

UC Berkeley

UC Berkeley Electronic Theses and Dissertations

Title

Gender, blue-collar work, and depression in the U.S. aluminum industry

Permalink

<https://escholarship.org/uc/item/1rk6335v>

Author

Elser, Holly

Publication Date

2019

Peer reviewed|Thesis/dissertation

Gender, blue-collar work, and depression in the U.S. aluminum industry

By

Holly Constance Elser

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Epidemiology

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Ellen A. Eisen, Chair

Professor Mark R. Cullen

Professor Arthur L. Reingold

Professor Nicholas P. Jewell

Professor Daniel J. Schneider

Spring 2019

Abstract

Gender, blue-collar work, and depression in the U.S. aluminum industry

By

Holly Constance Elser

Doctor of Philosophy in Epidemiology

University of California, Berkeley

Professor Ellen A. Eisen, Chair

Work has long been recognized as a fundamental determinant of health, and stressful work is linked with symptoms of psychiatric illness such as distress, sadness, hopelessness, and depressive disorder. Blue-collar work emerges in the literature as an important example of this connection. Not only do repetitive, monotonous, and physically demanding tasks predispose workers to disability and injury, the erratic schedules and long hours oftentimes associated with blue-collar jobs may uniquely predispose workers to depression. Blue-collar jobs, in contrast with clerical and white-collar jobs, are also frequently characterized by exposure to a range of physical hazards, including heat, noise, chemicals, and particulate matter.

Women now represent over one-fourth of the 12 million workers in manufacturing jobs in the U.S. Female blue-collar workers may have less opportunity to adjust work demands or modify their duties following injury and take longer work-related sick leave. However, our current understanding of the effects of blue-collar work on mental health outcomes, such as depression are based largely on the experiences of men. Because depression is more common and more persistent in women, the lack of evidence regarding risk for depression among female blue-collar workers constitutes an important gap in the literature.

In response, this dissertation is focused on the implications of gender and aspects of the work environment for the mental health of workers in the U.S. aluminum industry. The American Manufacturing Cohort (AMC) study database is comprised of multiple, linked administrative datasets that collectively provide detailed, longitudinal follow-up for understanding work-life exposures, health and economic outcomes in a cohort of U.S. light and specialty metals workers. The study data are the product of an academic-corporate partnership forged in 1997 between Alcoa, Inc. and the Occupational and Environmental Medicine Program at the Yale University School of Medicine with the goal of incorporating research findings into company policy in an effort to improve worker safety. Study data consist of several distinct administrative datasets, and records for individual workers can be deterministically linked across datasets with a unique, encrypted identifier. Complete medical claims data are available for workers enrolled in their local preferred provider organization (PPO) health insurance plan (approximately 97% of the workforce). The analyses described herein are based on records from 30,035 men and 7,148 women employed in blue- and white-collar jobs by Alcoa Inc. between January 2003 and

December 2013. They are the first to explicitly focus on the experiences of blue-collar women in the AMC Study.

For Chapter 1, I compare trends in depression by gender and occupational class in the study population of 37,183 workers. Chapters 2 and 3 are focused only on blue-collar workers. For Chapter 2, I characterize the association between the workplace gender composition and treatment for depression among male and female blue-collar workers. More specifically, I use g-computation to estimate risk differences that contrast the predicted risk of treatment for depression under hypothetical interventions on gender composition as compared with the observed data. Finally, in Chapter 3 I examine the effects of layoffs on remaining blue-collar workers' use of mental healthcare services and injury risk with a difference-in-differences approach. Collectively, these three chapters provide a novel examination of the association between specific aspects of blue-collar work and risk for depression, with an emphasis on the unique experiences of women, in an unusually rich and unique administrative database.

TABLE OF CONTENTS

I. DEDICATION	iii
II. ACKNOWLEDGEMENTS	iv
III. FUNDING	vi
IV. INTRODUCTION.....	vii
Overview - occupational class and health.....	vii
Blue-collar work, job strain, and mental health.....	vii
The changing world of work	viii
Gender discrimination in the changing world of work	viii
Female blue-collar workers and the implications for mental health	ix
Motivating the study of women in blue-collar jobs	x
References	xi
1. Gender, occupational class, and blue-collar work: A retrospective cohort study of U.S. aluminum manufacturers	
1.1 Abstract.....	2
1.2 Introduction	2
1.3 Methods.....	3
1.4 Results	6
1.5 Discussion	7
1.6 Conclusion.....	9
1.7 Tables and Figures.....	11
<i>Table 1</i>	<i>11</i>
<i>Table 2</i>	<i>12</i>
<i>Table 3</i>	<i>13</i>
<i>Table 4</i>	<i>14</i>
<i>Table 5</i>	<i>15</i>
<i>Figure 1.....</i>	<i>16</i>
1.8 Supplemental Materials.....	17
1.9 References	25
2. Workplace gender composition and treatment for depression among men and women in the U.S. aluminum industry	
2.1 Abstract.....	29
2.2 Introduction	29
2.3 Methods.....	30
2.4 Results	32
2.5 Discussion.....	33
2.6 Conclusion.....	34

2.7 Tables and Figures.....	36
<i>Table 1</i>	36
<i>Figure 1</i>	37
<i>Figure 2</i>	38
<i>Figure 3</i>	39
2.8 Supplemental Materials.....	40
2.9 References	51
3. Layoffs and the mental health and safety of remaining workers: A quasi-experimental study of the U.S. aluminum industry	
3.1 Abstract.....	55
3.2 Introduction	55
3.3 Methods.....	56
3.4 Results	58
3.5 Discussion.....	59
3.6 Conclusion.....	60
3.7 Tables and Figures.....	62
<i>Table 1</i>	62
<i>Figure 1</i>	63
<i>Figure 2</i>	64
<i>Figure 3</i>	65
3.8 Supplemental Materials.....	66
3.9 References	76
4. Conclusion	78

I. DEDICATION

For my parents, Jeanne Derderian and Jim Stewart, the two people in this world that I admire most. Thank you for teaching me to be curious.

II. ACKNOWLEDGEMENTS

I am indebted to so many friends, colleagues, and mentors who have been a constant source of support and encouragement over the past four years. First and foremost, I want to thank my dissertation chair and mentor, Ellen Eisen. Thank you for keeping your door open, for helping me work through problems both big and small, and for encouraging me to continue to learn and challenge myself intellectually. You are the professional example to which I aspire. I also would like to express my gratitude towards Mark Cullen, who took a chance on a precocious second year medical student with aspirations of becoming an epidemiologist. It has been a privilege to work with the AMC data, and I have benefitted enormously from your insight and expertise. I am also indebted to David Rehkopf, who has supported me throughout virtually every analysis I have undertaken as a doctoral student. Your perspective and your encouragement are invaluable, and I look forward to many future collaborations.

I would also like to thank my advisor Art Reingold for helping me to navigate the PhD program at Berkeley and for understanding the tensions between my dual roles as doctoral and medical student; Ray Catalano for always having my best interest and scholarship in mind; and Patrick Bradshaw for his generous and frequent provision of excellent statistical advice. I would like to thank my dissertation committee, including Nick Jewell, whose commitment to meaningful, applied research I admire. I am also grateful to Danny Schneider, who was endlessly patient as I fumbled my way through advanced courses in sociology and who has helped and encouraged me to understand the broader social context in which the questions I ask are situated.

I have been fortunate to work with two diverse and talented groups of scholars at the UC Berkeley School of Public Health and the Stanford Center for Population Health Sciences through the AMC Research Consortium. I am grateful to Andreas Neophytou, Sadie Costello, Sally Picciotto, Mary Combs, Liza Lutzker, Betsey Noth, and Jackie Ferguson at Berkeley, and to Sepideh Modrek, Rita Hamad, Amal Harrati, Suzanne Tamang, and April Falconi at Stanford. All of you have helped me develop as a scholar and strengthen and focus my research questions both substantively and methodologically. In particular, I am grateful to Erika Tribett for her friendship and support through various starts and setbacks, and to Valerie Meausoone, without whom I'm not sure I ever would have learned my way around the various AMC datasets or how to program in R.

My friends and family have offered ceaseless support throughout my time as a doctoral student. I have relied regularly on advice, expertise, and reassurance from my three incredible friends and colleagues, Ellicott Matthay, Joan Casey, and Dana Goin. I look forward to watching your brilliant careers for many years to come. I have also been delighted and surprised to have many conversations with my father, an artist, in which we have discussed the challenges common to both writing academic papers and oil paintings. Finally, I am eternally grateful to my husband Matt for his patience and support over the past four years. He has listened intently as I recount the small victories and challenges of my day-to-day research activities, has heard enough shop-talk to tell the story of John Snow and the Broad Street Pump in perfect detail, and has even helped me trouble-shoot R code. Words cannot express how much I appreciate you.

Most of all, I am indebted to the men and women of Alcoa, Inc. Although we will never meet, you have been among my most important teachers.

I would also like to acknowledge the co-authors on my dissertation publications. Their expertise, feedback, and mentorship were integral to this work.

1. Gender, occupational class, and depression: A retrospective cohort study of U.S. aluminum manufacturers.

Elser H, Rehkopf DH, Meausoone V, Jewell NP, Eisen EA, Cullen MR

Accepted for publication in *Epidemiology*, January 30, 2019

2. Workplace gender composition and treatment for depression among men and women in the U.S. aluminum industry

Elser H, Rehkopf DH, Bradshaw PT, Brick C, Schneider DJ, Eisen EA, Cullen MR

Submitted.

3. Layoffs and the mental health and safety of remaining workers: A quasi-experimental study of the U.S. aluminum industry

Elser H, Ben-Michael E, Rehkopf DH, Modrek S, Eisen EA, Cullen MR

Submitted.

III. FUNDING

This research was supported by the National Institute on Mental Health grant F31 MH 112246; the National Institute on Aging grant R01 AG 026291; and by the National Institute on Occupational Safety and Health R01 OH 009939. The conclusions expressed are solely those of the authors. The authors have no conflicts of interest to report.

IV. INTRODUCTION

Overview – occupational class and health

Epidemiologists have long recognized that working conditions have a profound impact on health and well-being.¹ The landmark Whitehall studies of the 1970s demonstrated an inverse association between occupational class and health among British civil servants, wherein those in higher occupational strata enjoyed decreased risk of cardiovascular disease and all-cause mortality as compared with civil servants with less prestigious, less remunerative positions.²⁻⁵ An inverse association between occupational class and disease risk has since been replicated in study populations from most wealthy countries.⁶ Factors such as lifestyle differences and exposure to overt workplace hazards (i.e. physical demand, particulate matter, chemicals, heat, and noise exposure) cannot fully explain health gradients by occupational class.^{5,7,8} Differences in health could plausibly reflect reverse causality – with systematic attainment of lower class by those with poor health or adverse health risk profiles⁹ – but notions of reverse causality cannot be reconciled with the simple fact that most low-grade jobs require demonstrable physical capabilities and reasonably good health.¹⁰

Robert Karasek's subsequent *Demand-Control Model* is one commonly referenced theoretical framework that links specific aspects of occupational class with worker health. According to the Karasek model, *job strain* is conceptualized by two orthogonal dimensions: decision latitude (control) and psychological demand. Relevant to the study of occupational class and health, the Karasek model acknowledges that not all jobs with low levels of psychological demand are healthy. It is instead the interaction with the amount of control that matters, and those jobs that combine high demand with low control are expected to result in the greatest *job strain* and resultant risk to worker health.¹¹

Blue-collar work, job strain, and mental health

Although the Karasek model was originally applied to the study of cardiovascular disease, multiple studies have since reported associations between job strain and a range of additional outcomes including sickness absence, medication use, and other physical and psychological symptoms.¹²⁻¹⁹ There is also consistent evidence linking job-strain and symptoms of psychiatric illness.^{20,21} Cross-sectional studies reveal strong links between job strain and workers' statements about life being boring, useless, hard, enjoyable, or rewarding.¹¹ In particular, unsupportive workplace relationships²²⁻²⁷ and lack of job control^{25,28} are risk factors for depression. High job demand^{23,24,27,29,30}, characterized by high levels of physical or mental effort or by fast-paced and repetitive work, is another such risk factor. Work-related stress is associated with increased risk for depression in cross-sectional studies³¹, even after controlling for general measures of stress.³² Longitudinal studies also supports a strong connection between work-related stress and symptoms of major depressive disorder.²⁰

Blue-collar work in particular emerges in the literature as an important example of this connection. The monotonous, repetitive, and highly physical nature of many blue-collar jobs (i.e. manufacturing, mining, and construction), coupled with oftentimes demanding and inflexible schedules, may predispose workers to psychiatric distress, depression, and anxiety. In one study of Italian blue-collar workers, high demand significantly increased depression risk for blue-collar workers,²³ as did excessive overtime and requirements to work quickly.²⁴ One previous study also found that the association between negative work-related events (i.e. business readjustment, changes in working hours) and anxiety was greater for blue-collar versus white-collar workers.³³

