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Opioid-related mortality after occupational injury in Washington State: accounting for preinjury opioid use

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Abstract

Objectives—To estimate the impact of occupational injury and illness on opioid-related mortality while accounting for confounding by preinjury opioid use.

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Contributors LIB is the guarantor of the study. LIB, PKO'L, KMA, YT and MPF conceived and designed the study. AA, PKO'L, YT and AB performed data analysis and interpretation. LIB drafted the manuscript. All authors participated in revising the work critically for important intellectual content, provided final approval of the version to be published and agreed 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.

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Disclaimer Guidelines: This study has followed the STROBE guidelines.

Competing interests None declared.

Ethics approval This study involves human participants and the Boston University Medical Center Institutional Review Board (IRB) (number H-32401) and the Washington State IRB (number D-110618-L) approved this study. Both IRBs waived informed consent based on the criteria under 45 CFR 46.116. They determined that (1) The research involves no more than minimal risk to subjects; (2) The research could not be carried out practicably without the waiver or alteration and (3) The waiver will not adversely affect the rights and welfare of the subjects.

Methods—We employed a retrospective cohort study design using Washington State workers' compensation data for 1994–2000 injuries linked to US Social Security Administration earnings and mortality data and National Death Index (NDI) cause of death data from 1994 to 2018. We categorised injuries as lost-time versus medical-only, where the former involved more than 3 days off work or permanent disability. We determined death status and cause of death from NDI records. We modelled separate Fine and Gray subdistribution hazard ratios (sHRs) and 95% CIs for injured men and women for opioid-related and all drug-related mortality through 2018. We used quantitative bias analysis to account for unmeasured confounding by preinjury opioid use.

Results—The hazard of opioid-related mortality was elevated for workers with lost-time relative to medical-only injuries: sHR for men: 1.53, 95% CI 1.41 to 1.66; for women: 1.31, 95% CI 1.16 to 1.48. Accounting for preinjury opioid use, effect sizes were reduced but remained elevated: sHR for men was 1.43, 95% simulation interval (SI) 1.20 to 1.69; for women: 1.27, 95% SI 1.10 to 1.45.

Conclusions—Occupational injuries and illnesses severe enough to require more than 3 days off work are associated with an increase in the hazard of opioid-related mortality. The estimated increase is reduced when we account for preinjury opioid use, but it remains substantial. Reducing work-related injuries and postinjury opioid prescribing and improving employment and income security may decrease opioid-related mortality.

INTRODUCTION

In 2000, there were approximately 8400 opioid-related deaths in the USA. By 2022, that number had risen to almost 82 000. During that period, opioid-related deaths also increased as a percentage of all drug-related deaths—from 48% to 76%.[1 2] Although the growing threat of opioid use in the USA has been widely recognised, little attention has been paid to the role of work-related injury, where the evidence of a relationship between injury, subsequent opioid use and overdose mortality has been growing.[3]

The pathway from injury at work to opioid-related mortality may begin with postinjury opioid use to manage pain and to help people return to work more quickly.[4 5] This pathway may be amplified if they work in insecure jobs.[3 6] Physicians may prescribe opioid pain medication and extend opioid prescriptions beyond what is optimal.[7] This may lead to using prescription opioids in different ways than intended, using medical opioids without a prescription or using illegal opioids, such as heroin or synthetic opioids like illegally made fentanyl.[8] For this study, we refer to these as opioid use. Note that, as we use it, the phrase 'opioid use' does not include taking opioids as prescribed. Opioid use strongly increases the risk of overdose.[9] Shaw *et al*[3] make a compelling case for the relationship between work-related injury and opioid-related mortality.

There is substantial evidence that opioids have been regularly dispensed to injured workers, often in high doses and for prolonged periods,[4 7] although the evidence for their effectiveness in controlling pain[10-12] and reducing disability[5] appears limited. Compared with injuries incurred outside work, a study indicated that work-related injuries resulted in 33% higher odds of opioid prescribing and 32.8 more days of opioids prescribed.[7] In the Washington State workers' compensation system, studies of low-back occupational injuries

in the early 2000s showed that 35%–42% of injured workers received opioid prescriptions for their injuries.[4 13] Multistate insurer studies showed similar rates.[14 15]

Prescription opioids may be an appropriate course of treatment for some injured workers. However, the consequences of improper use can be significant. Recent studies of injured workers have indicated that workplace injuries are associated with substantially elevated opioid-related poisonings,[16] drug-related mortality in general[17] and opioid-related mortality in specific.[6 18 19]

Postinjury opioids are not the only source of injury-related opioid mortality. Preinjury opioid use increases both the risk of opioid-related mortality and the risk of disabling injuries. It is thus a potential confounder of the injury–mortality relationship. The pathways from preinjury opioid use to mortality and disabling injury are not mutually exclusive and research supports the existence of both.[20-22]

Studies of opioid-related mortality among injured workers have found excess risk of drug and opioid-related mortality.[17-19] However, they have not accounted for confounding by preinjury opioid use. This study, based on Washington State data, addresses this limitation by using quantitative bias analysis (QBA). It accounts for the bias from missing information on preinjury opioid use by simulating what the data would look like had we measured this missing information and adjusted for it. These simulations are informed by external data on the distribution of the confounders in those with and without lost-time injuries and the strength of their effect on mortality.

