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Layoffs and the mental health and safety of remaining workers: a difference-in-differences analysis of the US aluminium industry

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Abstract

Background—Relatively few studies have examined the effects of layoffs on remaining workers, although the effects of layoffs and downsizing events may extend beyond those employees who lose their jobs.

Methods—We examined the effects of layoffs on mental healthcare utilisation and injury risk among workers at 30 US plants between 2003 and 2013. We defined layoffs as reductions in the hourly workforce of 20% or more at each plant. Using a difference-in-differences approach, we compared the change in outcomes during layoffs versus the same 3-month period 1 year previously, accounting for secular trends with control plants.

Results—Our study population included 15 502 workers and 7 layoff events between 2003 and 2013. Layoffs were associated with only minor decreases in injuries (−0.006, 95% CI −0.013 to 0.001). The probability of outpatient visits related to mental health increased by 1% during layoffs (0.010, 95% CI 0.003 to 0.017), and the probability of mental health-related prescriptions

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Contributors HE conceptualised and designed the study, performed the statistical analysis, interpreted results and drafted the manuscript. EB-M conceptualised and designed the study and interpreted the results. DR, SM and EAE contributed to the study design, interpretation of the data and analysis and critically revised the manuscript. MRC was responsible for data acquisition, contributed to the study design, interpretation of the data and analysis and critically revised the manuscript.

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increased by 1.4% (0.014, 95% CI -0.0006 to 0.027). Among women, the increase in outpatient visits was more pronounced (0.017, 95% CI 0.003 to 0.031). Increased prescription utilisation appeared attributable primarily to opioid use (0.016, 95% CI 0.005 to 0.027).

Conclusion—Our results indicate an association between layoffs and remaining workers' mental health and safety, although changes mental healthcare utilisation may reflect both changes in underlying mental health and changes in care-seeking. Future research on concordance of service utilisation and underlying health may yield valuable insight into the experiences employed workers in the wake of layoffs.

INTRODUCTION

The consequences of socioeconomic shocks such as plant closures, downsizing and layoffs for workers are well characterised. Job displacement, for example, has been linked with prolonged periods of subsequent unemployment, diminished earnings and declines in job quality.^{1–4} Job loss is also a major social stressor that may simultaneously disrupt family dynamics and social conditions.⁵ Job loss has also consistently been associated with poor health,^{6–9} psychiatric distress^{8 10–12} and drug and alcohol abuse.^{13–15}

Fewer studies have focused on the effects of layoffs on remaining workers—the so-called 'layoff survivors'. Yet the effects of layoffs and downsizing events may extend beyond those employees who lose their jobs.¹⁶ Remaining workers may experience greater job insecurity in the wake of layoffs, especially in the context of recessions when labour markets are relatively weak and other employment opportunities may be limited.¹⁷ Layoffs and the resultant job insecurity may additionally serve to weaken remaining workers' organisational commitment, increase work related stress and decrease job satisfaction.^{18–20}

Remaining workers may also experience psychiatric distress in the wake of layoffs due to guilt or remorse for their terminated coworkers.¹⁶ Research on the mental health effects of the Great Recession among continuously employed US workers found that rates of mental health-related outpatient visits and prescriptions increased most among workers at plants where mass layoffs had occurred.²¹ Layoffs and downsizing events may also increase rates of injury among the remaining workers, as one common expectation of management following downsizing is that output levels will not decline even with fewer workers to complete the tasks.^{22–24} Moreover, multitasking, job reassignment and associated management problems may increase injury risk.²⁵ Existing research also suggests that employees who perceive their jobs to be insecure report lower levels of safety knowledge and reduced motivation to comply with safety policies.²⁶

The present study adds to the growing literature on the short-term effects of layoffs on remaining workers. We examined the effects of layoffs on workers employed by a single aluminium manufacturer at one of 30 US plants between 2003 and 2013. Using a difference-in-differences (DID) approach, we estimated the association between layoffs and remaining workers' mental healthcare utilisation and injury risk. We hypothesised that due to increased psychiatric distress, real or perceived job insecurity and factors such as work intensification, job reassignment and changes in management, layoffs would lead to increased injury risk and mental healthcare utilisation among remaining workers.

METHODS

The present analyses used data from the American Manufacturing Cohort (AMC) Study, which include detailed, longitudinal health and employment records for workers employed by a single US aluminium manufacturer followed from 1 January 2003 to 31 December 2013.²⁷ The AMC Study database includes several administrative datasets—including personnel files, company payroll records, the occupational injury management system and medical insurance claims—that are deterministically linked using a unique, encrypted identifier for each individual worker.