The changing world of work

A deeper understanding of the complex and dynamic relationship between working conditions and individual health outcomes requires consideration of secular trends in the demographic characteristics of workers and profound macrostructural shifts in the US economy that have occurred over the past half-century. First, women's civilian labor force participation grew steadily from 34.8% in 1965 to 48.6% in 2015.^{34,35} The rise in women's labor supply has been attributed to factors such as growth in real wages for women; falling discrimination, as evidenced by the elimination of marriage bars; growth in the clerical sector; the growing demand for highly skilled workers; and labor-saving household technology.³⁶⁻³⁹ Strong quasi-experimental evidence also suggests that in the social, legal, and economic context of the 1960s and 1970s, early access to the birth control pill provided a powerful tool for women wishing to capitalize on emergent labor market opportunities.^{37,38}

The feminization of the workforce is coincident with three major qualitative changes in the US labor market since the 1970s that are also of substantial interest. The first is the rise in relative wages of nonproduction workers in the 1980s. This trend is attributed largely to technological innovation in the latter part of the twentieth century that resulted in increased demand for skilled labor.⁴⁰ Notably, the “upskilling” of labor took place predominantly in jobs held by women, and conferred additional preferential advantage to women who, on average, had attained higher levels of education than men by this time.⁴¹

The second change is a profound shift in power away from employees and towards the employer. Unions declined over the latter part of the twentieth century, weakening a traditional source of institutional protections for workers and helping to sever the postwar business-labor social contract. Union decline and deregulation reduced the countervailing forces that had enabled workers to share in the productivity gains that were made.^{42,43} The resultant shift in power away from employees was intensified by neoliberal globalization, which increased the amount of competition faced by companies, provided greater opportunities to outsource work to lower-wage countries, and opened up new labor pools through immigration. Employers have increasingly sought flexibility in their relations with workers, which has accelerated the growth of precarious work characterized by uncertainty, low wages, limited social benefits and statutory entitlements.⁴⁴

Gender discrimination in the changing world of work

While women's accelerated labor force participation reflects expanded work opportunities and relaxed norms, an extensive social sciences literature registers fundamental and persistent differences in men and women's labor market experiences across occupations. Specifically, women experience measurable social and economic discrimination across occupations as compared to their male counterparts.

First, it is clear that women, on average, earn less than men in virtually every single occupation for which there is sufficient data to calculate an earnings ratio, with female full-time workers earning only 79 cents for every dollar earned by men in 2014.⁴⁵ The gender pay gap is attributed to occupational sex-segregation;⁴⁶ vertical divisions of labor in which men are more likely to occupy higher ranks than women;^{47,48} and wage-penalties associated with motherhood. The persistence of the gender wage gap into the twenty-first century is worrisome. Not only do relative earnings signify how individuals are valued socially and economically, but earnings are

also a summary statistic for an individual's education, training, prior labor force experience, and expected future labor force participation.³⁹

Second, it has been demonstrated that women tend to perform more labor at home, in addition to paid work performed in the formal sector, and usually take primary responsibility for family well-being.^{49,50} Major studies on household time use conducted in the 1960s and 1970s revealed that women worked roughly an extra month of twenty-four hour days per year relative to their male partners and spouses.⁴⁵ Thus, while employment adds obligations to a woman's life, there is seldom any compensatory decrease in her domestic tasks.

Even women who work full-time still assume a disproportionate amount of the domestic burden as compared to men.⁵¹⁻⁵³ Work-related discrimination may carry consequences for women's mental health: having multiple roles (domestic and occupational) entails greater responsibility, time pressure, and ultimately, greater stress. Female workers typically report lower self-rated health as compared with male workers,⁵¹ and measurements of stress levels show that whereas men generally unwind rapidly at the end of the working day, women's stress levels remain high after work, particularly if they have children living at home.^{54,55}

Female blue-collar workers and the implications for mental health

The study of blue-collar women is motivated by early work linking increased job demand – whether psychological or physical – with inferior health; by demographic and macrostructural economic trends over the past half-century that have increased women's participation in historically male-dominated industries and occupations; and by persistent evidence of women's experience of social and economic discrimination as compared with male workers across the U.S. labor market. In the United States, women now comprise more than one fourth (27%) of the 12 million person manufacturing workforce,⁵² and the number of women in the manufacturing workforce is projected to increase globally and locally.^{52,53} Accelerated entry of women into historically male-dominated blue-collar jobs in recent decades is attributed to factors including organizational changes and benefits associated with blue-collar work, such as better pay, fringe benefits, training, and promotional opportunities.^{54,55} However, our knowledge regarding the unique health risks blue-collar work may pose to women in present-day work settings is decidedly limited.

Epidemiologic evidence consistently suggests that female blue-collar workers are more susceptible to physical injury as compared with their male counterparts. Anthropometric differences between men and women – men are taller, larger, heavier, and stronger than women on average – may equate to increased physical demand if tools, equipment, and arrangements in historically male-dominated workplaces are optimized for male rather than for female workers.⁵⁶⁻⁵⁸ Consistent with Karasek's *Demand-Control Model*, the increased physical demand places female workers at higher risk for injuries requiring first aid, medical treatment and work restriction even after adjusting for job, plant type and tenure (length of employment).⁵ Women also take longer periods of work-related sick leave on average as compared to male blue-collar workers.⁵⁹ Higher injury risk for women in both smelting and fabricating environments has also been demonstrated among workers employed by a multinational aluminum manufacturing company across 15 facilities from 2001 to 2010.⁵

Beyond physical risk, women may experience unique work-related psychosocial stress in blue-collar work environments. It is important to recognize that women's increased labor force

participation coincides temporally with deunionization and the resultant disappearance of well-compensated, unskilled manual labor. Attitudes towards female workers in blue-collar jobs may therefore be hostile, and there is evidence that female blue-collar workers may feel extra pressure to take risks in order to prove that they are able to do their jobs.⁶⁰ Further, workplace-based sexual harassment and sex discrimination are thought to be prevalent within historically male-dominated occupations. Consequently, female blue-collar workers' ability to interact socially and establish meaningful relationships in the workplace may be hindered with a preponderance of male coworkers or a male supervisor. Workplaces with higher percentages of female employees, in contrast, may reflect more progressive attitudes from management regarding women's capacity to execute blue-collar work successfully.

Finally, with recent declines in both the manufacturing sector and the bargaining power of unions, blue-collar jobs have become increasingly precarious. The resultant threat of job loss – whether from layoffs, curtailments, or plant closures – may have substantively different effects on the mental health of male and female workers given systematic differences in subsequent employment opportunity and economic constraints related to childcare or elder care.^{61,62}

Motivating the study of women in blue-collar jobs

Although female blue-collar workers face a unique set of challenges – ranging from physical stressors to scheduling demands – that may predispose them to poor mental health, the existing research on blue-collar work and depression largely fail to consider the experiences of female workers.⁶³⁻⁶⁵ Between 1990 and 2015, only four cross-sectional studies reported findings on mental health outcomes among female blue-collar workers. These studies are limited by their inclusion of only a very modest number of female blue-collar workers, and their reliance on cross-sectional design raises questions about temporality.⁶⁶ Nevertheless, they consistently find that blue-collar women have more depressive symptoms than professional women.⁶⁷ Factors such as having to overcompensate at work, increased responsibility, underutilization of skills, sexual harassment, and gender-based discrimination from supervisors and coworkers all predisposed female blue-collar workers to psychological distress.⁶⁸

The literature-to-date regarding the mental health of women in blue-collar jobs therefore leaves unanswered important questions regarding the magnitude of the association between the work environment and depression among blue-collar female workers, and the specific mechanisms by which the work environment may uniquely predispose female blue-collar workers to depression. It must be stated explicitly that findings on depression risk among female blue-collar workers should not be used to justify job segregation or inequitable health promotion measures, but rather should be used to design interventions that promote the health, wellbeing, and productivity of all workers. With this latter objective in mind, this dissertation is focused on examining work-related risk factors for depression among men and women employed in present-day industrial blue-collar jobs, with a particular emphasis on the experiences of blue-collar women.

References

1. Berkman LF, Kawachi I, Theorell T. Working Conditions and Health. In: Berkman LF, Kawachi I, Glymour MM, eds. *Social Epidemiology*. 2nd Edition. New York: Oxford University Press; 2014. p. 95-117.
2. Marmot MG, Adelstein AM, Robinson N, Rose GA. Changing social-class distribution of heart disease. *BMJ*. 1978;2(6145):1109 - 12.
3. Marmot MG, Rose G, Shipley M, Hamilton PJ. Employment grade and coronary heart disease in British civil servants. *J Epidemiol Commun H*. 1978;32(4):244-9.
4. Marmot MG, Shipley MJ. Do socioeconomic differences in mortality persist after retirement? 25 year follow up of civil servants from the first Whitehall study. *BMJ*. 1996;313(7066):1177-80.
5. Marmot MG, Smith G. Health inequalities among British civil servants in the Whitehall II study. *Lancet*. 1991;337(8754):1387-94.
6. Mackenbach JP, Stirbu I, Roskam A-JR, Schaap MM, Menvielle G, Leinsalu M, Kunst AE. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med*. 2008;358(23):2468-81.
7. MacDonald LA, Cohen A, Baron S, Burchfiel CM. Occupation as socioeconomic status or environmental exposure? A survey of practice among population-based cardiovascular studies in the United States. *Am J Epidemiol*. 2009;169(12):1411-21.
8. Cullen MR. Invited commentary: the search for preventable causes of cardiovascular disease—whither work? *Am J Epidemiol*. 2009;169(12):1422-5.
9. Clougherty JE, Souza K, Cullen MR. Work and its role in shaping the social gradient in health. *Ann Ny Acad Sci*. 2010;1186(1):102-24.
10. Bartley M. Unemployment and health: selection or causation--a false antithesis? *Sociol Health Ill*. 1988;10(1):41-67.
11. Karasek RA. Job demands, job decision latitude, and mental strain: Implications for job redesign. *Admin Sci Quart*. 1979;285-308.
12. Coburn D. Job-worker incongruence: consequences for health. *J Health Soc Behav*. 1975;16(2):198-212.
13. Baker DB. The study of stress at work. *Annu Rev Pub Health*. 1985;6(1):367-81.
14. Hackman JR, Lawler EE. Employee reactions to job characteristics. *J Appl Psychol*. 1971;55(3):259-86.
15. Hackman JR, Oldham GR. Development of the job diagnostic survey. *J Appl Psychol*. 1975;60(2):159-170.
16. Jenkins CD. Recent evidence supporting psychologic and social risk factors for coronary disease. *N Engl J Med*. 1976;294(18):987-94.
17. Kristensen TS. Cardiovascular diseases and the work environment: a critical review of the epidemiologic literature on nonchemical factors. *Scand J Work Env Health*. 1989;15(3):165-79.
18. Karasek RA, Theorell T, Schwartz JE, Schnall PL, Pieper CF, Michela JL. Job characteristics in relation to the prevalence of myocardial infarction in the US Health Examination Survey (HES) and the Health and Nutrition Examination Survey (HANES). *Am J Public Health*. 1988;78(8):910-8.
19. Alfredsson L, Karasek RA, Theorell T. Myocardial infarction risk and psychosocial work environment: an analysis of the male Swedish working force. *Soc Sci Med*. 1982;16(4):463-7.

