.8, 3.2)	2.6 (1.4, 3.9)	3.5 (2.3, 4.8)
Alcoholic liver disease and cirrhosis deaths			
Increasing less than average	0.2 (–1.4, 1.8)	–0.4 (–2.0, 1.2)	0.2 (–1.4, 1.8)
Increasing more than average	1.3 (–0.5, 3.2)	1.3 (–0.6, 3.2)	1.9 (0.0, 3.8)
Increasing less than average (with construction workers included)	1.6 (0.2, 3.0)	0.7 (–0.7, 2.1)	1.3 (–0.2, 2.7)

Model 1: non-standard work arrangements category only. Model 2: non-standard work arrangements, age group, gender, and race/ethnicity. Model 3: non-standard work arrangements, age group, gender, race/ethnicity, and educational attainment. CI, confidence interval.
[a]Bureau of Labor Statistics, Contingent Worker Survey, 2005/RAND-Princeton, Contingent Worker Survey, 2015.

a lower increase in non-standard work (Supplementary Table S1, available at *Annals of Work Exposures and Health* online).

The AAPC in the deaths of despair was substantially higher among workers in occupations with higher than average increases in the prevalence of non-standard work arrangements. A similar relationship was observed for opioid-related and alcoholic liver cirrhosis deaths, but not for suicides, for which AAPCs were generally similar for both groups (Fig. 3) Findings were not substantially different among the different models (Table 5).

Sensitivity analyses

When construction workers were included in the analyses, the findings remained generally similar. The highest occupational injury and illness rate category, which contains construction, had mortality rates substantially higher for opioid-related deaths. Rates were also higher, but not substantially so, for suicides and alcoholic liver disease and cirrhosis deaths (Table 2 and Supplementary Table S1, available at *Annals of Work Exposures and Health* online). A similar pattern was observed for perceived job insecurity, with the high insecurity category having much more elevated rates of opioid-related death than those without construction workers, but not as elevated for suicides and alcoholic liver disease and cirrhosis (Table 2 and Supplementary Table S1, available at *Annals of Work Exposures and Health* online).

Construction workers belong in the group of occupations for which non-standard work arrangements decreased less than the average for all workers. Including construction workers in the model resulted in less difference in the rate of change of the deaths of despair between the two non-standard work arrangement categories (Table 5).

In order to examine the cross-sectional relationship between alternative work arrangements and deaths of despair, we used data from the 2015 National Health Interview Survey, which asked questions about employment in alternative work arrangements. We found that workers in occupations with a higher percentage of workers employed as independent contractors or freelancers and employed at temporary agencies or as subcontractors had elevated mortality rates due to the deaths of despair (Supplementary Table S2, available at *Annals of Work Exposures and Health* online).

Discussion

This study identified a number of occupational factors associated with deaths of despair in MA through the combination of death certificate data with three other databases. In particular, rates of deaths of despair were elevated among workers in occupations with higher occupational injury and illness rates and more job insecurity. Additionally, deaths of despair increased at a faster rate among occupations with a larger increase in non-standard arrangements.

The findings in this study are consistent with a number of other studies that have suggested an association between occupational injury risk and opioid use and opioid-related deaths (Cifuentes *et al.*, 2010; Dembe *et al.*, 2012; Franklin *et al.*, 2012; Chen *et al.*, 2013; Kowalski-McGraw *et al.*, 2017; Hawkins *et al.*, 2019) and suicides (Applebaum *et al.*, 2019; Martin *et al.*, 2020). To the best of our knowledge, no previous studies demonstrated an association between occupational injuries and fatal alcoholic liver disease and cirrhosis.

The findings with respect to job insecurity build on previous evidence that job insecurity is associated with mental health issues (Ferrie *et al.*, 2002; Rugulies *et al.*, 2006; Stansfeld and Candy, 2006), including suicide ideation (Dalglish *et al.*, 2015; Milner *et al.*, 2016, 2018), and drug and alcohol use before and during work (Frone, 2006). The present study also showed that workers with higher levels of job insecurity had slightly elevated mortality rates for suicide and alcoholic liver disease and cirrhosis deaths.

Although previous research has found workers in temporary work arrangements to have a higher mortality rate due to alcohol-related causes (Kivimäki *et al.*, 2003), only a weak relationship was found between non-standard work arrangements and alcohol-related deaths in this study. Additionally, there were no major differences in suicide by change in an occupation's prevalence of non-standard work arrangements. The fact that previous work used individual-level data, while this study used aggregate level data, may explain the discrepant findings.