METHODS

Data

The Washington State Department of Labor and Industries provided workers' compensation data, including age, gender, employer industry, benefit payments and social security number (SSN). Our study population consisted of all people aged 15–80 who received workers' compensation benefits for injuries and illnesses occurring from 1994 through 2000. Occupational diseases comprised less than 1% of the study population. For conciseness, we will refer to the study population as injured workers. Figure 1 shows the steps used to assemble the research dataset.

We refer to injured workers who received cash benefits because they lost more than 3 days from work or had a permanent injury-related disability as the 'lost-time' group. Medical-only injuries received benefits for medical expenses but not to replace lost earnings and involved at most 3 days lost from work because of the injury. With 0–3 days lost from work, we considered these workers to be similar to uninjured workers of the same age, gender, income and industry, so we chose them as our comparison group. For workers with more than one injury, we chose the first lost-time injury. For those with medical-only but no lost-time injuries, we used the first injury. We excluded people whose injuries were fatal.

We observed missing or out-of-range values for at least one workers' compensation variable used in the statistical analysis in 3.9% of injuries. We dropped these from the research

dataset. Industry was the predominant missing or out-of-range variable used in the analysis, missing for 3.3% of injured workers. We also dropped cases for which the date of death in the data preceded the injury date (see figure 1).

We linked the workers' compensation data to Social Security earnings and mortality data based on name, date of birth, gender and SSN, successfully linking more than 95% of cases. In addition, we classified individuals as alive, dead or of unknown vital status using the Social Security Administration's (SSA's) Numerical Iidentification System and Vital Status System. For those who died, this system also provided the date of death. This dataset consisted of 733 599 observations.

We then linked a random sample of SSA observations stratified by gender and whether the injury was lost-time or medical-only with the National Death Index (NDI), following them from the date of injury through December 2018. We linked by exact match on last name, first name, date of birth, SSN and gender. There was 97.5% agreement about vital status between SSA and NDI. This allowed us to identify underlying and contributing causes of death for a sample of those who had died. These are the same methods of identifying injured workers and assessing mortality follow-up described in earlier studies.[17 23 24]

Mortality outcomes

We used the NDI data to validate the SSA vital status and to obtain causes of death. Because the NDI charges US$5 per record to provide death data, we did not have sufficient funds to match all deaths in our workers' compensation-SSA data. For this reason, we submitted a random sample of 17 000 deaths in the workers' compensation-SSA data, stratified by gender and by lost-time versus medical-only, to the NDI. There was agreement between the two sources for 97.5% of these observations. To determine concordance between SSA and NDI for people not classified as dead by the SSA, we also submitted 600 people with SSA unknown vital status (4 considered dead by NDI) and 1000 people classified as alive by the SSA (none considered dead by NDI). Because of the high concordance between the two sources, we treated as alive all observations classified as unknown or alive by the SSA and we classified as dead the 16 571 (of 17 000) observations considered by both SSA and NDI to have died. The final research dataset combining the SSA alive and unknown vital status data with the SSA-NDI linked sample has 669 689 individuals which, when weighted by the inverse of their sampling probabilities, represented 733 599 injured workers.

We defined opioid-related deaths using International Classification of Diseases-9 (ICD-9) and ICD-10 codes listed in online supplemental table A.1. To see if our results were sensitive to the choice of ICD codes, we used three definitions. Our preferred definition includes unclassified drug overdoses. We include these causes of death because most drug-related deaths involve opioids and research indicates that unclassified drug overdoses are largely opioid-related.[25] The Centers for Disease Control and Prevention ICD-10 codes for opioid overdose mortality do not include codes for opioid-related disorders (F11) or unspecified drug poisoning (T50.9) and include assault by drugs (X85) but are otherwise consistent with our preferred definition.[1] We based the ICD-9 codes on those provided by Warner *et al*.[26] To determine the sensitivity of our results to our choice of definition, we

also estimated the mortality impact of workplace injuries using a definition that excludes unclassified drug overdoses and a third outcome: all drug-related mortality.