Layoff events

We identified layoff events using the company payroll database. We calculated the number of hourly workers on the company payroll for every quarter at each of 30 US plants between 1 January 2003 and 31 December 2013. Next, we calculated the percent change in the size of the hourly workforce from quarter-to-quarter for each plant. We defined layoff events as any quarter in which the size of the hourly workforce at a given plant decreased by 20% or more.

For plants where layoffs occurred (ie, treated plants), we retained only the quarter in which the layoff event occurred and the same 3-month period from the previous year as the reference quarter. We selected the same quarter from the previous year as the reference for two reasons: first, this approach controls for potential seasonality in mental healthcare utilisation and injury risk.^{28–32} Second, on inspecting the data, we noted that many layoff events identified were preceded by a substantial reduction in the size of the workforce. However, for all plants that experienced layoff events, the previous year provided a comparison quarter in which the workforce remained relatively stable. Control plants were those where no layoff events occurred.

Our analysis was restricted to the hourly workforce. For workers at treated plants, we retained only those workers who were actively employed and insured for all 3 months of the layoff quarter and reference quarter. For workers at control plants, we retained all worker-quarter pairs that corresponded to the layoff and reference quarters at treated plants. Our analysis therefore entails comparison of the same group of workers during the 3-month layoff period versus 1 year prior within each plant.

Outcome assessment

Our outcomes of interest were injury and two measures of mental healthcare utilisation. We identified occupational injuries using the company incident management system database. We created an indicator variable for each worker for each quarter in which an injury occurred throughout the study period. Injuries included first aid events as well as Occupational Safety and Health Administration (OSHA) recordable events (medical treatment, restricted work and lost work time).³³

We created a quarterly indicator variable for whether each worker had an outpatient visit related to mental health using relevant primary outpatient diagnostic codes from the International Classification of Diseases, 9th Revision. These included 296 (episodic mood disorders); 300 (anxiety, dissociative and somatoform disorders); 303 (alcohol abuse); 304

and 305 (drug dependence), 309 (adjustment reaction); and 311 (depressive disorder not elsewhere classified). Second, we created a quarterly indicator for whether each worker filled a prescription related to mental health. Consistent with previous research on the health effects of economic shocks, we included prescriptions for opioids, antidepressants, sleep aids and anxiolytics.^{34 35}

Covariates

A priori we identified individual-level variables that could potentially affect the association between layoffs and the mental health and safety using company personnel files. These included categories of gender, race ethnicity (Black, Hispanic, white and other), hire year and continuous age.

Statistical analyses

We used a DID approach³⁶ to examine the effect of layoff events on remaining workers. We separately examined outpatient visits related to mental health, prescriptions related to mental health and injuries. The DID estimator subtracted the change in the probability of each outcome between the layoff quarter and referent quarter for workers at plants where no layoffs occurred (ie, control plants) from the change in the probability of each outcome for at treated plants. Any changes that occurred in injury risk and mental healthcare utilisation at control plants presumably result only from secular trends. Under the assumption that secular trends are parallel among workers at treated and control plants and that the model is correctly specified, the resulting DID estimator corresponds to the change in each outcome that is attributable to the layoff event itself.

We estimated the population average association between layoffs and each of our three outcomes of interest. Formally, let Y_{ist} be the outcome of interest for worker i in group s at time t where group is defined as plant and time specifies a specific 3 month period (ie, quarter). The variable I_{st} is an indicator for whether a layoff event occurred at plant s during the 3 month period t . We estimated the following regression equation using generalised estimating equations with an identity link and an exchangeable working correlation structure:

$$E(Y_{ist}) = A_s + B_t + \beta I_{st}$$

where A_s represents fixed effects for plant and B_t represents fixed effects for each of the fourteen study quarters. The plant fixed effect accounts for regional differences in mental health provider networks and physician prescribing practices, and the study quarter fixed effects accounts for secular trends. The coefficient β therefore corresponds to our estimate of interest: the difference in the probability of the outcome of interest attributable to layoffs. This specification is a common generalisation of the most basic DID setup (with two time periods and two groups).³⁷ We subsequently added a vector of individual-level X_{ist} covariates to the model, which included categories of gender, race/ethnicity, hire year and a natural spline for age with three degrees of freedom.

As men and women often have different experiences with respect to pay, promotion and assigned tasks at work,^{38 39} we hypothesised that male and female workers may have responded differently to layoffs with respect to mental healthcare utilisation and injury risk. We therefore conducted a gender-stratified analysis and additionally include a test for interaction by including a product term between the layoff indicator and gender. All analyses were conducted with R version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria).