20. Pieper CF, LaCroix AZ, Karasek RA. The relation of psychosocial dimensions of work with coronary heart disease risk factors: a meta-analysis of five United States data bases. *Am J Epidemiol.* 1989;129(3):483-94.
21. Eaton WW, Muntaner C, Bovasso G, Smith C. Socioeconomic status and depressive syndrome: the role of inter-and intra-generational mobility, government assistance, and work environment. *J Health Soc Behav.* 2001;42(3):277.
22. Kawakami N, Araki S, Kawashima M. Effects of job stress on occurrence of major depression in Japanese industry: A case-control study nested in a cohort study. *J Occup Environ Med.* 1990;32(8):722-5.
23. d'Errico A, Cardano M, Landriscina T, Marinacci C, Pasian S, Petrelli A, Costa G. Workplace stress and prescription of antidepressant medications: A prospective study on a sample of Italian workers. *Int Arch Occ Env Hea.* 2011;84(4):413 - 424.
24. Eaton WW, Muntaner C, Sapag JC. Socioeconomic Stratification and Mental Disorder. In: Horwitz AV, Scheid TL, eds. *A Handbook for the Study of Mental Health.* 2nd Edition. New York, NY: Cambridge University Press; 1999. p 259-83.
25. Cohidon C, Santin G, Imbernon E, Goldberg M. Working conditions and depressive symptoms in the 2003 decennial health survey: The role of the occupational category. *Soc Psych Psych Epid.* 2010;45(12):1135-47.
26. Inoue A, Kawachi I. Interpersonal conflict and depression among Japanese workers with high or low socioeconomic status: Findings from the Japan work stress and health cohort study. *Soc Sci Med.* 2010;71(1):173-80.
27. Niedhammer I, Davis S, Degioanni S. Association between workplace bullying and depressive symptoms in the French working population. *J Psychosom Res.* 2006;61(2):251-9.
28. Kawamaki N, Haratani T, Araki S. Effects of perceived job stress on depressive symptoms in blue-collar workers of an electrical factory in Japan. *Scand J Work Env Health.* 1992;18(3):195-200.
29. Niedhammer I, Goldberg M, Leclerc A, Bugel I, David S. Psychosocial factors at work and subsequent depressive symptoms in the Gazel cohort. *Scand J Work Env Health.* 1998;24(3):197-205.
30. DeSanto IJ, Cullen MR, Cantley L, Slade MD, Fiellin M, Kasl SV. Effects of externally rated job demand and control on depression diagnosis claims in an industrial cohort. *Am J Epidemiol.* 2010;171(3):303-11.
31. Kleppa E, Sanne B, Tell GS. Working overtime is associated with anxiety and depression: The Hordaland Health Study. *J Occup Environ Med.* 2008;50(6):658-66.
32. Kivimäki M, Kalimo R. Self-esteem and the occupational stress process: testing two alternative models in a sample of blue-collar workers. *J Occup Health Psychol.* 1996;1(2):187-96.
33. Rose RC, Beh L, Uli J, Idris K. Quality of work life: Implications of career dimensions. *J Soc Sci.* 2006;2(2):61-7.
34. U.S. Bureau of Labor Statistics. Women in the labor force: a databook. Available from: <https://www.bls.gov/opub/reports/womens-databook/2016/home.htm>. Accessed April 2019.
35. U.S. Bureau of Labor Statistics. Spotlight on Statistics: Women at work. Available from: <https://www.bls.gov/spotlight/2017/women-at-work/home.htm>. Accessed April 2019.
36. Costa DL. From Mill Town to Board Room: The Rise of Women's Paid Labor. *J Econ Perspect.* 2000;14(4):101-22.
37. Bailey MJ. More Power to the Pill: The Impact of Contraceptive Freedom on Women's Life Cycle Labor Supply. *Q J Econ.* 2006;121(1):289-320.

38. Bailey MJ. "Momma's Got the Pill": How Anthony Comstock and *Griswold v. Connecticut* Shaped US Childbearing. *Am Econ Rev.* 2010;100(1):98-129.
39. Goldin C. A grand gender convergence: its last chapter. *Am Econ Rev.* 2014;104(4):1-30.
40. Berman E, Bound J, Griliches Z. Changes in the demand for skilled labor within US manufacturing: Evidence from the annual survey of manufacturers. *Q J Econ.* 1994;109(2):367-97.
41. Gregory M. Gender and economic inequality. In: Nolan B, Salverda W, Smeeding TM, eds. *The Oxford Handbook of Economic Inequality*. New York: Oxford University Press; 2011. p. 285 - 314.
42. Kalleberg AL. Precarious Work, Insecure Workers: Employment Relations in Transition. *Am Sociol Rev.* 2009;74(1):1-22.
43. Kalleberg AL. Job Quality and Precarious Work: Clarifications, Controversies, and Challenges. *Work and Occupation.* 2012;39(4):427-48.
44. Arnold D, Bongiovi JR. Precarious, Informalizing, and Flexible Work: Transforming Concepts and Understandings. *Am Behav Sci.* 2012;57(3):289-308.
45. Hochschild A, Machung A. *The Second Shift: Working Families and the Revolution at Home*. New York: Penguin Books, 2012.
46. Messing K, Elabidi D. Desegregation and occupational health: How male and female hospital attendants collaborate on work tasks requiring physical effort. *Pol Pract Health Saf.* 2003;1(1):83-103.
47. Bird CE, Fremond AM. Gender, time use, and health. *J Health Soc Behav.* 1991;32(2):114-29.
48. Adams GA, King LA, King DW. Relationships of job and family involvement, family social support, and work-family conflict with job and life satisfaction. *J Appl Psychol.* 1996;81(4):411-20.
49. Frone MR. Work-family conflict and employee psychiatric disorders: The national comorbidity survey. *J Appl Psychol.* 2000;85(6):888-95.
50. Frankenhaeuser M, Lundberg U, Fredrikson BM, Toumisto M, Myrsten AL. Stress on and off the job as related to sex and occupational status in white-collar workers. *J Organ Behav.* 1989;10:321-46.
51. Lundberg U, Frankenhaeuser M. Stress and workload in men and women in high ranking position. *J Occup Health Psych.* 1999;4(2):142-51.
52. Zahm SH, Pottern LM, Lewis DR, Ward MH, White DW. Inclusion of women and minorities in occupational cancer epidemiological research. *J Occup Med.* 1994;36(8):842-7.
53. United States Department of Labor Bureau of Labor Statistics. Women in the Labor Force: A Databook, December 2011. Available from: <http://www.bls.gov/cps/wlf-databook-2011.pdf>. Accessed April 2019.
54. Lederer M. Blue-Collar Jobs for Women. *Nat F.* 1981;61(4):20.
55. Palmer HT, Lee JA. Female workers' acceptance in traditionally male-dominated blue-collar jobs. *Sex Roles.* 1999;22(9-10):607-26.
56. Messing K, Stevenson J. Women in procrustean beds: Strength testing and the workplace. *Gend Work Organ.* 1996;3(3):156-67.
57. Blue CL. Women in nontraditional jobs: Is there a risk for musculoskeletal injury? *Workplace Health Saf.* 1993;41(5):235-40.
58. Courville J, Vézina N, Messing K. Comparison of the work activity of two mechanics: a woman and a man. *Int J Ind Ergonom.* 1991;7(2):163-74.

59. Messing K, Ostlin P. Gender equality, work, and health: a review of the evidence. Available from: http://www.who.int/occupational_health/publications/genderwork/en. Accessed April 2019.
60. Department of Mental Health and Substance Dependence. Gender Disparities in Mental Health. Available from: http://www.who.int/mental_health/media/en/242.pdf. Accessed April 2019.
61. Prévost J, Messing K. Stratégies de conciliation d'un horaire de travail variable avec des responsabilités familiales. *Le Travail Humain*. 2001;64(2):119-43.
62. Tausig M. The sociology of work and well-being. In: Aneshensel CS, Phelan JC, Bierman A, eds. *Handbook of the Sociology of Mental Health*. 2nd Edition. New York, NY: Springer; 2013. p 433-455.
63. Maffeo PA, Ford TW, Lavin PF. Gender differences in depression in an employment setting. *J Pers Assess*. 1990;55(1-2):249-62.
64. Niedhammer I, Saurel-Cubizolles MJ, Piciotti M, Bonenfant S. How is sex considered in recent epidemiological publications on occupational risks? *Occup Environ Med*. 2000;57(8):521-7.
65. Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm SH, Wegman D, Sctock SR, de Grosbois S. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med*. 2003;43(6):618-29.
66. Elser H, Falconi AM, Bass M, Cullen MR. Blue-collar work and women's health: A systematic review of the evidence from 1990 to 2015. *SSM Popul Health*. 2018;6:195-244.
67. Riley AL, Keith VM. Work and housework conditions and depressive symptoms among married women: the importance of occupational status. *Women Health*. 2004;38(4):1-17.
68. Goldenhar LM, Swanson NG, Hurrell JJ, Ruder A, Deddens J. Stressors and adverse outcomes for female construction workers. *J Occup Health Psych*. 1998;3(1):19.

Chapter 1: Gender, occupational class, and blue-collar work: a retrospective cohort study of U.S. aluminum manufacturers

1.1 Abstract

Industrial blue-collar workers face multiple work-related stressors, but evidence regarding the burden of mental illness among today's blue-collar men and women remains limited. In this retrospective cohort study, we examined health and employment records for 37,183 blue- and white-collar workers employed by a single U.S. aluminum manufacturer from 2003 - 2013. Using Cox proportional hazards regression, we modeled time to first episode of treated depression by gender and occupational class. Among cases, we modeled rates of depression-related service use with generalized gamma regression. Compared with their white-collar counterparts, blue-collar men were more likely to be treated for depression (HR = 1.3, 95% CI 1.1 - 1.4) as were blue-collar women (HR = 1.4, 1.2 - 1.6). Blue-collar women were most likely to be treated for depression as compared with white-collar men (HR = 3.2, 95% CI 2.1 - 5.0). However, blue-collar workers used depression-related services less frequently than their white-collar counterparts among both men (RR = 0.91, 95% CI 0.84 - 0.98) and women (RR = 0.82, 95% CI 0.77 - 0.88). Blue-collar workers were more likely to be treated for depression compared with white-collar workers, and blue-collar women were most likely to be treated for depression compared with white-collar men. However, blue-collar men and women used depression-related healthcare services less frequently than white-collar workers. These findings underscore that blue-collar women may be uniquely susceptible to depression and suggest that blue-collar workers encounter barriers to care-seeking related mental illness other than insurance status.

1.2 Introduction

Increased risk of psychiatric distress is consistently observed among workers of lower occupational strata.¹⁻³ Similarly, prior research finds increased risk for depression and anxiety among industrial blue-collar workers compared with white-collar workers.⁴ Trends such as these may be explained by the fact that a predisposition towards mental illness leads to downward social mobility into blue-collar jobs (i.e. "drift") or precludes the attainment of socioeconomic position that otherwise might be expected (i.e. "selection"). Alternatively, aspects of blue-collar work may increase the risk of mental illness through an etiologic process or prolong the duration of symptoms.⁵⁻⁷ These processes may work simultaneously to increase the burden of depression among blue-collar workers,² although most longitudinal analyses of depression suggest socioeconomic position plays an etiologic role in the onset of depression.⁸⁻¹¹ Indeed, past research identifies several aspects of blue-collar jobs – including physical demand; their monotonous, repetitive nature; oftentimes inflexible and demanding work hours; negative coworker interactions; and requirements to work quickly – as independent risk-factors for depression and anxiety.¹²⁻¹⁶

The existing literature on blue-collar workers' mental health faces at least two notable limitations, however. First, findings from present-day working-class populations remain scarce despite labor trends that have fundamentally altered the nature of blue-collar jobs over the past 30 years. In the United States, these trends include industry deregulation; technological innovations (computerization and automation); union decline and weakened institutional protections for workers; and an overall decline in manufacturing.¹⁷⁻²¹ The net effect of these trends is that blue-collar jobs are increasingly scarce and decreasingly characterized by the benefits and entitlements that once made them desirable.

Second, past research also largely fails to consider the mental health of women in industrial blue-collar jobs. Even within occupations, women often have different experiences with respect to pay, promotion, and assigned tasks as compared with men.^{22,23} Women in blue-collar jobs may face a wide range of additional stressors including increased physical strain if tools and work arrangements are not optimized for female anthropometrics;^{22,24,25} workplace-based sexual harassment and sex discrimination from managers and coworkers;²⁶⁻²⁹ increased job insecurity and lack of control over work;^{28,30} and greater conflict between work schedules and family obligations.^{31,32} Careful study of female blue-collar workers' mental health should be further motivated by the fact that women now constitute a substantial proportion of the U.S. manufacturing workforce (approximately 29% in 2013),³³ and that in the general population, risk of mood disorders is approximately doubled in women compared with men.³⁴⁻³⁶

In this retrospective cohort study, we characterize trends in depression by gender and occupational class among 37,183 men and women employed by a single U.S. aluminum manufacturer between 2003 and 2013. Because of substantive changes in blue-collar work in recent decades and the additional stressors faced by women in these jobs, our focus is on occupational class, which relates to social relations of ownership and control over productive assets, rather than occupational status, which refers to the ordering of persons along a continuum based on their socioeconomic attributes.⁷ To that end, white-collar workers constitute an appropriate comparison group insofar as their jobs are less likely to be characterized by isolation, temporal inflexibility, physical demand, or gender discrimination.

Our study had two primary scientific objectives. First, we modeled time to first episode of treated depression over the course of the study period by gender and occupational class. Second, among workers who experienced at least one episode of treated depression, we compared rates of monthly depression-related service use by gender and occupational class. We hypothesized *a priori* that, due to factors such as selection, drift, and the wide range of stressors associated with blue-collar jobs, both male and female blue-collar workers would be more likely to experience depression and would use depression-related services more frequently than their counterparts in white-collar jobs.