Bias parameters for QBA

Our unmeasured confounder is preinjury opioid use, defined as using prescription opioids in different ways than intended, using medical opioids without a prescription or using illegal opioids, such as heroin or synthetic opioids like illegally made fentanyl. To simulate the unmeasured confounder, we specify distributions for the prevalence of the confounder within each exposure group (prevalence of preinjury opioid use for both lost-time and medical-only injuries) and the strength of the effect of the confounder on the outcome (risk ratios relating opioid use to opioid mortality). For the latter, we relied on a 2022 study by Lewer *et al*[27] that estimated drug-related mortality (including drug-induced suicide) among people in England diagnosed with opioid-related conditions during 2001–2018.[27] We chose this study because it was one of the few that provided separate mortality estimates for men and women, because the time frame is similar to that of this study and because the definition of opioid-related mortality was similar to that used in this study. The estimated standardised mortality ratios were 56 for women and 51 for men. No studies have estimated the impact on opioid-related mortality by gender. We used the formula in Jones and Swerdlow[28] to convert standardised mortality ratios into relative risks by adjusting for the population prevalence of the risk factor. To do this, we used estimates of the prevalence of opioid use in England from the UK Government.[29] UK government estimates suggest that the prevalence of opioid use in England varied little between 2001/2002 and 2016/2017, despite a substantial increase in the opioid mortality rate.[30 31] We note that the prevalence estimates for England were similar to those found by McHugh *et al*[32] for the USA. For the relative risk of opioid-related mortality for people using opioids, we specified trapezoidal distributions. For women, the distribution was ~trap (minimum=50, lower mode=55, upper mode=65, maximum=100). For men, the distribution was ~trap (minimum=95, lower mode=120, upper mode=145, maximum=190). The mean values of these distributions were 69.2 for women and 138.5 for men, corresponding to the mean values derived from Lewer *et al.*[27]

We used the Merative MarketScan Research Commercial Claims and Encounters and Health and Productivity Management databases from 2004 to 2014 to specify distributions for the prevalence of preinjury opioid use among workers with lost-time and medical-only injuries. The Merative MarketScan databases use longitudinal data from over 250 medium and large employers and health plans throughout the USA. The data include medical diagnosis codes (ICD-9-CM) and information on workers' compensation injury date and medical and wage-replacement payments. We used the MarketScan data to measure opioid use in the 12 months before injury, using ICD codes related to opioid use disorder, dependence and poisoning.

We drew separate MarketScan samples for men and women, matching medical-only to lost-time cases using 3–1 nearest-neighbour matching without replacement, estimating propensity scores based on age, industry and year of injury. From this, we derived gender-specific estimates of the percent of lost-time and medical-only injuries with opioid use in the year before injury. We used beta distributions derived from these estimates in our QBA,

giving us distributions with a mean equal to the observed prevalence in the propensity score matched dataset. For men, we specified a distribution for the prevalence of the confounder among those with lost-time injuries as ~beta (99, 40 972) and for medical-only injuries ~beta (175, 123 038); for women, the distribution for lost-time injuries, was ~beta (21, 17 317) and for medical-only injuries ~beta (30, 51 984).

Statistical analysis

For each subject, we determined the time in follow-up, with the start of follow-up beginning at the date of injury and continuing until the date of death or 31 December 2018, whichever came first. We estimated subdistribution hazard ratios (sHRs) and 95% CIs for the association between lost-time injuries and opioid-related mortality using Fine and Gray competing risks regression.[33] Separate estimates for men and women controlled for earnings category and industry at baseline. We estimated sHRs for all three mortality outcome measures described above. We stratified estimates by age category to account for non-proportional hazards.

We then conducted a probabilistic QBA, bias-adjusting the observed data to account for unmeasured preinjury opioid use. To reduce the time involved in running 10 000 QBA iterations, we randomly sampled 25 000 observations in each of the four groups (men and women, lost-time and medical-only) with alive or unknown status. Thus, our QBA dataset consisted of 100 000 living and 16 571 who died, which, when weighted by the inverse of their sampling probabilities, represented 653 762 living and 79 837 dead injured workers.

We used the distributions of the prevalence of preinjury opioid use and of the risk ratio of opioid-overdose mortality from preinjury opioid use described in the methods section. We simulated the unmeasured confounder in our dataset by sampling from these distributions. Based on 10 000 regressions including the simulated confounder, we used the median estimated sHR as a point estimate and the 2.5th and 97.5th percentiles as a 95% simulation interval (SI). For a more detailed description, see Fox *et al.*[34] To examine the sensitivity of our results to the distribution of preinjury opioid rates used in the QBA, we doubled these percentages in an additional simulation.

RESULTS

Table 1 presents summary statistics for our overall sample of 733 599 observations in the data. In this table and the statistical analysis, we weighted observations by their inverse sampling probabilities. We generated counts and frequencies of the distribution at baseline of age at injury, preinjury annual earnings and industry for subjects with a lost-time injury and those with medical-only injuries. Opioid-related and all drug-related deaths were more common among men than women and among workers with lost-time compared with medical-only injuries.