Sensitivity analyses

We conducted the following sensitivity analyses: first, we restricted our analysis to control quarters where there was no more than a 7.5% change in the size of the workforce. This threshold corresponds to the largest change in the reference quarters of treated plants. We next conducted a separate analysis for each prescription type (antidepressants, anxiolytics, sleep aids and opiates); visit type (depressive disorders, anxiety and substance use); and injury type (first aid and OSHA reportable). Third, because news of earlier layoffs may affect worker behaviour during subsequent layoffs, we examined each layoff event separately. Finally, we implemented a negative exposure controls analysis⁴⁰ by randomly selecting eight new plants that did not experience a layoff event within our study period. We repeated our main analysis after assigning the dates of the observed layoff events to the eight randomly selected control plants. A null relationship between the layoff event and our outcomes of interest at these randomly selected control plants provides evidence that our main results were not due to time trends.

RESULTS

Between January 2003 and December 2013, we identified seven layoff events at eight of 30 US plants. Treated plants were located in all four regions of the USA. The majority of layoff events occurred in 2009 at the height of the Great Recession, although the earliest layoff event occurred between October and December of 2004. In figure 1, we depict the size of the workforce throughout the period for one treated plant and one control plant, both of which were located in the Northeastern USA. Additional details of layoff events are summarised in the online supplement (online supplementary table 1 and figure 1). The population included 15 502 workers, of whom 4158 were employed at a plant that experienced at least one layoff event (ie, treated plants). The age distribution and the percentages of non-white workers were similar in treated and control plants, although workers at control plants tended to be hired earlier than workers at treated plants (table 1). On average, 37.6 injuries occurred per 1000 quarters of follow-up, and there were 28.7 outpatient visits and 144.7 prescriptions related to mental health per 1000 quarters of follow-up.

Estimated association between layoffs and worker mental health and safety

We find that layoff events were associated with a small decrease in the probability of reported injuries (-0.006 , 95% CI -0.013 to 0.001). Layoff events were associated with an increase in the probably of both outpatient visits (0.010 , 95% CI 0.003 to 0.017) and prescriptions (0.014 , 95% CI -0.0006 to 0.027) related to mental health (figure 2). Our

test for interaction provided some evidence for differences in men and women's responses to layoffs, particularly for outpatient visits (0.012, 95% CI -0.004 to 0.0217) (online supplementary table 2). When we restricted our analysis to male workers, we observed a more substantial decrease in reported injuries (-0.010, 95% CI -0.018 to 0.001). Among women, we observed a more substantial increase in the probability of a mental health-related outpatient visits (0.017, 95% CI 0.003 to 0.031) (figure 3). As anticipated with a DID design, unadjusted and adjusted analyses yielded similar estimates (online supplementary tables 3 and 4).

Sensitivity analyses

Our analysis with restricted control quarters yielded results similar to those we observed in our main analysis with all control quarters included (online supplementary tables 3 and 5).

We analysed the association between layoffs and subtypes of injury, outpatient visit and prescription (figure 3). Results suggested that the increase in outpatient visits associated with layoffs occurred primarily through increases in depression-related visits (0.007, 95% CI 0.001 to 0.012) and anxiety-related visits (0.005, 95% CI 0.0004 to 0.009). Results suggested further that the observed increase in prescriptions occurred primarily through an increase in the probability of opioid prescriptions (0.016, 95% CI 0.005 to 0.027). The observed decrease in reported injuries was not clearly attributable to either injuries requiring first aid or OSHA-recordable events (online supplementary table 65). Our analysis of each treatment period separately did not suggest any trends over time (online supplementary table 7).

Finally, as a negative controls analysis, we repeated our main analysis among all workers with plants where no layoff event occurred. As expected, we observed no association between the negative control plants and the change in the probability of injury or of outpatient visits and prescriptions related to mental health (online supplementary table 8).

DISCUSSION

Economic shocks such as layoffs are involuntary, undesired and unscheduled. In their stress process framework, Pearlin and colleagues¹² argue that life events such as layoffs yield considerable stress for workers through their immediate demands for readjustment; diminished self-esteem and a reduced sense of control; and through the subsequent strain they create in other life domains including marriage, parenthood and household economic well-being. Depression, according to Pearlin and colleagues, is a common and salient consequence of these collective stressors. Indeed, consistent with the Stress Process Model, past research consistently finds that socioeconomic shocks such as plant closures, downsizing and layoffs are linked with subsequent psychiatric distress and depression for affected workers.^{8 10 11} The consequences of layoffs for workers who remain employed have received relatively less attention.

For the present study, we examined the association between layoffs and the mental health and safety of remaining workers employed by a single manufacturing firm. Data from the AMC Study provided detailed, longitudinal records for the hourly workforce at 30 US

plants between 2003 and 2013. We used a quasiexperimental DID approach and minimised the potential for selection bias by comparing the rates of each outcome of interest in the same group of workers during and 1 year prior to each layoff event. Under the assumption that secular trends are parallel among workers at treated and control plants and that the model is correctly specified, the resulting DID estimate corresponds to the change in each outcome attributable to the layoff event itself. Consistent with our primary study hypothesis, we find evidence of increased use of outpatient visits related to mental health and modest increases in use of prescriptions related to mental health. By contrast, we observe limited evidence for decreases in reported injuries attributable to layoffs. These results were robust to several sensitivity analyses, including multivariate adjustment and negative exposure controls analysis.