1.3 Methods

Study Population and Design

We conducted a retrospective cohort study of workers employed by a single firm at one of 32 U.S. aluminum plants between January 1, 2003 and December 31, 2013. Study data consisted of distinct administrative datasets. Records for individual workers were deterministically linked across datasets with a unique, encrypted identifier. Complete medical claims data were available for workers enrolled in their local preferred provider organization (PPO) health insurance plan. We therefore examined health and employment records for all personnel who were actively employed and enrolled in their local PPO plan for at least one month throughout the study period (approximately 97% of workers). Plan characteristics for this study population have been described in detail previously, and local PPO plans were identical with respect to coverage, including psychiatric services, and differed only with respect to family coverage and deductible rates.³⁷

Follow-up for each worker extended from the date they first became eligible for insurance (on or after January 1, 2003) until either the end of eligibility or 31 December 2013. We restricted our

cohort to workers between the ages of 18 and 65 at the start of follow-up. To ensure that retirees were excluded from our analysis, we further restricted our sample to workers hired after 1 January 1975 with activity in their employment records within three years of the date they first became eligible.

Occupational Class

Occupational class was ascertained from company personnel files. Consistent with previous analysis of these data, we classified hourly workers as blue-collar and salaried employees as white-collar.^{38,39}

Depression Measures

We created two separate measures of depression using primary outpatient diagnostic codes from the International Classification of Diseases, Ninth Revision (ICD-9) and records of filled prescriptions from medical claims. We included ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311 and prescriptions for antidepressants included selective serotonin reuptake inhibitors (SSRI), selective norepinephrine reuptake inhibitors (SNRI), tricyclic antidepressants (TCAs), and monoamine oxidase inhibitors (MAOIs).

We first created a case definition for treated depression, which included all workers with at least two depression-related outpatient visits *or* two prescribed antidepressants within 365 days at any point throughout the study period. We defined the date of the first episode of treated depression as the date of the second prescribed antidepressant or the second depression-related outpatient visit (whichever came first). We intended this case definition to be sufficiently flexible so as to capture workers who were being actively treated for depression through pharmacotherapy but not billed with a depression-specific ICD-9 code by their provider. Because study data lacked additional information regarding workers' past histories of mental illness, we were unable to differentiate between new-onset versus preexisting disease. Our measure therefore corresponds to the date of the first observed episode of treated depression within the study period.

Second, we calculated rates of monthly depression-related service use among the cases. For each case, we summed all months in which there was a depression-related outpatient visit or prescription and divided this sum by the total duration of PPO eligibility in years. Because prescriptions varied in duration, we assumed that prescriptions lasting between 45 and 75 days were equivalent to two consecutive months of depression-related service use, and prescriptions lasting 75 to 95 days were equivalent to three consecutive months of service use. The final rate measure summarized the average number of months per year in which each case used depression-related services and was bounded between zero and 12 months per year. Any rate that exceeded the upper bound – which occurred for a small fraction of cases when prescriptions extended into periods of non-eligibility – was truncated at 12 months per year.

Covariates

We derived basic demographic characteristics (gender, age, race/ethnicity), plant location, and calendar year from company personnel files. We created categorical variables for gender, race/ethnicity (Black, Hispanic, white, and other) and a set of indicator variables for plant location and calendar year. Using eligibility files, we measured the number of dependent children (i.e. children younger than 18) listed on their insurance policy for each worker for each year of follow-up. We created a categorical variable with values of zero, one, two, and three or

more dependent children. We ascertained whether workers had a dependent spouse on their insurance policy for each year of follow-up using eligibility files.

We further characterized our study population by summarizing additional employment characteristics derived from personnel files, including whether workers were hired after the study period commenced (i.e. “new hires”); tenure at baseline for workers hired prior to January 1, 2003; and annual wages at the start of follow-up, which we ascertained using W2 data. These variables were not included in any analyses since they were temporally preceded by gender and occupational class, and therefore could not confound our associations of interest.

Analysis of Gender, Occupational Class, and Treated Depression

We modeled time to first episode of treated depression among blue- versus white-collar workers separately for men and women. To examine the combined roles of occupational class and gender, we conducted a pooled analysis of male and female workers in which we examined the time to first episode of treated depression among blue-collar women, blue-collar men, and white-collar women as compared with the referent group of white-collar men.

For both analyses, we used Cox proportional hazards regression with attained age as the underlying time scale. Age of entry was defined as age at the start of follow-up for each worker (on or after 1 January 2003). We allowed for changes in occupational class over the course of follow-up with a time-varying exposure variable. We adjusted for potential confounders, including race/ethnicity, dependent spouse, and number of dependent children. We accounted for regional differences in mental health provider network with fixed effects for plant location. Secular trends in mental healthcare use (i.e. before and after the Great Recession) have been studied previously in this study population.⁴⁰ In this analysis, we accounted for secular trends in mental healthcare use with fixed effects for calendar year.

Analysis of Monthly Depression-Related Service Use

We modeled the rate ratio for monthly depression-related service use among blue- and white-collar workers for men and women separately and conducted a pooled analysis in which we examined service use among blue-collar women, blue-collar men, and white-collar women as compared with white-collar men. We used generalized linear models with the gamma family and log link specified. Generalized gamma regression is an alternative to linear regression with log transformation that is appropriate for positive, right-skewed, and continuous outcomes such as our rate measure.⁴¹ Models were simultaneously adjusted for age, age squared, calendar year, race/ethnicity, number of dependent children, marital status, and plant location. Age was mean-centered and rescaled such that model coefficients correspond to the change in use rates for a 10-year increase in age. Values for all covariates were taken at the start of follow-up.

To account for non-independence of workers within plant locations (i.e. clustering), we used a cluster bootstrap approach to estimate 95% confidence intervals and resampled at the level of the plant location in all analyses. All statistical analyses were performed with R version 3.2.3. This study was approved by the Institutional Review Boards at the University of California, Berkeley and at Stanford University.

Sensitivity Analyses

Past research suggests reasonable concordance between medical claims and medical records or self-report.⁴²⁻⁴⁴ The use of medical insurance claims data to define various health outcomes –

including depression and anxiety – have also been described previously for this study population.^{40,45,46} To assess the robustness of outcomes defined using medical claims in the present study, we created six alternative case definitions for treated depression, ranging from very sensitive (i.e., first prescribed antidepressant) to very specific (i.e., two outpatient visits plus one prescription within 365 days). We additionally assessed the robustness of our findings to the inclusion and exclusion of anxiety-related diagnostic codes (ICD9 293.84, 300.00 – 300.02). Additional sensitivity analyses included an analysis of time to first episode of treated depression *among* workers hired after the start of follow-up (i.e. after January 1, 2003) and separate assessment of the counts of unique depression-related outpatient visits and prescriptions by occupational class.

1.4 Results

Of the 37,201 workers who satisfied the inclusion criteria, we excluded 17 for whom race/ethnicity was missing. Our final study sample included 7,148 women followed for 309,565 person-months and 30,035 men followed for 1,681,394 person-months. Demographic, employment, and health characteristics for the study sample are presented in Table 1. The majority of workers had blue-collar jobs for both women (74%) and men (80%). Examples of blue-collar job titles included material handler, machine operator, and pot tender. White-collar job titles included human resources manager, senior general accountant, and associate electrical engineer. A small fraction of white-collar workers had supervisory roles in the factory environment (i.e. production supervisors). Only a small percentage of workers (3.7%) were promoted from blue- to white-collar jobs over the course of the study period.

As compared with blue-collar workers, white-collar workers were more likely to be white with higher median annual wages at baseline. Male workers were more likely to have a dependent spouse and dependent children on their health insurance plan at baseline. Using our primary case definition, there were 1,903 blue-collar women (36%) and 629 white-collar women (34%) who were treated for depression at some point throughout study period. Among men, 4,689 blue-collar workers (19%) and 1,171 white-collar workers (20%) were treated for depression (Table 1). Among the cases, we find that half of workers received treatment for depression through a combination of outpatient visits and prescriptions (50%), although many cases were treated exclusively through prescriptions for antidepressants (37%) and a minority of cases were treated exclusively in outpatient visits. Median rates of depression-related service use were higher in white-collar workers for both men and women (Table 1 and Figures 1 and 2 in the Supplemental Materials).

Gender, Occupational Class, and Treated Depression

Among men, blue-collar workers were more likely to be treated for depression over the study period compared with white-collar workers (Hazard Ratio = 1.3, 95% CI 1.1 - 1.4). Similarly, blue-collar women were more likely to be treated for depression compared with white-collar women (HR = 1.36, 1.7 – 1.6) (Table 2 and Figures 1 and 2 in the Supplemental Materials). In our pooled analysis, we found that blue-collar women were most likely to be treated for depression compared with white-collar men (HR = 3.2, 95% CI 2.1 – 5.0), followed by white-collar women (HR = 2.4, 95% CI 1.7 – 3.7) and blue-collar men (HR = 1.3, 95% CI 1.1 – 1.5). For both men and women, workers with dependent children were more likely to be treated for depression whereas non-white workers were less markedly likely to be treated for depression over the study period (Table 2, Table 3).

Rates of Monthly Depression-Related Service Use

Among workers treated for depression, blue-collar men and women used depression-related healthcare services less frequently than their white-collar counterparts. The rate of monthly depression-related service use among blue-collar men was 0.91 times the rate of monthly use among white-collar men (95% CI 0.84 – 0.98). Similarly, the rate of monthly depression-related service use among blue-collar women was 0.82 times that of white-collar women (95% CI 0.77 – 0.88). As compared with white-collar men, rates of service use were lowest among blue-collar men (RR = 0.90, 95% CI 0.85 – 0.97) and highest among white-collar women (RR = 1.3, 95% CI 1.2 – 1.4). Overall, rates were decreased among those with dependent children and among non-white workers, and use rates were substantially lower for non-White workers (Tables 4 and 5, Figures 3 and 4 in the Supplemental Materials).

Sensitivity Analyses

To assess the robustness of the outcome, we created six alternative outcome definitions and further assessed whether results were sensitive to the exclusion of anxiety-related outpatient visits (Figure). We found that HRs for time to first depression episode were consistent across all case specifications (top panel). Results were similar, though slightly attenuated, with the exclusion of anxiety-related outpatient visits (bottom panel). We summarize our six alternative case definitions as well as HRs and 95% CI from Cox proportional hazards regression in the Supplemental Materials (Table 1 in the Supplement).

Next, we modeled time to first episode of treated depression since hire by restricting our analysis to workers hired after the start of follow-up (Table 2 in the Supplement). Consistent with our primary analysis, blue-collar men hired after the start of follow-up were more likely to be treated for depression (1.3, 1.1 – 1.5). In contrast with our primary analysis, we found no evidence that blue-collar women were more likely to be treated for depression than white-collar women among the new hires (0.95, 0.80 – 1.1). Our analyses of the counts of unique depression-related outpatient visits and prescriptions, respectively, were consistent with findings from our analysis of the rate of monthly depression-related service use (Tables 3 and 4 in the Supplement).

1.5 Discussion

In this retrospective cohort study, we characterized trends in depression by gender and occupational class among more than 37,000 men and women employed by a single U.S. aluminum manufacturer between 2003 and 2013. We first modeled time to first episode of treated depression by gender and occupational class. We additionally examined trends in monthly depression-related service use by gender and occupational class among workers with at least one episode of treated depression within the study period (i.e. cases). All workers in our study population received health insurance from their employer, and psychiatric services were covered through local PPO plans.

We observed that women were substantially more likely than to be treated for depression within the study period than men (35% of female workers versus 20% of male workers). This finding is consistent with findings from the general populations, and with women's greater propensity to seek mental health treatment⁴⁷ and higher frequency of affective disorders or mental distress that is consistently documented among women in the general population.³⁴ Among both men and women, we found that blue-collar workers were more likely to be treated for depression at least

once over the study period as compared with white-collar workers, although examination of the percentages of blue- and white-collar workers treated for depression over the study period suggests that the differences between blue- and white-collar workers are slight as compared with the differences between men and women overall.

In our pooled analysis of male and female workers, we found that blue-collar women were more than three times as likely to experience an episode of treated depression within the study period as compared with white-collar men, which underscores that women in blue-collar jobs may uniquely susceptible to depression. Non-white workers were considerably less likely than white workers to experience depression throughout the study period, which may reflect decreased propensity to seek care in general or greater stigma surrounding mental illness within racial and ethnic minority groups.⁴⁸⁻⁵⁰

These trends in depression by occupational class may reflect a variety of factors, such as the downward social mobility among individuals predisposed to mental illness (i.e. “drift”), the downward selection into lower occupational strata than would otherwise be expected, or an etiologic role of work in onset or exacerbation of underlying depression.⁵⁻⁷ Aspects of the blue-collar work environment that may lead to depression onset include physical demand; the monotonous, repetitive nature of production; inflexible and demanding work hours; negative coworker interactions; and requirements to work quickly.¹²⁻¹⁶ Among female blue-collar workers, physical strain, sexual harassment and discrimination, job insecurity and lack of control over work, and work-life conflict may also contribute to onset of depression or exacerbate underlying disease.^{22,24-32} For today’s blue-collar worker, these stressors exist within the broader context of economic uncertainty, real or perceived job insecurity, and weakened statutory entitlements and protections.