Table 2 shows the competing risk estimates of the effect of a lost-time injury on opioid-related mortality. Using our preferred measure of opioid-related deaths (including those involving unspecified drugs), we estimated an sHR for men of 1.53, 95% CI 1.41 to 1.66, controlling for age, industry and earnings in the year before the injury. Estimated sHRs were

similar when unspecified drugs were excluded from the definition of opioid-related drugs, with an estimated sHR for men of 1.47, 95% CI 1.34 to 1.61. Estimated sHRs were also similar when the dependent variable was any drug-related death. For women, the estimated sHR for our preferred measure was 1.31, 95% CI 1.16 to 1.48. Estimates for the other definitions were similar. sHRs and confidence limits for all covariates using our preferred outcome measure are presented in online supplemental table A.2.

In our QBA accounting for bias resulting from preinjury opioid use, we focused on our preferred measure of opioid-related mortality (including deaths associated with unknown drugs). We used estimates of preinjury opioid use from the MarketScan data. See online supplemental table A.3. We derived from Lewer *et al*[27] mortality relative risk estimates for people who used opioids and people who did not.

Table 3 presents the results. Accounting for bias related to preinjury opioid use reduced estimated sHRs to 1.43 for men and 1.27 for women. The lower bound of the 95% SIs remained above 1.0 for both. Doubling the simulation values of preinjury opioid use reduced the estimated sHRs still further, but the lower bound of the 95% SI remained above 1.0.

DISCUSSION

Before accounting for unobserved confounding, we found substantial excess opioid-related mortality among workers with lost-time injuries compared with medical-only injuries using our preferred case definition. The estimated effect was similar when we excluded mortality from unknown drugs and when we estimated the impact on all drug-related deaths.

Adjusting for confounding by preinjury opioid use reduced estimates of the impact of lost-time injuries on fatal opioid overdose and increased their dispersion. Still, the estimated sHRs were substantial and 95% SIs remained above 1.0. Doubling preinjury opioid use prevalence in the QBA reduced the effect estimates, but the SIs still remained above 1.0.

Strengths of the study: first, the sample size is large, with median follow-up of 20 years, which facilitates our ability to detect elevated opioid mortality. Second, we combined information from several sources, which allowed us to identify cause of death and consider important confounders. Third, this is the only study to date to explicitly account for confounding by preinjury opioid use.

This study has some limitations. The literature lacks gender-specific estimates of the impact of opioid use on opioid mortality. This led us to use estimates of the impact on drug-related mortality in our QBA.[27] A recent meta-analysis provides similar estimates for the impact of opioid use on opioid-related and drug-related mortality.[35] However, if the risk ratio for opioid-related mortality among people with opioid use is higher than the risk ratio for all drug-related mortality, our QBA adjustments may be insufficient.

The MarketScan data are based on medical insurance reporting and thus only include opioid use captured by this source. If the disparity in prevalence of preinjury opioid use between medical-only and lost-time injured workers were greater than indicated by the MarketScan

data, residual confounding by preinjury opioid use would remain. We addressed this issue with a QBA that doubled the MarketScan estimates.

The MarketScan data reference a period several years after the injury dates in our study. If the disparity in prevalence of preinjury opioid use between medical-only and lost-time injured workers was rising during this period, this would bias our estimates toward the null.

We do not account for any impact of differences in preinjury medically prescribed opioid use between lost-time and medical-only injured workers. This may be a risk factor for postinjury opioid use and subsequent opioid-related mortality and thus be a source of residual confounding. In addition, our measure of preinjury opioid use includes all opioid overdoses, including those from medically prescribed uses. This creates measurement errors in this variable.

It is also possible that medical-only injuries, even though they involve at most 3 days lost from work (and often no lost time), could lead to opioid use and subsequent increased opioid-related mortality. In this case, our results may underestimate the true hazard of opioid use for work-related injuries.

Other studies, also using medical-only injuries as a comparison group, have examined the contribution of workplace injuries to drug-related mortality. Applebaum *et al,* in a study of New Mexico injured workers, found an HR for drug-related mortality of 2.93 for women and 1.29 for men[17] In a West Virginia study, Martin *et al*[18] estimated an HR of 1.89 for opioid overdoses among workers with lost-time low-back injuries. A more recent study of injured workers with upper extremity neuropathy found an HR of 1.47 for accidental poisoning, much of which is opioid related.[19] None of these studies accounted for unobserved confounding. The West Virginia study found a higher HR than did the current study. Physicians prescribe opioids for low back pain at a higher rate than for other injuries,[36] which may partially explain this disparity. Compared with the New Mexico study, we found a lower HR for women and a higher one for men. This suggests that our results may not be generalisable to other states within the USA or to other countries. We know, for example, that, over the period covered by this study, Washington State has had a drug overdose mortality rate that fell from above the median state to well below it, whereas West Virginia has consistently had the highest drug overdose mortality rate in the USA.[37] Additional studies may, therefore, be required to determine generalisability and reasons for differing estimates of the impact of lost-time occupational injuries on opioid-related mortality.

The landscape of opioid use and overdose has changed dramatically over the study period. Opioid prescribing has declined since its peak in 2016, but fentanyl use has increased.[38] The net result has been a continued increase in the number of opioid deaths in the USA.[1 2] Indeed, reducing prescription opioid availability may cause people to seek illicit opioids to control their pain.[39] Additional research is needed to clarify the importance of this dynamic.