As injuries are relatively rare in this study population, it is not clear whether the small decrease in reported injuries—although statistically significant—reflects a meaningful change. Of note, this finding is inconsistent with the extant literature, which largely posits that injuries should be increased in the context of layoffs because remaining workers are more likely to disregard occupational health and safety guidelines in order to maintain production levels or be reassigned to tasks with which they are less familiar and therefore ill-suited.^{22–24} It may be that workers become hypervigilant in the context of layoffs and therefore are less likely to injure themselves in the context of layoffs.⁴¹ Alternatively, it may be that injury risk remains does in fact increase, but workers refrain from reporting injuries in the context of layoffs due to real or perceived job insecurity.

In our stratified analysis, we observed more pronounced increase in mental healthcare utilisation among female workers. In particular, we observed a 1.7% increase in the probability of a mental health-related outpatient visit during layoffs among female workers. The apparent difference between men and women's use of mental healthcare services during layoffs may reflect systematic differences in perceived job security and control over work between men and women or additional strain due to conflict between work and family obligations.^{42–45} This finding is also fairly consistent with the literature, as higher prevalence of affective disorders and utilisation of healthcare services for mental health is consistently observed among women as compared with men.^{46 47}

Our analysis of outcome subcategories suggests the observed increase mental health-related outpatient visits is due primarily to an increase in depression-related and anxiety-related outpatient visits. This finding is consistent with the notion that layoffs may increase psychiatric distress among remaining workers, which translates to increased utilisation of related healthcare service. By contrast, the observed increase in mental health-related prescriptions seems to be attributable to a 1.6% in the probability of opioid prescription during layoffs. This is perhaps surprising given the observed reduction in reported injuries. It is unlikely secular trends in opioid use previously reported within this study population⁴⁸ explain this finding, as secular trends are accounted for with the comparison plants and with fixed effects for each of the fourteen study quarters. It is possible that workers fail to report injuries that occur during layoffs but subsequently seek medication to treat the resultant pain. Alternatively, this finding may reflect the fact that workers will seek out opioid prescriptions in anticipation of losing their health insurance or as a treatment for

the psychiatric distress that results from layoffs. These competing explanations cannot be disentangled with the study data, but the apparent injury-opioid paradox we observe deserves further consideration.

Limitations

There are key limitations of the present study that we discuss briefly here. First, there are limitations related to DID model assumptions. We assumed that the observed changes in injury risk and mental healthcare utilisation are attributable to layoff events. The assumption of parallel trends—that changes in our outcomes of interest would have been the same in treated and control plants in the absence of layoffs—is untestable. A time-varying imbalance between the treatment and control plants could therefore have biased results.

Second, because all workers included in the present study were employed by a single firm, it is possible that workers in control plants changed their behaviours over time with respect to injury reporting and mental healthcare utilisation in anticipation of layoffs. We anticipate that such behaviour changes would attenuate the estimated associations between layoff events and our outcomes of interest. We further noted that several plants experienced smaller reductions in the size of the workforce in the months that immediately preceded the quarter that we designated as the treated quarter. Whether these earlier layoffs would lead to habituation among workers or to an amplified response is unclear.

Our outcome measurements indicate changes in mental healthcare utilisation and reported injuries. Changes in mental healthcare utilisation may reflect changes in underlying disease status, moral hazard or some combination thereof and should therefore not be interpreted as a proxy for worker mental health. Likewise, we are unable to establish whether changes in recorded injuries are attributable to differences in reporting during layoffs or true changes in worker safety.

CONCLUSION

We examined the impact of layoffs on remaining workers. We find limited evidence that injury rates changed during layoffs and find evidence that mental healthcare utilisation—and use of outpatient services in particular—increased during layoffs. The apparent increase in outpatient visits appears primarily attributable to depression-related and anxiety-related visits, whereas the increase in prescriptions appears primarily attributable to increased rates of opioid prescription during layoffs. This latter finding is perhaps surprising given the lack of any clear, concomitant change in injuries. Overall, our results suggest that layoffs may lead to changes in mental healthcare utilisation and safety practices among remaining workers. Apparent decreases in injuries may reflect real changes in injury risk or changes in reporting practices. Similarly, changes in mental healthcare utilisation may reflect true underlying psychiatric distress, moral hazard or some combination thereof. Future research on the concordance of service utilisation and workers' underlying health and safety may yield valuable insight into the experiences of workers who remain employed after substantial layoffs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability statement

Data are available on reasonable request.