The present results suggest that demographic differences between occupations may explain some of the associations observed here. After controlling for age, sex, race/ethnicity, and education, many of the rate ratios were substantially attenuated. In particular, education appeared to have the biggest impact on the findings. There are a few possible interpretations of these findings. Education is expected to correlate with occupation, which may explain some of the attenuation. Also, education may be related to within-occupation variability in the risk for deaths of despair because workers within the same occupation but with lower education may hold lower status jobs with more physical and psychosocial exposures. Additionally, lower education may contribute to lower employability, which may further contribute to the deaths of despair.

This study has some limitations. Most importantly, the measures of exposure utilized for this study were assessed at the group level. Within these major occupational groups, there is likely variation in exposure and individual-level misclassification may have resulted. We cannot be certain whether any of the workers who died from the deaths of despair actually experienced any of the exposures. The most we can say is that occupations with the characteristics under study also had elevated mortality rates or trends due to certain deaths of despair. Additionally, because of the wide variety of data sources that were combined for this analysis and the fact that these data were collected at the national level, certain occupations and workers could have been misclassified with respect to the exposures analysed here. This misclassification could be caused by differences between the exposures at the national level compared to MA, differences in the characteristics of workers who die from deaths of despair compared to workers overall, and/or temporal differences in when the data were collected.

Further misclassification may be caused by the fact that death certificates only have information about usual occupation. Therefore, workers might not have held the same occupations at the time of death. Similarly, some of the potential mechanisms linking work features to deaths of despair include job loss on the posited causal pathway. If a decedent was no longer in the labour force at the time of death and this was reflected on the death certificate, then they would be excluded from this study even if they had been exposed to any of the examined factors while they were working. Some of this misclassification could be differential if certain occupations were more likely to have workers who have left the workforce or be unemployed—for example due to disability or early retirement.

An additional limitation is the possible overlap between perceived job insecurity and non-standard work arrangements, in that they both have to do with the consistency of employment. Although the two are not synonymous with each other (Bodin *et al.*, 2020), as noted above, workers with non-standard work arrangements are more likely to have insecure employment. In the case of the variables analysed here, perceived job insecurity is about whether the worker is actually worried about losing their job, while the determination of non-standard work was about the nature of their employment. The

impact of this conceptual overlap on the findings of this study are not clear. Of eleven occupations where the prevalence of non-standard work arrangements increased more than the average, only four were in the higher perceived job insecurity category.

In a similar way, to a certain extent all three of the factors examined here coincide with each other. For example, of the five occupations in the highest category of occupational injury and illness rates, three of them were in the high category for perceived job insecurity. On the other hand, of the seven occupations with the lowest occupational injuries and illnesses, three of them were categorized as high perceived job insecurity and only one as low job insecurity. Some correlation may also exist between the injury and illness categories and changes in non-standard work arrangements. Of the eleven occupations where the prevalence of non-standard work arrangements increased more than the average, seven were in one of the two highest occupational injury and illness rate categories. An analysis that utilized more detailed occupation categories could provide more information about the relationships between these factors.

Alternative hypotheses for these associations cannot be ruled out. For example, in the case of the association between occupational injury risk and opioids, it may be the case that occupations where workers are more likely to use opioids for non-work reasons may also be occupations where workers are more likely to be injured (Kowalski-McGraw *et al*., 2017). Data used to classify occupations according to their level of perceived job insecurity and changes in non-standard work arrangements came from national surveys. It may be that occupations in MA are systematically different in these factors. Classification of job insecurity was based on data from 2015 but applied to the preceding 5-year period, which might have introduced misclassification.

Confounding also potentially explains some of these results. Although multivariable analyses suggests that demographic confounders do not account for all of the associations observed, controlling for these factors did result in attenuated RRs, especially with respect to job insecurity. Because we do not have data about other potential individual-level confounders, we cannot rule them out as potentially explaining some of these findings.

Conclusions

The findings from this exploratory analysis suggest a hypothesis about what 'despair' might look like in an occupational context. In particular, workers in occupations with high injury and illness rates, high levels of job insecurity, and increases in workers with non-standard work arrangements may be at an elevated risk for the deaths of despair. The potential interactions between these factors deserve further attention. Further research should examine the risk factors for deaths of despair at the individual level.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Conflict of interest

None declared.

Data availability

The data used in this study can be requested from the Massachusetts Registry of Vital Records and Statistics.

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