As a sensitivity analysis, we restricted our analysis to workers hired after the start of follow-up and modeled time to first episode of treated depression *since hire*. Consistent with findings for all male workers, we find that blue-collar men hired after the start of follow-up are more likely to be treated for depression within the study period as compared with white-collar men. However, we find no evidence that blue-collar women hired after the start of follow-up were more likely to experience depression. While there is no clear, single explanation for the observed heterogeneity among female workers, our findings could reflect a higher burden of depression among newly hired white-collar women, a decreased burden of depression among newly hired blue-collar women, or greater stigma and less permissive norms surrounding mental healthcare use among women newly hired into blue-collar jobs.

Finally, we examined rates of monthly depression-related healthcare use over the course of the study period among workers treated for depression. Although we hypothesized that blue-collar workers would use depression-related services more frequently, we found that male and female blue-collar workers used depression-related services less frequently than their white-collar counterparts. As compared with white-collar men, blue-collar men used depression-related services the least frequently and white-collar women used services most frequently. In this insured population, patterns of use by occupational class and gender cannot be explained by systematic differences in insurance status. Less frequent service use may reflect systematically less severe depression among blue-collar men and women. Perhaps more plausibly, lower rates among blue-collar workers may reflect barriers to mental healthcare service use other than insurance status, including greater stigma or less permissive norms surrounding mental

healthcare use in working class populations; scheduling demands and temporal inflexibility associated with hourly work; blue-collar workers' sensitivity to the out-of-pocket costs associated with service use; or provider behaviors.

Limitations

The present study is not without limitations. First, our study was based on data from a single firm and may therefore have limited generalizability even to other U.S. manufacturers if differences in organizational culture and institutional practices translate to meaningful differences in worker mental health and mental healthcare use. No direct measures of household composition were available, and we could only ascertain whether workers had a dependent spouse or child on their health insurance policy each year. These measures are likely to systematically underestimate parity and marital status, especially for women, but nevertheless may be an important indicator of each worker's economic responsibilities towards household members. We were also unable to adjust for several characteristics – including previous employment and educational attainment – that likely confound our analyses. Our analysis of depression-related service use is restricted to cases, and therefore be susceptible to collider stratification bias if there are unmeasured common causes of caseness and service use rates (such as genetic factors, underlying disease severity, or care seeking propensity). These unmeasured factors will be negatively correlated with occupational class among the cases even if they are independent of occupational class in the general working population class, thereby confounding our association of interest.

Our analysis entailed comparison of two broad and heterogeneous groups – blue- and white-collar workers. Some white-collar jobs may be characterized by work experiences that are similar to blue-collar jobs and vice versa. For example, production managers and supervisors are white-collar workers whose jobs may entail exposure to physical demand, occupational hazards and social environment that is similar or equivalent to those of blue-collar workers. Similarly, clerical workers may be more equivalent to blue-collar workers with respect to their control over work and job security. This heterogeneity inherent in our definition of occupational class is equivalent to exposure misclassification.

Finally, there are at least three notable limitations related to our outcome of interest. First, absent any information on workers' past histories of mental illness, we are unable to differentiate between incident and prevalent depression, even among new hires. Second, we anticipate that outcome misclassification is likely. Because we measured depression outcomes using medical claims, our case definition does not capture untreated depression or treatment for depression received outside of the worker's PPO network. It is commonly noted that the majority of individuals with psychiatric illness do not receive treatment,⁵¹ and moreover it cannot be assumed that treated depression is more severe than untreated depression given multiple cultural and economic pathways to treatment.^{52,53} Finally, we are unable to identify instances of off-label antidepressant prescriptions (for fibromyalgia, neuropathic pain, or other psychiatric morbidities). Unless these sources of outcome misclassification are collectively differential with respect to occupational class, however, we anticipate that their net effect would be to attenuate study findings.

1.6 Conclusion

For the present study, we found that blue-collar workers were more likely to be treated for depression within study period than white-collar workers. Blue-collar women were most likely to

be treated for depression as compared with white-collar men, a finding which underscores that women in blue-collar jobs may uniquely susceptible to depression. Among both men and women, non-white workers were less likely to experience depression throughout the study period. In our analysis of depression-related service use, we found that blue-collar men and women used depression-related services less frequently than their white-collar counterparts. In this insured population, our findings may reflect additional barriers to mental healthcare use among blue-collar workers including increased stigma or less permissive norms around mental healthcare use; provider behavior; temporal inflexibility; blue-collar workers' greater sensitivity mental healthcare costs. As many of these barriers are potentially modifiable, future public health research may aim to identify the predominant mechanisms that explain systematic differences in mental healthcare use by occupational class that we have observed.

Table 1. Baseline Demographic, Employment, and Health Characteristics for Active Workers at 32 U.S. Aluminum Plants, 2003 – 2013

		Women (N = 7,148)		Men (N = 30,035)	
		Blue Collar (N = 5,279)	White Collar (N = 1,869)	Blue Collar (N = 24,124)	White Collar (N = 5,911)
Demographic Characteristics					
Age – Median (IQR) ^a		44 (36 – 51)	41 (32 – 49)	42 (32 – 51)	44 (36 – 50)
Race – N (%)					
White		3,427 (65)	1,513 (81)	17,561 (73)	5,004 (85)
Black		871 (17)	164 (8.8)	2,585 (11)	355 (6.0)
Hispanic		748 (14)	101 (5.4)	2,839 (12)	278 (4.7)
Other		233 (4.4)	91 (4.9)	1,139 (4.7)	274 (4.6)
Dependent Spouse – N (%)		2,033 (39)	820 (44)	15,213 (63)	4,487 (76)
Number of Dependent Children – N (%)					
None		3,247 (62)	1,239 (66)	12,875 (53)	2,844 (48)
One		1,007 (19)	310 (17)	4,457 (19)	1,151 (20)
Two		655 (12)	231 (12)	4,093 (17)	1,237 (21)
Three or more		370 (7.0)	89 (4.8)	2,699 (11)	679 (12)
Employment Characteristics					
New Hires – N (%)		2,446 (46)	831 (45)	10,053 (42)	1,974 (33)
Tenure at Baseline (Years) ^b – Median (IQR)		2.9 (1.0 – 5.2)	5.0 (1.8 – 15)	5.5 (2.0 – 19)	4.0 (1.4 – 17)
Annual Wages ^c – Median (IQR)		\$29K (17 – 40)	\$46K (31 – 61)	\$40K (23 – 50)	\$59K (42 – 76)
Health Characteristics					
Person–months of Follow-Up – N		221,210	88,355	1,301,649	379,745
Number of Cases – N (%) ^{d,e}		1,903 (36)	629 (34)	4,689 (19)	1,171 (20)
Avg. Utilization Rate for Cases ^f – Median (IQR)		2.8 (1.0 – 7.0)	4.0 (1.4 – 8.6)	2.08 (0.73 – 5.8)	2.61 (0.8 – 7.2)

a. IQR = Interquartile range

b. Tenure at baseline is calculated for workers who were hired prior to the start of follow-up on January 1, 2003

c. Wage data are missing for 200 women and 809 men

d. We define the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first).

e. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

f. Percentages do not account for variable follow-up time.

g. Average utilization rates for cases correspond to the sum of all months in which there was either a depression-related outpatient visit or filled prescription for a prescribed antidepressant by the total duration of PPO eligibility in years, taking into account prescription duration.

Table 2. Adjusted hazards ratios time to first depression episode by occupational class among male and female workers ^{a, b}

Covariates	Women (N = 7,148)			Men (N = 30,035)		
	Workers	Cases – N (%) ^{c,d}	Hazard Ratios ^e (95% CI)	Workers	Cases – N (%) ^{c,d}	Hazard Ratios ^e (95% CI)
Occupational Class						
White-collar	1,869	629 (34)	1.0	5,911	1,171 (20)	1.0
Blue-collar	5,279	1,866 (35)	1.4 (1.2 – 1.6)	24,124	4,689 (19)	1.3 (1.1 – 1.4)
Dependent Children						
None	4,486	1,570 (35)	1.0	15,719	2,906 (19)	1.0
One	1,317	482 (36)	1.1 (1.0 – 1.2)	5,608	1,111 (20)	1.1 (0.98 – 1.2)
Two	886	303 (34)	1.1 (0.91 – 1.3)	5,330	1,185 (22)	1.2 (1.1 – 1.3)
Three or more	459	140 (31)	1.3 (1.1 – 1.5)	3,378	658 (20)	1.2 (1.1 – 1.3)
Dependent Spouse						
No	4,295	1,400 (33)	1.0	10,335	1,414 (14)	1.0
Yes	2,853	1,095 (38)	0.90 (0.83 – 0.97)	19,700	4,446 (23)	1.0 (0.95 – 1.1)
Race/Ethnicity						
White	4,940	1,990 (40)	1.0	22,565	5,092 (23)	1.0
Black	1,035	245 (24)	0.50 (0.42 – 0.60)	2,940	278 (9.5)	0.46 (0.34 – 0.62)
Hispanic	839	195 (23)	0.75 (0.63 – 0.91)	3,117	387 (12)	0.73 (0.62 – 0.87)
Other	334	65 (20)	0.52 (0.32 – 0.82)	1,413	103 (7.3)	0.43 (0.29 – 0.63)

a. Results correspond to separate analyses among male workers (N = 30,035) and female workers (N = 7,148).

b. Attained age was used as the timescale in Cox proportional hazards models. Separate models for male and female workers were adjusted for occupational class, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location and calendar year.

c. We defined the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first). Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

d. Percentages do not account for variable follow-up time.

e. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

Table 3. Adjusted hazards ratios time to first depression episode by gender and occupational class ^a

Covariates	All Workers (N = 37,183)		
	Workers, N	Cases, N (%) ^{b,c}	Hazard Ratios ^d (95% CI)
Gender and Occupational Class			
White-Collar Men	5,911	1,171 (20)	1.0
Blue-Collar Men	24,124	4,689 (19)	1.3 (1.1 – 1.5)
White-Collar Women	1,869	629 (34)	2.4 (1.7 – 3.4)
Blue-Collar Women	5,279	1,866 (35)	3.2 (2.1 – 5.0)
Dependent Children			
None	20,205	4,476 (22)	1.00
One	6,925	1,593 (23)	1.1 (1.0 – 1.2)
Two	6,216	1,488 (24)	1.2 (1.0 – 1.3)
Three or more	3,837	798 (21)	1.2 (1.1 – 1.3)
Dependent Spouse			
No	14,630	2,814 (19)	1.0
Yes	22,553	5,541 (25)	0.97 (0.92 – 1.0)
Race/Ethnicity			
White	20,205	7,082 (35)	1.00
Black	3,975	523 (13)	0.48 (0.35 – 0.66)
Hispanic	3,966	582 (15)	0.73 (0.61 – 0.87)
Other	1,737	168 (9.6)	0.46 (0.30 – 0.71)

a. Attained age was the timescale in Cox proportional hazards regression. The model was adjusted for gender and occupational class categories, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location and calendar year.

b. We defined the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first). Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

c. Percentages do not account for variable follow-up time.

d. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

Table 4. Adjusted rate ratios for monthly depression-related service use by occupational class among male and female workers ^{a,b}

Covariates	Women (N = 2,495)		Men (N = 5,860)	
	Workers, N (%)	Rate Ratios (95% CI) ^{d,e}	Workers, N (%)	Rate Ratios (95% CI) ^{d,e}
Age ^c				
Age Squared		1.2 (1.1 – 1.2)		1.2 (1.2 – 1.2)
Occupational Class		0.99 (0.95 – 1.0)		0.99 (0.79 – 1.0)
White-collar	592 (24)	1.0	1,065 (18)	1.0
Blue-collar	1,903 (76)	0.82 (0.77 – 0.88)	4,795 (82)	0.91 (0.84 – 0.98)
Dependent Children				
None	1,433 (57)	1.0	2,566 (44)	1.0
One	514 (21)	0.87 (0.77 – 1.0)	1,183 (20)	0.86 (0.79 – 0.94)
Two	348 (14)	0.81 (0.72 – 0.91)	1,274 (22)	0.91 (0.85 – 0.97)
Three or more	200 (8.0)	0.71 (0.61 – 0.82)	837 (14)	0.86 (0.80 – 0.94)
Dependent Spouse				
No	1,412 (57)	1.0	1,506 (26)	1.0
Yes	1,083 (43)	0.97 (0.92 – 1.0)	4,354 (74)	2.0 (0.92 – 1.1)
Race/Ethnicity				
White	1,990 (80)	1.0	5,092 (87)	1.0
Black	245 (9.8)	0.68 (0.61 – 0.76)	278 (4.7)	0.63 (0.45 – 0.71)
Hispanic	195 (7.8)	0.72 (0.59 – 0.89)	387 (6.6)	0.63 (0.55 – 0.73)
Other	65 (2.6)	0.85 (0.68 – 1.1)	103 (1.8)	0.76 (0.63 – 0.93)

a. Results correspond to separate analyses restricted to male workers (N = 2,495) and female workers (N = 5,680) who satisfied our primary case definition for depression.