REFERENCES

1. Ruhm CJ. Are workers permanently scarred by job displacements? *The American economic review* 1991;81:319–24.
2. Jacobson LS, LaLonde RJ, Sullivan DG. Earnings losses of displaced workers. *The American economic review* 1993:685–709.
3. Farber HS. What do we know about job loss in the United States? Evidence from the displaced workers survey, 1984–2004. *Economic Perspectives* 2005;29:13–29.
4. Fallick BC. A review of the recent empirical literature on displaced workers. *ILR Review* 1996;50:5–16.
5. Strully KW. Job loss and health in the U.S. labor market. *Demography* 2009;46:221–46. [PubMed: 21305391]
6. Dooley D, Catalano R. Health effects of economic instability: a test of economic stress hypothesis. *Journal of Health and Social Behaviour* 1983;4:46–60.
7. Korpi T, disadvantage A. Accumulating disadvantage. longitudinal analyses of unemployment and physical health in representative samples of the Swedish population. *Eur Sociol Rev* 2001;17:255–73.
8. Montgomery S, Cook DG, Bartley MJ. Unemployment pre-dates symptoms of depression and anxiety resulting in medical consultation in young men. *Int J Epidemiol* 1999;28:95–100. [PubMed: 10195671]
9. Wadsworth MEJ, Montgomery SM, Bartley MJ. The persisting effect of unemployment on health and social well-being in men early in working life. *Soc Sci Med* 1999;48:1491–9. [PubMed: 10369448]
10. Dooley D, Catalano R, Wilson G. Depression and unemployment: panel findings from the epidemiologic catchment area study. *Am J Community Psychol* 1994;22:745–65. [PubMed: 7639201]
11. Kessler RC. The effects of stressful life events on depression. *Annu Rev Psychol* 1997;48:191–214. [PubMed: 9046559]
12. Pearlin LI, Menaghan EG, Lieberman MA, et al. The stress process. *J Health Soc Behav* 1981;22:337–56. [PubMed: 7320473]
13. Kivimäki M, Honkonen T, Wahlbeck K, et al. Organisational downsizing and increased use of psychotropic drugs among employees who remain in employment. *J Epidemiol Community Health* 2007;61:154–8. [PubMed: 17234876]
14. Pelfrene E, Vlerick P, Moreau M, et al. Use of benzodiazepine drugs and perceived job stress in a cohort of working men and women in Belgium. results from the BELSTRESS-study. *Soc Sci Med* 2004;59:433–42. [PubMed: 15110431]
15. Sikora P, Moore S, Greenberg E, et al. Downsizing and alcohol use: a cross-lagged longitudinal examination of the spillover hypothesis. *Work Stress* 2008;22:51–68.