Finally, we note that opioid-related deaths as this and other studies have defined them are not the only source of increased mortality from opioid use. For example, studies have

shown substantial excess AIDS-related and viral hepatitis mortality among people who use opioids.[35]

CONCLUSIONS

This study found substantial excess opioid-related mortality among workers in Washington State with lost-time occupational injuries when compared with medical-only injuries. This finding strengthens the argument that workplace injuries have contributed to the epidemic of opioid overdose deaths in the USA which has continued to expand for more than a decade. One benefit of reducing occupational injury rates can be reducing opioid deaths. In addition, strengthened monitoring of postinjury prescribing of opioid painkillers may reduce the risk of opioid overdose. However, such efforts should not overlook the importance of effective opioid and non-opioid pain management to avoid workers' replacing prescriptions with their potentially more deadly non-prescription counterparts.

Job insecurity and general economic insecurity may lead workers to return to work while still in pain.[3] They may seek pain relief through opioids, leading to long-term use. Economic insecurity is an important problem in the USA, with many families lacking the savings to cover living expenses if they become unemployed.[40] The issues we raise here are thus embedded in broader concerns about employment quality and social insurance.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

Data may be obtained from a third party and are not publicly available. Individually identifiable information is not available from the US Social Security Administration. It may be possible to obtain data from the Washington State Department of Labor and Industries with appropriate data-sharing agreements and assurances of confidentiality as approved by the Washington State Institutional Review Board. National Death Index data are available on approval by the NDI.

REFERENCES

1. Hedegaard H, Miniño AM, Spencer MR, et al. Drug overdose deaths in the united states, 1999–2020. NCHS data brief, number 428. 2021. Available: https://www.cdc.gov/nchs/data/databriefs/db428.pdf
2. Spencer MR, Garnett MF, Miniño AM. Drug overdose deaths in the united states, 2002–2022. NCHS data brief, number 491. 2023. Available: https://www.cdc.gov/nchs/data/databriefs/db491.pdf
3. Shaw WS, Roelofs C, Punnett L. Work Environment Factors and Prevention of Opioid-Related Deaths. Am J Public Health 2020;110:1235–41. [PubMed: 32552015]
4. Franklin GM, Rahman EA, Turner JA, et al. Opioid use for chronic low back pain: A prospective, population-based study among injured workers in Washington state, 2002-2005. Clin J Pain 2009;25:743–51. [PubMed: 19851153]
5. Haight JR, Sears JM, Fulton-Kehoe D, et al. Early High-Risk Opioid Prescribing Practices and Long-Term Disability Among Injured Workers in Washington State, 2002 to 2013. J Occup Environ Med 2020;62:538. [PubMed: 32730031]
6. Hawkins D, Punnett L, Davis L, et al. The Contribution of Occupation-Specific Factors to the Deaths of Despair, Massachusetts, 2005-2015. Ann Work Expo Health 2021;65:819–32. [PubMed: 33889956]
7. Asfaw A, Quay B, Bushnell T, et al. Injuries That Happen at Work Lead to More Opioid Prescriptions and Higher Opioid Costs. J Occup Environ Med 2022;64:e823–32. [PubMed: 36136663]
8. Kolodny A, Courtwright DT, Hwang CS, et al. The prescription opioid and heroin crisis: a public health approach to an epidemic of addiction. Annu Rev Public Health 2015;36:559–74. [PubMed: 25581144]
9. Jones CM, Einstein EB, Compton WM. Changes in Synthetic Opioid Involvement in Drug Overdose Deaths in the United States, 2010-2016. JAMA 2018;319:1819–21. [PubMed: 29715347]
10. Busse JW, Wang L, Kamaleldin M, et al. Opioids for Chronic Noncancer Pain: A Systematic Review and Meta-analysis. JAMA 2018;320:2448–60. [PubMed: 30561481]
11. Abdel Shaheed C, Maher CG, Williams KA, et al. Efficacy, Tolerability, and Dose-Dependent Effects of Opioid Analgesics for Low Back Pain: A Systematic Review and Meta-analysis. JAMA Intern Med 2016;176:958–68. [PubMed: 27213267]
12. Chou R, Turner JA, Devine EB, et al. The effectiveness and risks of long-term opioid therapy for chronic pain: a systematic review for a National Institutes of Health Pathways to Prevention Workshop. Ann Intern Med 2015;162:276–86. [PubMed: 25581257]
13. Stover BD, Turner JA, Franklin G, et al. Factors associated with early opioid prescription among workers with low back injuries. J Pain 2006;7:718–25. [PubMed: 17018332]
14. Mahmud MA, Webster BS, Courtney TK, et al. Clinical management and the duration of disability for work-related low back pain. J Occup Environ Med 2000;42:1178–87. [PubMed: 11125681]
15. Cifuentes M, Webster B, Genevay S, et al. The course of opioid prescribing for a new episode of disabling low back pain: opioid features and dose escalation. Pain 2010;151:22–9. [PubMed: 20705393]
16. Carnide N, Feng G, Song C, et al. Occupational patterns of opioid-related harms comparing a cohort of formerly injured workers to the general population in Ontario, Canada. Can J Public Health 2024.
17. Applebaum KM, Asfaw A, O'Leary PK, et al. Suicide and drug-related mortality following occupational injury. Am J Ind Med 2019;62:733–41. [PubMed: 31298756]
18. Martin CJ, Jin C, Bertke SJ, et al. Increased overall and cause-specific mortality associated with disability among workers' compensation claimants with low back injuries. Am J Ind Med 2020;63:209–17. [PubMed: 31833089]
19. Martin CJ, Woods S, Bertke S, et al. Increased Mortality Associated With Disability Among Workers' Compensation Claimants With Upper Extremity Neuropathy. J Occup Environ Med 2023;65:798–802. [PubMed: 37367631]