b. We used a generalized linear model with the gamma distribution and log link to estimate average rate ratios. Separate models for male workers and female workers were simultaneously adjusted for age, age squared, occupational class, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location.

c. Age was mean-centered and rescaled such that average rate ratios correspond to a 10-year increase in age.

d. Average use rates for cases correspond to the sum of all months in which there was either a depression-related outpatient visit or filled prescription for a prescribed antidepressant by the total duration of PPO eligibility in years, taking into account prescription duration. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

e. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

Table 5. Adjusted rate ratios for depression-related service use by gender and occupational class ^a

Covariates	All Cases (N = 8,355)	
	Workers (%)	Rate Ratios (95% CI) ^{c,d}
Age ^b		1.2 (1.2 – 1.2)
Age Squared		0.99 (0.97 – 1.0)
Gender and Occupational Class		
White-collar men	1,065 (13)	1.0
Blue-collar men	4,795 (57)	0.90 (0.85 – 0.97)
White-collar women	592 (7.1)	1.3 (1.2 – 1.4)
Blue-collar women	1903 (23)	1.0 (0.98 – 1.1)
Dependent Children		
None	3,999 (48)	1.0
One	1,697 (20)	0.86 (0.81 – 0.92)
Two	1,622 (19)	0.88 (0.83 – 0.94)
Three or more	1,037 (12)	0.83 (0.76 – 0.89)
Dependent Spouse		
No	2,918 (35)	1.0
Yes	5,437 (65)	0.98 (0.94 – 1.0)
Race/Ethnicity		
White	7,082 (85)	1.0
Black	523 (6.3)	0.61 (0.54 – 0.69)
Hispanic	582 (7.0)	0.66 (0.57 – 0.75)
Other	168 (2.0)	0.79 (0.67 – 0.93)

- a. We used a generalized linear model with the gamma distribution and log link to estimate average rate ratios. The model was simultaneously adjusted for age, age squared, gender and occupational class categories, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location.
- b. Age was mean-centered and rescaled such that average rate ratios correspond to a 10-year increase in age.
- c. Average use rates for cases correspond to the sum of all months in which there was either a depression-related outpatient visit or filled prescription for a prescribed antidepressant by the total duration of PPO eligibility in years, taking into account prescription duration. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).
- d. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

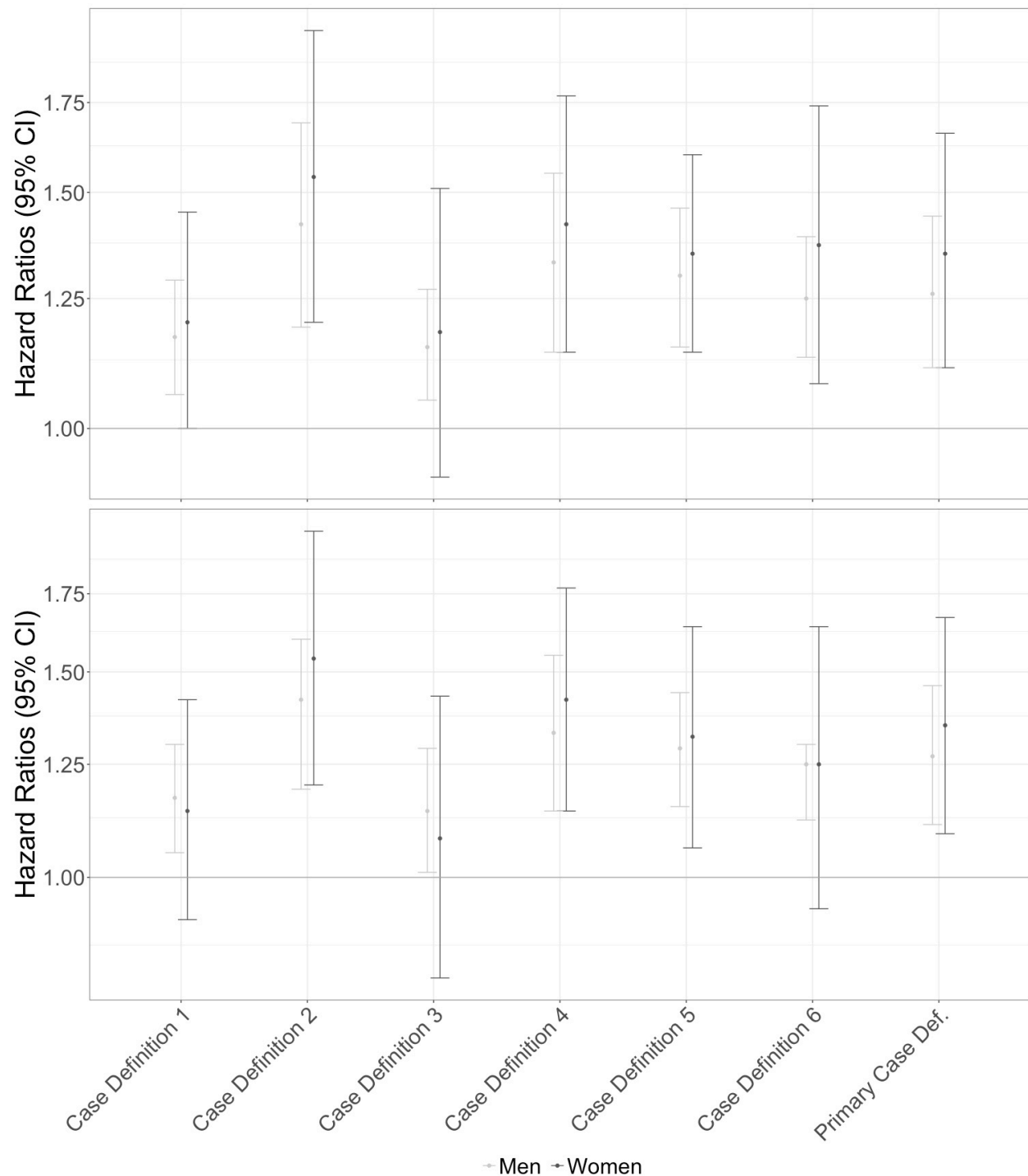
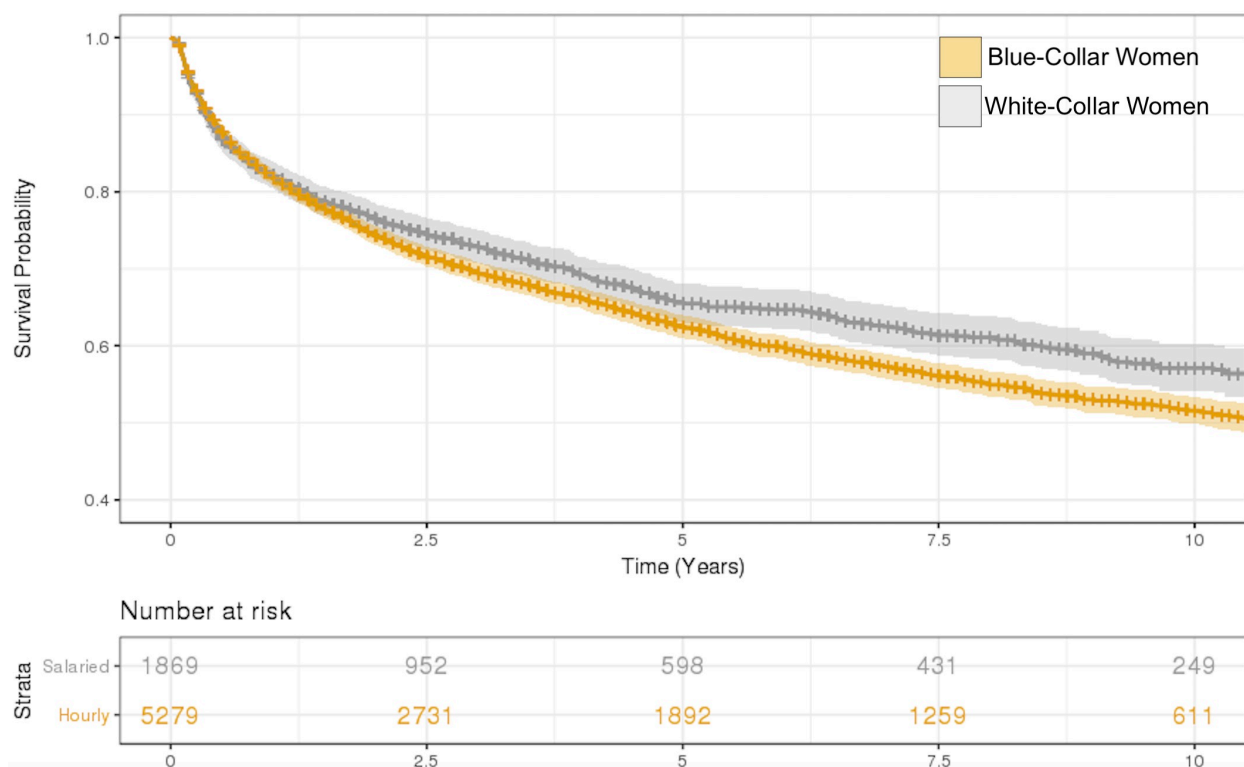
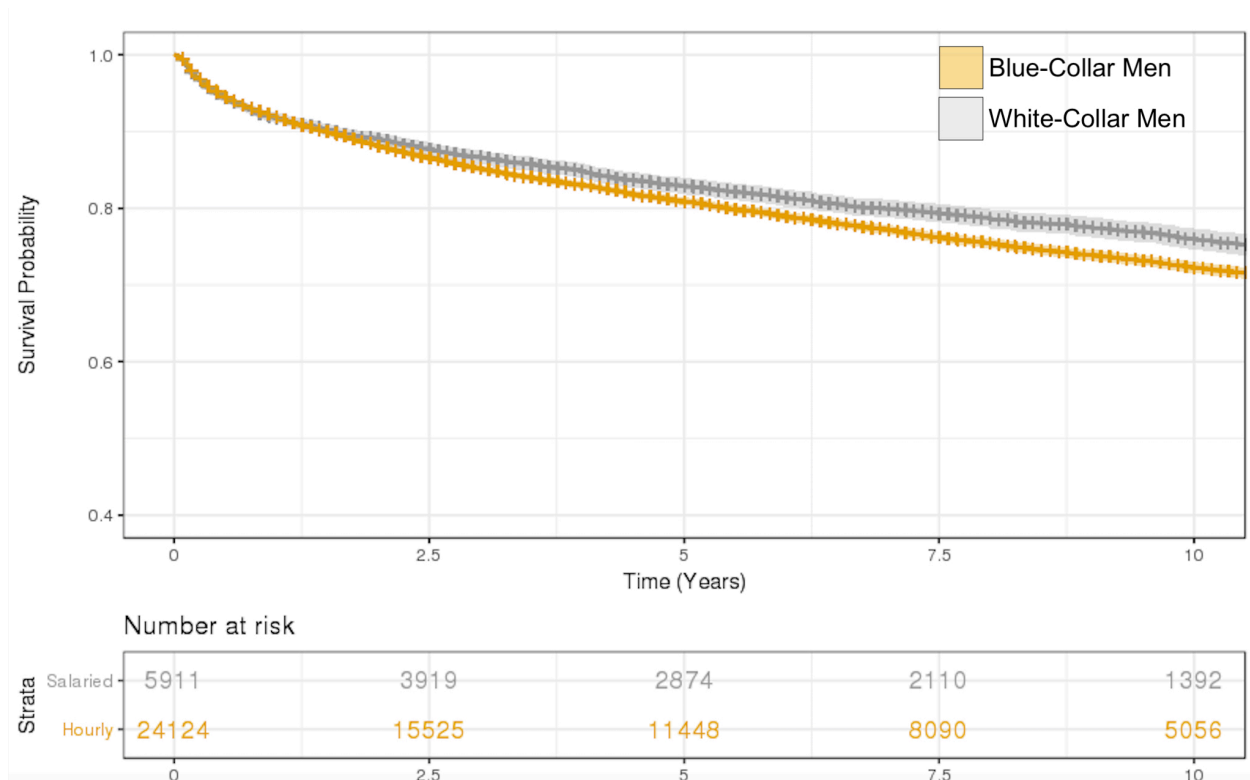


Figure 1. Sensitivity analysis of alternative case definitions for first depression episode We constructed six alternative case definitions for first depression episode: first outpatient visit (Case Definition 1); first prescribed antidepressant (Case Definition 2); second outpatient visit in 365 days (Case Definition 3); second prescription in 365 days (Case Definition 4); one outpatient visit and one prescribed antidepressant in 365 days (Case Definition 5); and two outpatient visits plus one prescribed outpatient visit in 365 days (Case Definition 6). We assessed the robustness of our case-definition to the inclusion (**top panel**) and exclusion (**bottom panel**) of anxiety-related ICD-9 codes. All models used attained age as the timescale, were simultaneously adjusted for race/ethnicity, dependents spouse, number of dependent children, plant location and calendar year. We included a product term between sex and occupational class in order to estimate separate HRs for men and women. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 200 repetitions.