16. Brockner J, Davy J, Carter C. Layoffs, self-esteem, and survivor guilt: motivational, affective, and attitudinal consequences. *Organ Behav Hum Decis Process* 1985;36:229–44.
17. Hamad R, Modrek S, Cullen MR. The effects of job insecurity on health care utilization: findings from a panel of U.S. workers. *Health Serv Res* 2016;51:1052–73. [PubMed: 26416343]
18. Ashford SJ, Lee C. Content, cause, and consequences of job insecurity: a theory-based measure and substantive test. *Acad Mana J* 1989;32:803–29.
19. Davy JA, Kinicki AJ, Scheck CL. Developing and testing a model of survivor responses to layoffs. *J Vocat Behav* 1991;38:302–17.
20. Modrek S, Cullen MR. Job insecurity during recessions: effects on survivors' work stress. *BMC Public Health* 2013;13:929. [PubMed: 24093476]
21. Modrek S, Hamad R, Cullen MR. Psychological well-being during the great recession: changes in mental health care utilization in an occupational cohort. *Am J Public Health* 2015;105:304–10. [PubMed: 25521885]
22. Quinlan M, Bohle P. Overstretched and unreciprocated commitment: reviewing research on the occupational health and safety effects of downsizing and job insecurity. *Int J Health Serv* 2009;39:1–44. [PubMed: 19326777]
23. Cappelli P *Change at work* Oxford university press on demand 1997.
24. Tang TL- P, Fuller RM. Corporate downsizing: what managers can do to lessen the negative effects of layoffs. *SAM Advanced Management Journal* 1995;60.
25. Quinlan M, Bohle P. Contingent work and occupational safety. *The psychology of workplace safety* 2004;34:81–105.
26. Probst TM, Brubaker TL. The effects of job insecurity on employee safety outcomes: cross-sectional and longitudinal explorations. *J Occup Health Psychol* 2001;6:139:159. [PubMed: 11326726]
27. Elser H, Neophytou AM, Tribett E, et al. Cohort profile: the American manufacturing cohort (AMC) study. *Int J Epidemiol* 2019;71. [PubMed: 30428050]
28. Harmatz MG, Well AD, Overtree CE, et al. Seasonal variation of depression and other moods: a longitudinal approach. *J Biol Rhythms* 2000;15:344–50. [PubMed: 10942266]
29. Maes M, Meltzer HY, Suy E, et al. Seasonality in severity of depression: relationships to suicide and homicide occurrence. *Acta Psychiatr Scand* 1993;88:156–61. [PubMed: 8249645]
30. Oyane NMF, Bjelland I, Pallesen S, et al. Seasonality is associated with anxiety and depression: the Hordaland health study. *J Affect Disord* 2008;105:147–55. [PubMed: 17573120]
31. Vegso S, Cantley L, Slade M, et al. Extended work hours and risk of acute occupational injury: a case-crossover study of workers in manufacturing. *Am J Ind Med* 2007;50:597–603. [PubMed: 17594716]
32. Wehr TA, Rosenthal NE. Seasonality and affective illness. *Am J Psychiatry* 1989;146:829. [PubMed: 2662784]
33. Tessier-Sherman B, Cantley LF, Galusha D, et al. Occupational injury risk by sex in a manufacturing cohort. *Occup Environ Med* 2014;71:oemed-2014–102083:610.
34. Modrek S, Cullen MR. Health consequences of the 'Great Recession' on the employed: Evidence from an industrial cohort in aluminum manufacturing. *Soc Sci Med* 2013;92:105–13. [PubMed: 23849284]
35. Kozman D, Graziul C, Gibbons R, et al. Association between unemployment rates and prescription drug utilization in the United States, 2007–2010. *BMC Health Serv Res* 2012;12:435. [PubMed: 23193954]
36. Angrist JD, Krueger AB. Empirical strategies in labor economics. In: *Handbook of labor economics*. Elsevier, 1999: 3. 1277–366.
37. Bertrand M, Duflo E, Mullainathan S. How much should we trust differences-in-differences estimates? *Q J Econ* 2004;119:249–75.
38. Messing K, Dumais L, Courville J, et al. Evaluation of exposure data from men and women with the same job title. *J Occup Med* 1994;36:913–7. [PubMed: 7807275]
39. Reskin BF, Padavic I. *Men and women at work*. Thousand Oaks, CA: Pine ForgePress. ReskinMen and women at work 1994 1994.

40. Lipsitch M, Tchetgen Tchetgen E, Cohen T. Negative controls: a tool for detecting confounding and bias in observational studies. *Epidemiology* 2010;21:383–8. [PubMed: 20335814]
41. Catalano R, Dooley D. Does economic change provoke or uncover al disorder: a preliminary test. *Mental health and the economy* 1979:321–46.
42. Gruber JE, Bjorn L. Blue-Collar blues: the sexual harassment of women autoworkers. *Work and Occupations* 1982;9:271–98.
43. Harrell WA. Perceived risk of occupational injury: control over pace of work and blue-collar versus white-collar work. *Percept Mot Skills* 1990;70:1351–9. [PubMed: 2399107]
44. Hocschild A, Machung A. *The second shift: working families and the revolution at home*. Penguin Books, 2012.
45. Messing K, Punnett L, Bond M, et al. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med* 2003;43:618–29. [PubMed: 12768612]
46. Mojtabai R Use of specialty substance abuse and mental health services in adults with substance use disorders in the community. *Drug Alcohol Depend* 2005;78:345–54. [PubMed: 15893166]
47. Kessler R Epidemiology of women and depression. *J Affect Disord* 2003;74:5–13. [PubMed: 12646294]
48. 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]

What is already known on this subject

- The negative consequences of job loss are well characterised and include prolonged subsequent unemployment, diminished earnings and declines in job quality as well as poor health, psychiatric distress and substance use. Relatively fewer studies consider the consequences of economic shocks such as layoffs for the mental health and safety of remaining workers.

What this study adds

- We find limited evidence that injury rates changed during layoffs but note increased utilisation of outpatient visits and prescriptions for mental health. The increase in outpatient visits was more pronounced among female workers, and the increase in prescriptions appears attributable largely to increases in opioid prescriptions during layoffs. Future research on the concordance of service utilisation and workers' underlying health and safety may yield valuable insight into the experiences of workers who remain employed after substantial layoffs.