20. Kowalski-McGraw M, Green-McKenzie J, Pandalai SP, et al. Characterizing the Interrelationships of Prescription Opioid and Benzodiazepine Drugs With Worker Health and Workplace Hazards. J Occup Environ Med 2017;59:1114–26. [PubMed: 28930799]
21. Nkyekyer EW, Fulton-Kehoe D, Spector J, et al. Opioid and Benzodiazepine Use Before Injury Among Workers in Washington State, 2012 to 2015. J Occup Environ Med 2018;60:820–6. [PubMed: 29668527]
22. Asfaw A, Boden LI. Impact of workplace injury on opioid dependence, abuse, illicit use and overdose: a 36-month retrospective study of insurance claims. Occup Environ Med 2020;77:648–53. [PubMed: 32332060]
23. Boden LI, O'Leary PK, Applebaum KM, et al. The impact of non-fatal workplace injuries and illnesses on mortality. Am J Ind Med 2016;59:1061–9. [PubMed: 27427538]
24. Busey A, Asfaw A, Applebaum KM, et al. Mortality following workplace injury: Quantitative bias analysis. Ann Epidemiol 2021;64:155–60. [PubMed: 34607011]
25. Boslett AJ, Denham A, Hill EL. Using contributing causes of death improves prediction of opioid involvement in unclassified drug overdoses in US death records. Addiction 2020;115:1308–17. [PubMed: 32106355]
26. Warner M, Chen LH, Makuc DM, et al. Drug poisoning deaths in the United States, 1980-2008. NCHS Data Brief 2011;81:1–8.
27. Lewer D, Brothers TD, Van Hest N, et al. Causes of death among people who used illicit opioids in England, 2001-18: a matched cohort study. Lancet Public Health 2022;7:e126–35. [PubMed: 34906332]
28. Jones ME, Swerdlow AJ. Bias in the standardized mortality ratio when using general population rates to estimate expected number of deaths. Am J Epidemiol 1998;148:1012–7. [PubMed: 9829874]
29. Office for Health Improvement & Disparities and UK Health Security Agency. Estimates of opiate and crack use in England: main points and methods. 2023. Available: https://www.gov.uk/government/publications/opiate-and-crack-cocaine-use-prevalence-estimates/estimates-of-opiate-and-crack-use-in-england-main-points-and-methods
30. U.K. Home Office. Drug misuse: findings from the 2016 to 2017 CSEW. 2017. Available: https://www.gov.uk/government/statistics/drug-misuse-findings-from-the-2016-to-2017-csew
31. U.K. Office for National Statistics. Deaths related to drug poisoning by date of occurrence, England and Wales. 2023. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/deathsrelatedtodrugpoisoningbydateofoccurrence
32. McHugh RK, Nguyen MD, Chartoff EH, et al. Gender differences in the prevalence of heroin and opioid analgesic misuse in the United States, 2015-2019. Drug Alcohol Depend 2021;227:108978. [PubMed: 34488078]
33. Fine JP, Gray RJ. A Proportional Hazards Model for the Subdistribution of a Competing Risk. J Am Stat Assoc 1999;94:496–509.
34. Fox MP, MacLehose RF, Lash TL. Applying Quantitative Bias Analysis to Epidemiologic Data. Springer Science & Business Media, 2021.
35. Larney S, Tran LT, Leung J, et al. All-Cause and Cause-Specific Mortality Among People Using Extramedical Opioids: A Systematic Review and Meta-analysis. JAMA Psychiatry 2020;77:493–502. [PubMed: 31876906]
36. Pensa MA, Galusha DH, Cantley LF. Patterns of Opioid Prescribing and Predictors of Chronic Opioid Use in an Industrial Cohort, 2003 to 2013. J Occup Environ Med 2018;60:457–61. [PubMed: 29135839]
37. National Center for Health Statistics. Drug overdose mortality by state. 2023. Available: https://www.cdc.gov/nchs/pressroom/sosmap/drug_poisoning_mortality/drug_poisoning.htm
38. Olfson M, Waidmann T, King M, et al. Population-Based Opioid Prescribing and Overdose Deaths in the USA: an Observational Study. J Gen Intern Med 2023;38:390–8. [PubMed: 35657466]
39. Kertesz SG, Gordon AJ. A crisis of opioids and the limits of prescription control: United States. Addiction 2019;114:169–80. [PubMed: 30039595]