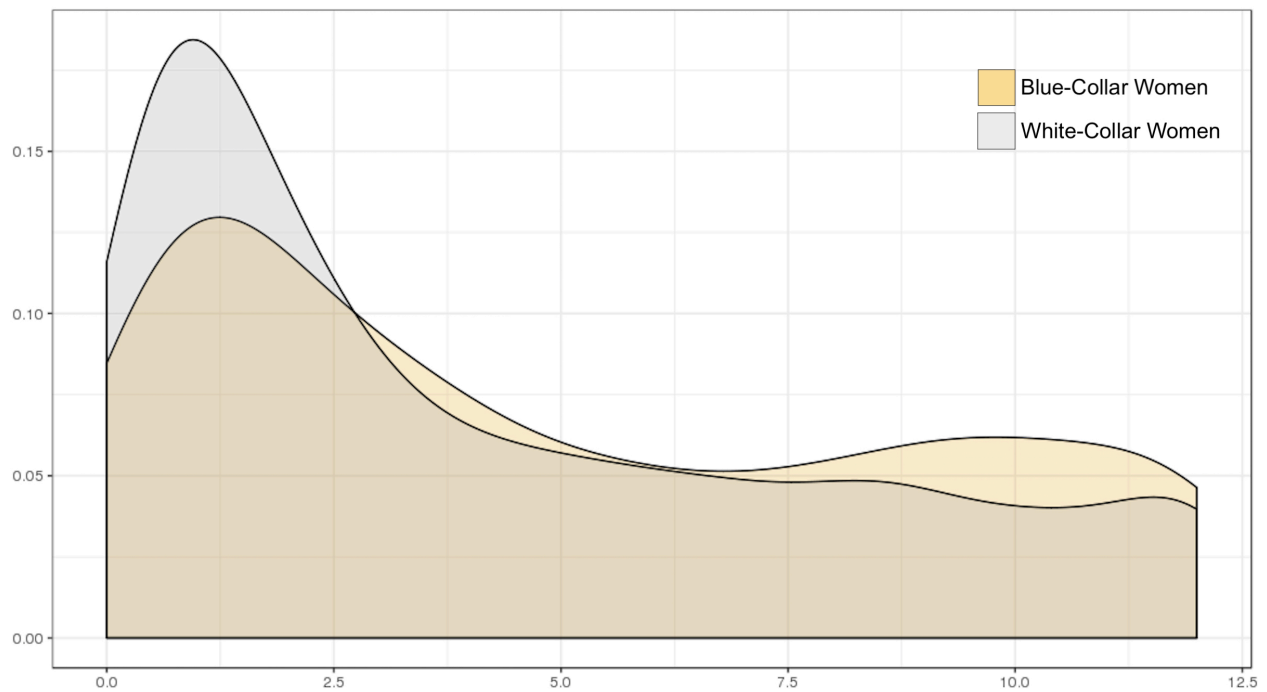
1.8 Supplemental Materials



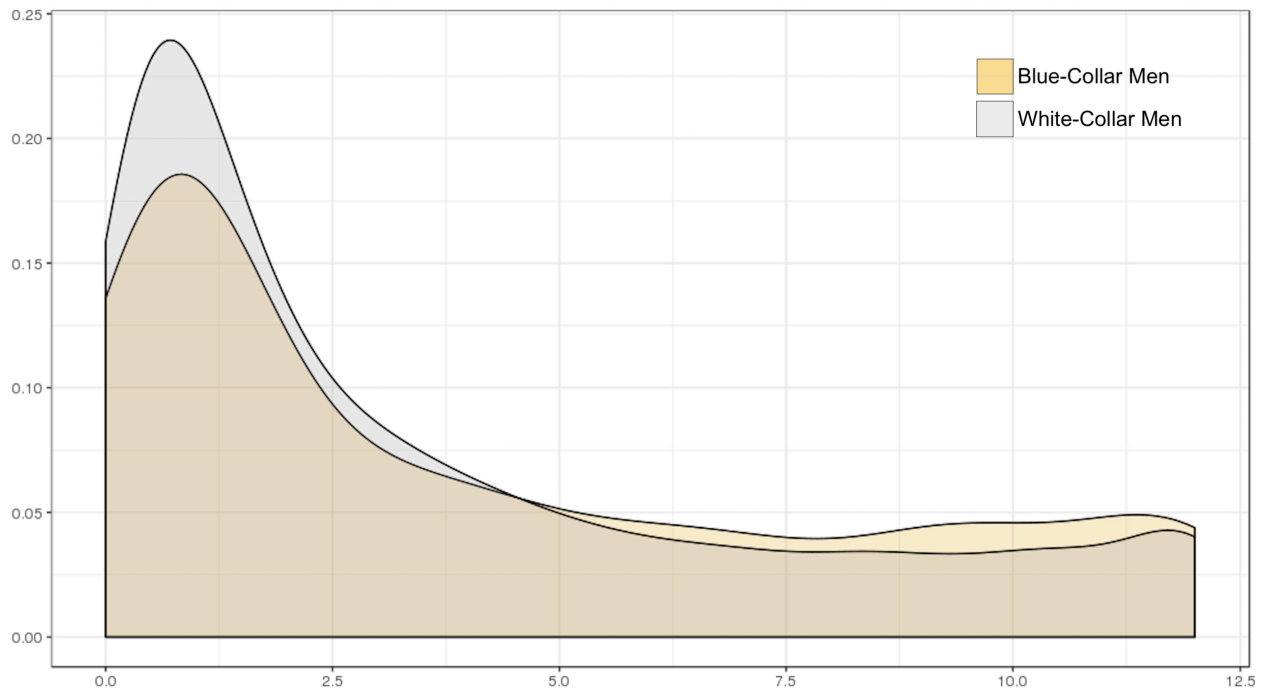
Supplemental Figure 1. Time to first depression episode is measured from the start of the study period on January 1, 2003 or PPO enrollment, whichever came first. We define the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first). Depression-related outpatient visits were identified using ICD-9 codes 296.2 – 296.3, 293.84, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).



Supplemental Figure 2. Time to first depression episode is measured from the start of the study period on January 1, 2003 or PPO enrollment, whichever came first. We define the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first). Depression-related outpatient visits were identified using ICD-9 codes 296.2 – 296.3, 293.84, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).



Supplemental Figure 3. Density plots for rates of depression-related service utilization among blue- and white-collar women. Among the 2,495 women who satisfied our primary case definition for depression, we identified all months in which they were eligible for the local PPO plan and utilized depression-related healthcare services (either a prescribed antidepressant or a depression-related outpatient visit). Average utilization rates for cases correspond to the sum of all months in which there was either a depression-related outpatient visit or filled prescription for a prescribed antidepressant by the total duration of PPO eligibility in years, taking into account prescription duration. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).



Supplemental Figure 4. Density plots for rates of depression-related service utilization among blue- and white-collar men. Among the 5,860 men who satisfied our primary case definition for depression, we identified all months in which they were eligible for the local PPO plan and utilized depression-related healthcare services (either a prescribed antidepressant or a depression-related outpatient visit). Average utilization rates for cases correspond to the sum of all months in which there was either a depression-related outpatient visit or filled prescription for a prescribed antidepressant by the total duration of PPO eligibility in years, taking into account prescription duration. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

Supplemental Table 1. Adjusted hazards ratios for time to first depression episode among blue- and white-collar workers for six alternative case definitions including and excluding anxiety-related ICD-9 codes^a

	Includes Anxiety-Related ICD Codes^b HR (95% CI) ^d	Excludes Anxiety-Related ICD Codes^c HR (95% CI) ^d
Case Definition 1: First outpatient visit		
Male blue-collar workers (ref. male white-collar)	6,110 Cases 1.17 (1.06 – 1.29)	4,809 Cases 1.17 (1.05 – 1.30)
Female blue-collar workers (ref. female white-collar)	1.20 (1.00 – 1.45)	1.14 (0.92 – 1.42)
Case Definition 2: First prescription		
Male blue-collar workers (ref. male white-collar)	8,693 Cases 1.42 (1.19 – 1.69)	--
Female blue-collar workers (ref. female white-collar)	1.54 (1.20 – 1.98)	
Case Definition 3: Two outpatient visits within 1 year		
Male blue-collar workers (ref. male white-collar)	4,142 Cases 1.15 (1.05 – 1.27)	3,351 Cases 1.14 (1.01 – 1.29)
Female blue-collar workers (ref. female white-collar)	1.18 (0.92 – 1.51)	1.08 (0.82 – 1.43)
Case Definition 4: Two prescriptions within 1 year		
Male blue-collar workers (ref. male white-collar)	7,061 Cases 1.33 (1.14 – 1.55)	--
Female blue-collar workers (ref. female white-collar)	1.42 (1.14 – 1.77)	
Case Definition 5: One outpatient visits plus rx within 1 year		
Male blue-collar workers (ref. male white-collar)	4,163 Cases 1.30 (1.15 – 1.46)	3,311 Cases 1.29 (1.15 – 1.44)
Female blue-collar workers (ref. female white-collar)	1.35 (1.14 – 1.60)	1.32 (1.06 – 1.64)
Case Definition 6: Two outpatient visits plus rx within 1 year		
Male blue-collar workers (ref. male white-collar)	2,913 Cases 1.25 (1.13 – 1.39)	2,308 Cases 1.25 (1.12 – 1.30)
Female blue-collar workers (ref. female white-collar)	1.37 (1.08 – 1.74)	1.25 (0.94 – 1.64)
Primary Case Definition		
Male blue-collar workers (ref. male white-collar)	8,355 Cases 1.26 (1.11 – 1.44)	8,134 Cases 1.27 (1.11 – 1.46)
Female blue-collar workers (ref. female white-collar)	1.35 (1.11 – 1.66)	1.35 (1.09 – 1.67)

- a. All Cox proportional hazards models used attained age as the timescale, were adjusted for race/ethnicity (Black, Hispanic, white, other), dependents spouse, number of dependent children, plant location and calendar year. We included a product term between sex and occupational class in order to estimate separate HRs for men and women.
- b. Depression-related outpatient visits were identified using ICD-9 codes 296.2 – 296.3, 293.84, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).
- c. We additionally assessed the robustness of our case-definition to the exclusion of anxiety-related ICD-9 codes (293.84, 300.00 – 300.02).
- d. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 200 repetitions.

Supplemental Table 2. Adjusted hazards ratios time to first depression episode among men and women hired after the start of follow-up ^{a, b}

Covariates ^a	Women (N = 3,277)			Men (N = 12,027)		
	Workers	Cases – N (%) ^{c,d}	Hazard Ratios ^e (95% CI)	Workers	Cases – N (%) ^{c,d}	Hazard Ratios ^e (95% CI)
Occupational Class						
White-Collar	831	241 (29.1)	1.00	1,974	281 (14.2)	1.00
Blue-Collar	2,446	715 (29.2)	0.95 (0.80 – 1.12)	10,053	1,446 (14.4)	1.26 (1.06 – 1.50)
Dependent Children						
None	2,013	539 (26.8)	1.00	6,525	716 (11.0)	1.00
One	578	194 (33.6)	1.15 (0.96 – 1.36)	2,116	344 (15.8)	1.16 (0.97 – 1.38)
Two	444	152 (34.2)	1.28 (1.03 – 1.59)	2,052	412 (20.1)	1.31 (1.12 – 1.54)
Three or more	242	71 (29.3)	1.29 (1.06 – 1.57)	1,334	255	1.31 (1.09 – 1.56)
Dependent Spouse						
No	2,288	604 (26.4)	1.00	6,509	605 (9.3)	1.00
Yes	989	352 (35.6)	0.81 (0.68 – 0.95)	5,518	1,122 (20.3)	1.00 (0.86 – 1.14)
Race/Ethnicity						
White	2,033	715 (35.2)	1.00	7,766	1,434 (18.5)	1.00
Black	461	99 (21.5)	0.52 (0.41 – 0.65)	1,338	79 (5.9)	0.39 (0.29 – 0.53)
Hispanic	567	114 (20.1)	0.95 (0.64 – 1.42)	2,009	166 (8.3)	0.56 (0.43 – 0.73)
Other	216	28 (12.9)	0.45 (0.21 – 0.96)	914	48 (5.3)	0.35 (0.26 – 0.49)

a. Results correspond to separate analyses among male workers (N = 12,027) and female workers (N = 3,277) hired after January 1, 2003.

b. Attained age was used as the timescale. Separate models for male and female workers were adjusted for occupational class, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location and calendar year.