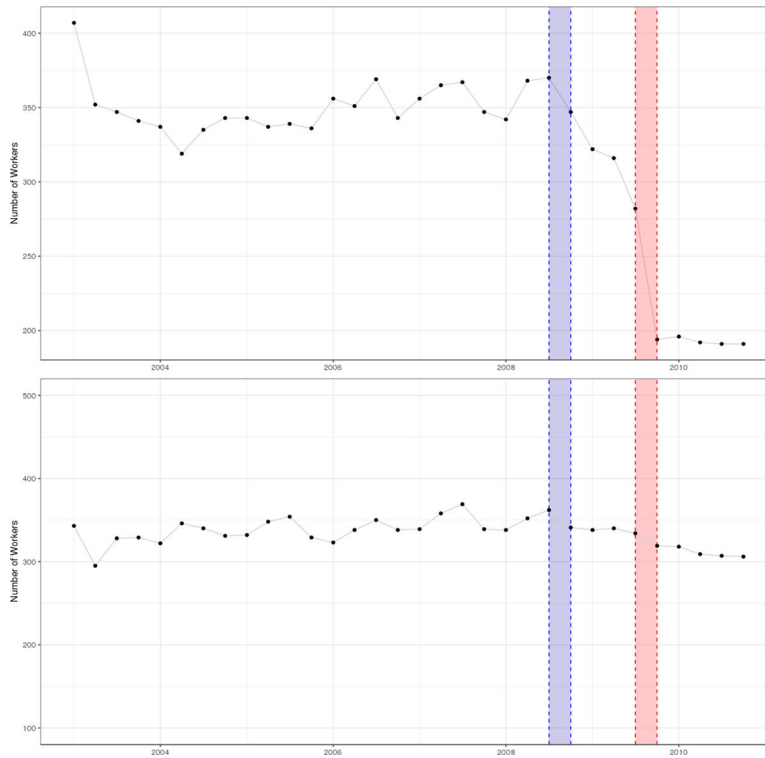


Figure 1. Workforce size throughout the study period at a treated and control plant. We plot the number of hourly workers on the company payroll at a plant located in the northeastern USA where layoffs occurred between July and September of 2009 (top panel) and the number of hourly workers on the company payroll at a plant located in the northeastern USA where no layoff events occurred within the study period (bottom panel). The red dotted lines demarcate the quarter in which the layoffs occurred at the treated plant, and the blue dotted lines demarcate the same 3-month period from the previous year, which serves as the reference quarter in our analysis.

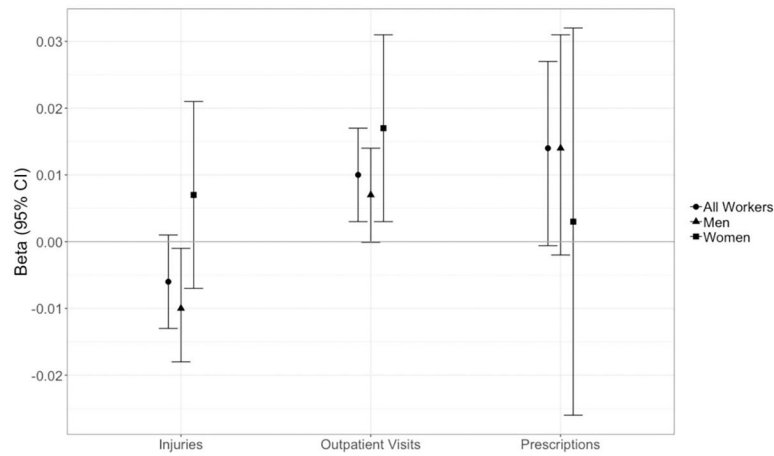


Figure 2.

Difference-in-differences estimates for the effect of layoffs on injury risk and mental healthcare utilisation. We used generalised estimating equations with the identity link to estimate the marginal (population average) effects of layoffs on the probability of each outcome of interest (injuries; outpatient visits and prescriptions for worker mental health) and specified an exchangeable working correlation structure to account for non-independence of outcomes among workers clustered within plant locations. All models included fixed effects for plant location, quarter and an indicator variable that equalled one in the treated plants during the quarter of layoffs and was zero otherwise. We conducted a pooled analysis among all workers ($n = 15\,502$) as well as stratified analyses in which we examined the effects of layoffs on our outcomes of interest among male workers ($n = 12\,569$) and female workers ($n = 2933$). We characterised injuries with a quarterly indicator variable that equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration recordable events (medical treatment, restricted work and lost work time). We characterised outpatient visits related to mental health with a quarterly indicator variable that equals one if a mental health-related outpatient visit occurred and is zero otherwise. Outpatient visits for mental health were identified using International Classification of Diseases, 9th Revision codes 296 (episodic mood disorders); 300 (anxiety, dissociative and somatoform disorders); 303 (alcohol abuse); 304 and 305 (drug dependence), 309 (adjustment reaction); and 311 (depressive disorder not elsewhere classified). We characterised prescriptions related to mental health with an indicator variable that equals one if there was a filled prescription related to mental health and is zero otherwise. We included prescriptions for antidepressants, anxiolytics, opiates and sleep aids.