40. Board of Governors of the Federal Reserve System. Report on the economic well-being of U.S. Households in 2022. 2023. Available: https://www.federalreserve.gov/publications/2023-economic-well-being-of-us-households-in-2022-expenses.htm

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Studies in the USA have shown that workplace injuries are associated with substantially elevated drug-related mortality in general and opioid-related mortality in specific.
- None of these studies have accounted for preinjury opioid use, which could confound the injury–mortality relationship.

WHAT THIS STUDY ADDS

- After accounting for gender, age, earnings and industry, we found elevated mortality hazards in Washington State for both women and men with lost-time injuries compared with those with only medical-care benefits.
- Estimated increased cause-specific mortality hazard was similar for two measures of opioid-related mortality and for all drug-related mortality.
- By using quantitative bias analysis, this study addressed confounding by preinjury opioid use, a potential source of bias not addressed in other studies. For this study, we define opioid use as using prescription opioids in different ways than intended, using medical opioids without a prescription and/or using illegal opioids, such as heroin or synthetic opioids like illegally made fentanyl.
- Using quantitative bias analysis to account for preinjury opioid use reduced, but did not eliminate, the estimated effect of occupational injury on opioid-related mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- Future research on the impact of occupational injuries on opioid-related health effects should address preinjury opioid use as a potential confounder.
- Reduced postinjury opioid prescribing, improved opioid and non-opioid pain management and greater job security may decrease opioid-related mortality.
- Future research should investigate what mechanisms, including reducing postinjury opioid prescribing, improving pain management, strengthening social insurance programmes and improving postinjury employment opportunities, are most effective at reducing postinjury opioid mortality of workers with non-fatal workplace injuries.
- Preventing occupational injuries will not only reduce disability and improve worker employment and earnings. It is also likely to reduce opioid use and subsequent opioid-related mortality.

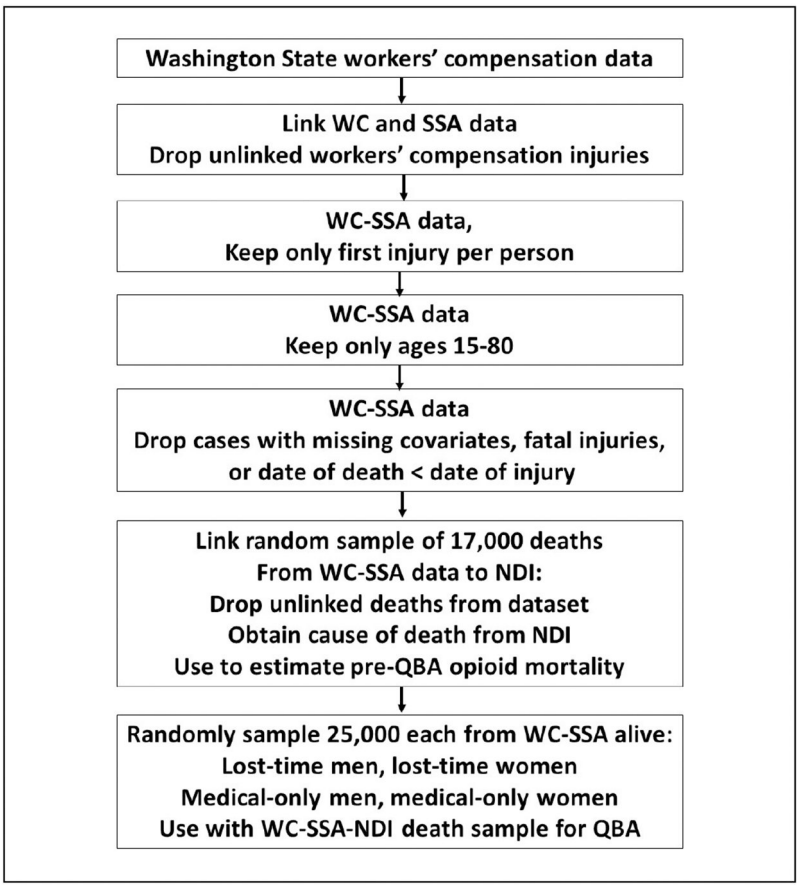

Figure 1.

Development of opioid mortality research datasets. NDI, National Death Index; QBA, quantitative bias analysis; SSA, Social Security Administration; WC, workers' compensation.

Table 1

Study population summary statistics, Washington State workers' compensation, 1994–2000 (N=733 599)

	Men		Women	
	Lost-time injury	Medical-only injury	Lost-time injury	Medical-only injury
	N=152 378	N=308 310	N=84 527	N=188 385
Baseline characteristics				
Age at injury (years), %				
<25	14.6	26.6	12.2	23.3
25–34	27.0	30.7	22.9	26.0
35–44	28.2	23.6	31.6	25.8
45–54	19.0	13.4	23.4	18.0
55–64	10.0	5.0	8.8	6.1
65+	1.3	0.7	1.2	0.9
Annual preinjury earnings (2007$), %				
Less than US$10 000	19.5	24.8	27.2	31.2
US$10 000–US$19 999	16.1	16.9	24.3	22.9
US$20 000–US$29 999	15.5	15.7	19.4	17.7
US$30 000–US$39 999	14.4	13.0	12.8	11.8
US$40 000–US$49 999	12.6	11.0	7.3	7.1
US$50 000–US$59 999	9.4	7.7	4.3	4.2
US$60 000–US$70 000	6.2	4.8	2.7	2.7
US$70 000+	6.4	6.3	2.0	2.4
Industry, %				
Agriculture, forestry and fishing	4.4	4.2	2.3	2.4
Mining	0.5	0.3	0.0	0.0
Non-durable manufacturing	11.4	9.4	5.8	4.9
Durable manufacturing	12.0	12.4	6.8	5.5
Transportation	10.2	6.0	5.5	3.3
Wholesale	6.9	7.5	3.4	3.5
Finance, insurance and real estate	1.3	1.7	2.8	3.5

	Men		Women	
	Lost-time injury	**Medical-only injury**	**Lost-time injury**	**Medical-only injury**
	N=152 378	**N=308 310**	**N=84 527**	**N=188 385**
Services	8.3	10.2	10.0	9.9
Health	1.8	2.4	17.0	16.1
Government	6.1	4.9	4.8	4.3
Construction	19.2	16.2	1.8	1.7
Retail	13.2	19.6	25.2	28.4
Law, education and social Services	4.7	5.3	14.6	16.5
Characteristics, end of follow-up				
Years follow-up, median (IQR)	20.8 (3.9)	20.9 (3.8)	20.8 (3.8)	20.8 (3.7)
Opioid-related deaths including unknown drugs, n (% of column N)	1046 (0.69)	1434 (0.47)	430 (0.28)	712 (0.23)
Opioid-related deaths excluding unknown drugs, n (% of column N)	853 (0.56)	1219 (0.40)	330 (0.22)	547 (0.18)
Drug-related deaths, N (% of column N)	1188 (0.78)	1676 (0.54)	501 (0.33)	812 (0.26)

All numbers are weighted to account for sampling of deaths. Numbers may not add exactly to their total because of rounding.

Table 2

Association between lost-time injury in Washington State 1994–2000 and opioid and drug overdose mortality through 2018

	Men				Women			
	Lost-time	Medical-only			Lost-time	Medical-only		
	N=152 378	N=308 310			N=84 527	N=188 385		
Cause of death	CMR	CMR	sHR	95% CI	CMR	CMR	sHR	95% CI
Opioids including unknown drugs	33.0	22.3	1.53	1.41 to 1.66	24.5	18.2	1.31	1.16 to 1.48
Opioids not including unknown drugs	26.9	18.9	1.47	1.34 to 1.61	18.8	14.0	1.33	1.16 to 1.52
Any drug	37.5	26.0	1.47	1.36 to 1.59	28.5	20.7	1.32	1.18 to 1.48

HR estimates are adjusted for age and industry at time of injury and earnings in the year before injury and account for competing risks from all other causes. All observations are weighted to account for sampling.

CMR, crude mortality rate; sHR, subdistribution HR.

Table 3

Association between lost-time injury in Washington 1994–2000 and opioid-related mortality through 2018, indirect adjustment for preinjury opioid use*

	Median sHR†	2.5th percentile	97.5th percentile
Base preinjury opioid use estimates‡			
Men			
Lost-time injury	1.43	1.20	1.69
Medical-only injury	Reference		
Women			
Lost-time injury	1.27	1.10	1.45
Medical-only injury	Reference		
Doubled preinjury opioid use estimates‡			
Men			
Lost-time injury	1.35	1.12	1.61
Medical-only injury	Reference		
Women			
Lost-time injury	1.22	1.05	1.41
Medical-only injury	Reference		

*Direct adjustment for age, preinjury earnings and industry and indirect adjustment for preinjury opioid use. Opioid-related mortality includes poisoning by unspecified drugs. All observations are weighted to account for sampling. These estimates use the definition of opioid-related mortality that includes unknown drugs as a cause of death.

†Median subdistribution HR (sHR) for 10 000 iterations using simulated preinjury opioid use and opioid-related mortality relative risk.

‡Estimated preinjury opioid use values derived from MarketScan data.