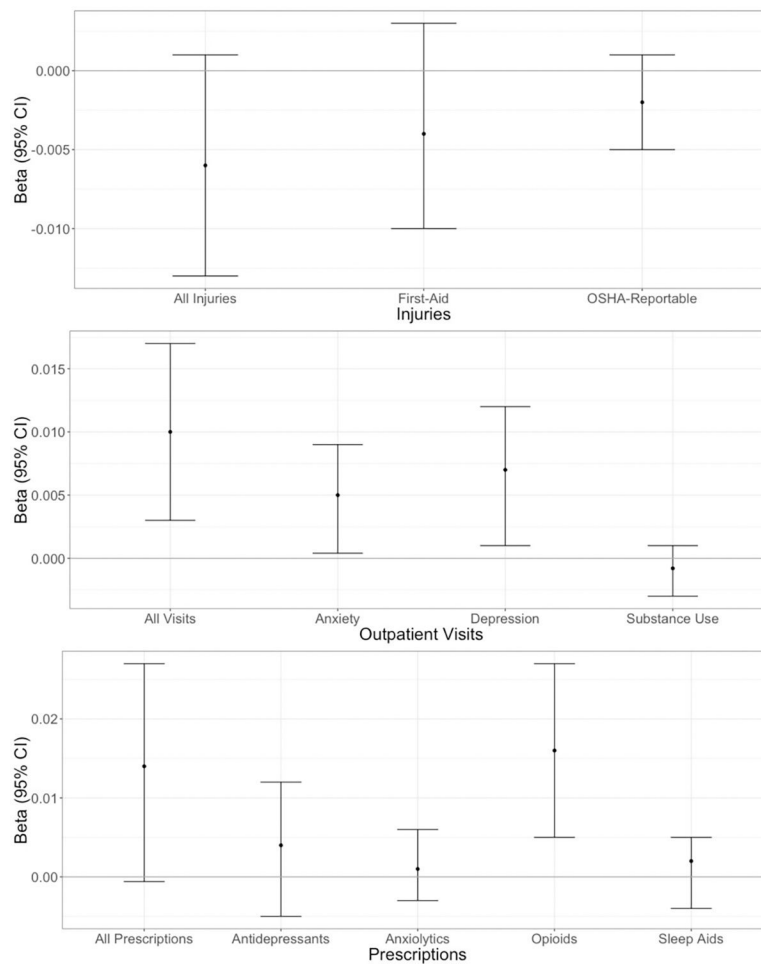


Figure 3. Differences-in-differences estimates for the effect of layoffs by subcategories of injuries, outpatient visits and prescriptions. We used generalised estimating equations with the identity link to estimate the marginal (population average) effects of layoffs on the probability of each outcome of interest (injuries; outpatient visits and prescriptions for worker mental health) and specified an exchangeable working correlation structure to account for non-independence of outcomes among workers clustered within plant locations. All models included fixed effects for plant location, quarter and an indicator variable that equaled one in the treated plants during the quarter of layoffs and was zero otherwise. We separately analysed the effect of layoffs on all injuries; injuries requiring first-aid; and OSHA recordable events (top panel). We separately analysed the effect of layoffs on all outpatient visits related to mental illness; depression-related outpatient visits (ICD-9 codes 296.2–296.35, 309 and 311); anxiety-related outpatient visits (ICD-9 codes 300); and outpatient visits for substance use (ICD-9 303–305) (middle panel). We separately analysed the effect of layoffs on all prescriptions, prescribed antidepressants, prescribed anxiolytics, prescribed sleep aids and prescribed opioids (bottom panel). ICD-9, International Classification of Diseases, 9th Revision; OSHA, Occupational Safety and Health Administration.

Table 1

Demographic characteristics of workers at treated and control plants *

	Treated plants (N=4158)	Control plants (N=11 344)
Men, N (%)	3078 (74.0)	9491 (83.7)
Race/ethnicity, N (%)		
White	3019 (72.6)	8442 (74.4)
Black	737 (17.7)	1027 (9.1)
Hispanic	275 (6.6)	1379 (12.2)
Other	127 (3.1)	496 (4.4)
Hire year [†] , N (%)		
Before 2000	803 (19.3)	4,723 (41.6)
2000–2002	2363 (56.8)	3088 (27.2)
After 2002	994 (23.9)	3540 (31.2)
Age, median (IQR)	47.5 (39.0–53.5)	47.7 (39.8–53.9)

* Study data include 30 US plants. The eight treated US plants experienced a layoff event within the study period (reduction in size of workforce >20%), and the 20 control plants experienced no such event within the study period.

[†] Tertiles were defined based on the distribution of hire year among all workers at treated and control plants.