c. We defined the date of the first depression episode within the study period as the second depression-related outpatient visit *or* the second prescribed antidepressant within 365 days (whichever was first). Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311; antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

d. Percentage of workers who became cases over the study period does not account for variable follow-up time.

e. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

Supplemental Table 3. Adjusted rate ratios for average number of depression-related outpatient visits per year among cases with at least one depression-related visit within the study period ^{a,b}

Covariates	Women (N = 1,555)		Men (N = 3,686)	
	N (%)	Rate Ratio (95% CI) ^{d,e,f}	N (%)	Rate Ratio (95% CI) ^{d,e,f}
Age ^c				
Age Squared		0.98 (0.91 – 1.09)		0.99 (0.92 – 1.06)
Occupational Class		1.02 (0.90 – 1.15)		1.04 (0.99 – 1.10)
White-Collar	374 (24.1)	1.00	675 (18.3)	1.00
Blue-Collar	1,181 (75.9)	0.84 (0.64 – 0.94)	3,011 (81.7)	0.92 (0.76 – 1.10)
Dependent Children				
None	837 (53.8)	1.00	1,449 (39.3)	1.00
One	342 (22.0)	0.78 (0.51 – 0.97)	743 (20.2)	0.85 (0.70 – 1.03)
Two	228 (14.7)	0.67 (0.49 – 0.89)	885 (24.0)	0.98 (0.80 – 1.21)
Three or more	148 (9.5)	0.62 (0.44 – 0.99)	609 (16.5)	0.90 (0.75 – 1.09)
Dependent Spouse				
No	917 (59.0)	1.00	1,001 (27.2)	1.00
Yes	638 (41.0)	0.89 (0.72 – 1.12)	2,685 (72.8)	0.85 (0.71 – 1.01)
Race/Ethnicity				
White	1,226 (78.8)	1.00	3,169 (86.0)	1.00
Black	162 (10.4)	1.03 (0.83 – 1.34)	174 (4.7)	1.02 (0.70 – 1.29)
Hispanic	126 (8.1)	1.24 (0.97 – 2.13)	269 (7.3)	1.01 (0.79 – 1.28)
Other	41 (2.6)	1.15 (0.64 – 2.37)	74 (2.0)	1.34 (0.87 – 2.05)

a. Results correspond to separate analyses restricted to male workers (N = 3,686) and female workers (N = 1,555) with at least one depression-related outpatient visit.

b. We used a generalized linear model with the gamma distribution and log link to estimate average rate ratios. Separate models for male workers and female workers were adjusted for age, age squared, occupational class, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location.

c. Age was mean-centered and rescaled such that average rate ratios correspond to a 10-year increase in age.

d. We divided the number of unique, depression-related outpatient visits within the study period by total PPO eligibility time in years. Depression-related outpatient visits were identified using ICD-9 codes 293.84, 296.2 – 296.3, 300, 309, and 311.

e. Counts of unique visits were truncated at the 95th percentile separately for men and women

f. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

Supplemental Table 4. Adjusted rate ratios for average number of prescribed antidepressants per year among cases with at least one depression-related prescription within the study period ^{a,b}

Covariates	Women (N = 2,287)		Men (N = 5,061)	
	N (%)	Rate Ratio (95% CI) ^{d,e,f}	N (%)	Rate Ratio (95% CI) ^{d,e,f}
Age ^c				
Age Squared		1.17 (1.11 – 1.24)		1.21 (1.18 – 1.25)
Occupational Class		0.99 (0.96 – 1.03)		0.98 (0.96 – 1.00)
White-Collar	514 (22.5)	1.00	883 (17.4)	1.00
Blue-Collar	1,773 (77.5)	0.77 (0.70 – 0.86)	4,178 (82.6)	0.85 (0.78 – 0.91)
Dependent Children				
None	1,323 (57.8)	1.00	2,284 (45.1)	1.00
One	472 (20.6)	0.86 (0.77 – 0.98)	1,010 (20.0)	0.86 (0.78 – 0.94)
Two	320 (14.0)	0.81 (0.69 – 0.94)	1,083 (21.4)	0.90 (0.82 – 0.98)
Three or more	172 (7.5)	0.71 (0.61 – 0.83)	684 (13.5)	0.87 (0.80 – 0.95)
Dependent Spouse				
No	1,296 (56.7)	1.00	1,270 (25.1)	1.00
Yes	991 (43.3)	0.99 (0.93 – 1.05)	3,791 (74.9)	1.00 (0.94 – 1.06)
Race/Ethnicity				
White	1,846 (80.7)	1.00	4,484 (88.6)	1.00
Black	218 (9.5)	0.65 (0.56 – 0.75)	200 (4.0)	0.59 (0.46 – 0.74)
Hispanic	164 (7.2)	0.73 (0.54 – 0.99)	303 (6.0)	0.61 (0.51 – 0.72)
Other	59 (2.6)	0.86 (0.67 – 1.11)	74 (1.4)	0.73 (0.56 – 0.96)

a. Results correspond to separate analyses restricted to male workers (N = 5,061) and female workers (N = 2,287) with at least one prescribed antidepressant

b. We used a generalized linear model with the gamma distribution and log link to estimate average rate ratios. Separate models for male workers and female workers were adjusted for age, age squared, occupational class, dependent children, dependent spouse, race/ethnicity (Black, Hispanic, white, other), and included fixed effects for plant location.

c. Age was mean-centered and rescaled such that average rate ratios correspond to a 10-year increase in age.

d. We divided the number of unique 30-day prescriptions by total PPO eligibility time in years. Counts of prescriptions were truncated at the 95th percentile separately for men and women. Antidepressants included selective serotonin reuptake inhibitors (SSRI); selective norepinephrine reuptake inhibitors (SNRI); tricyclic antidepressants (TCAs) and monoamine oxidase inhibitors (MAOIs).

e. Counts of unique visits were truncated at the 95th percentile separately for men and women

f. We estimated 95% confidence intervals by resampling from plant location using a cluster bootstrap with 1,000 repetitions.

1.9 References

1. Muntaner C, Eaton W, Diala C, Kessler R, Sorlie P. Social class, assets, organizational control and the prevalence of common groups of psychiatric disorders. *Soc Sci Med*. 1998;47(12):2043-53.
2. Eaton WW, Muntaner C, Bovasso G, Smith C. Socioeconomic status and depressive syndrome: the role of inter-and intra-generational mobility, government assistance, and work environment. *J Health Soc Behav*. 2001;42(3):277.
3. Eaton WW, Muntaner C, Sapag JC. Socioeconomic Stratification and Mental Disorder. In: Horwitz AV, Scheid TL, eds. *A Handbook for the Study of Mental Health*. 2nd Edition. New York, NY: Cambridge University Press; 1999. p 259-83.
4. Joensuu M, Väänänen A, Koskinen A, Kivimäki M, Virtanen M, Vahtera J. Psychosocial work environment and hospital admissions due to mental disorders: a 15-year prospective study of industrial employees. *J Affect Disorders*. 2010;124(1):118-25.
5. Eaton WW. The sociology of mental disorders. Westport, CT: Praeger; 2001.
6. Dohrenwend BP, Levav I, Shrout PE, Schwartz S, Naveh G, Link BG, Skodol AE, Stueve A. Socioeconomic status and psychiatric disorders: the causation-selection issue. *Science*. 1992;255(5047):946-52.
7. Muntaner C, Eaton WW, Miech R, O'Campo P. Socioeconomic position and major mental disorders. *Epidemiol Rev*. 2004;26(1):53-62.
8. Wheaton B. The sociogenesis of psychological disorder: Reexamining the causal issues with longitudinal data. *Am Sociol Rev*. 1978;43(3):383-403.
9. Johnson JG, Cohen P, Dohrenwend BP, Link BG, Brook JS. A longitudinal investigation of social causation and social selection processes involved in the association between socioeconomic status and psychiatric disorders. *J Abnorm Psychol*. 1999;108(3):490-9.
10. Miech RA, Caspi A, Moffitt TE, Wright BRE, Silva PA. Low socioeconomic status and mental disorders: a longitudinal study of selection and causation during young adulthood. *Am J Sociol*. 1999;104(4):1096-1131.
11. Power C, Stansfeld SA, Matthews S, Manor O, Hope S. Childhood and adulthood risk factors for socio-economic differentials in psychological distress: evidence from the 1958 British birth cohort. *Soc Sci Med*. 2002;55(11):1989-2004.
12. DeSanto IJ, Cullen MR, Cantley L, Slade MD, Fiellin M, Kasl SV. Effects of externally rated job demand and control on depression diagnosis claims in an industrial cohort. *Am J Epidemiol*. 2010;171(3):303-11.
13. Kawamaki N, Haratani T, Araki S. Effects of perceived job stress on depressive symptoms in blue-collar workers of an electrical factory in Japan. *Scand J Work Env Hea*. 1992;18(3):195-200.
14. Kawamaki N, Araki S, Kawashima M, Masumoto T, Hayashi T. Effects of work-related stress reduction on depressive symptoms among Japanese blue-collar workers. *Scand J Work Env Hea*. 1997;23(1):54-9.
15. d'Errico A, Cardano M, Landriscina T, Marinacci C, Pasian S, Petrelli A, Costa G. Workplace stress and prescription of antidepressant medications: A prospective study on a sample of Italian workers. *Int Arch Occ Env Hea*. 2011;84(4):413-24.
16. Cohidon C, Santin G, Imbernon E, Goldberg M. Working conditions and depressive symptoms in the 2003 decennial health survey: The role of the occupational category. *Soc Psych Psych Epid*. 2010;45(12):1135-47.
17. Arnold D, Bongiovi JR. Precarious, Informalizing, and Flexible Work: Transforming Concepts and Understandings. *Am Behav Sci*. 2012;57(3):289-308.

18. Berman E, Bound J, Griliches Z. Changes in the demand for skilled labor within US manufacturing: Evidence from the annual survey of manufacturers. *Q J Econ*. 1994;109(2):367-97.
19. Navarro V. The labor process and health: a historical materialist interpretation. *Int J Health Serv*. 1982;12(1):5-29.
20. Kalleberg AL. Job Quality and Precarious Work: Clarifications, Controversies, and Challenges. *Work Occupation*. 2012;39(4):427-48.
21. Kalleberg AL. Precarious Work, Insecure Workers: Employment Relations in Transition. *Am Sociol Rev*. 2009;74(1):1-22.
22. Messing K, Dumais L, Courville J, Seifert AM, Boucher M. Evaluation of exposure data from men and women with the same job title. *J Occup Med*. 1994;36(8):913-7.
23. Padavic I, Reskin BF. *Women and men at work*. Thousand Oaks: Pine Forge Press; 2002.
24. Courville J, Vézina N, Messing K. Comparison of the work activity of two mechanics: a woman and a man. *Int J Indust Ergonom*. 1991;7(2):163-74.
25. Messing K, Lippel K, Demers D, Mergler D. Equality and difference in the workplace: Physical job demands, occupational illnesses, and sex differences. *Feminist Formations*. 2000;12(3):21-49.
26. Mansfield PK, Koch PB, Henderson J, Vicary JR, Cohn M, Young EW. The job climate for women in traditionally male blue-collar occupations. *Sex Roles*. 1991;25(1-2):63-79.
27. Gruber JE. The impact of male work environments and organizational policies on women's experiences of sexual harassment. *Gender Soc*. 1998;12(3):301-20.
28. Gruber JE, Bjorn L. Blue-collar blues: The sexual harassment of women autoworkers. *Work Occupation*. 1982;9(3):271-98.
29. Maypole DE, Skaine R. Sexual harassment of blue-collar workers. *J Sociol Soc Welfare*. 1982;9:682.
30. Harrell WA. Perceived risk of occupational injury: Control over pace of work and blue-collar versus white-collar work. *Percept Motor Skill*. 1990;70(3_Suppl):1351-9.
31. Hochschild AR, Machung A. *The second shift: working families and the revolution at home*. New York: Penguin Books; 2015.
32. Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm SH, Wegman D, Sctock SR, de Grosbois S. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med*. 2003;43(6):618-29.
33. U.S. Bureau of Labor Statistics. *Women in the labor force: A databook*. Available from: <https://www.bls.gov/opub/reports/womens-databook/2016/home.htm> Accessed April 2019.
34. Kessler RC, Berglund P, Demler O, Jin R, Koretz D, Merikangas KR, Rush AJ, Walters EE, Wang PS. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). *JAMA*. 2003;289(23):3095-105.
35. Kessler RC. Epidemiology of women and depression. *J Affect Disorders*. 2003;74(1):5-13.
36. Rutter M, Caspi A, Moffitt TE. Using sex differences in psychopathology to study causal mechanisms: unifying issues and research strategies. *J Child Psychol Psych*. 2003;44(8):1092-115.
37. Einav L, Finkelstein A, Pascu I, Cullen MR. How general are risk preferences? Choices under uncertainty in different domains. *Am Econ Rev*. 2012;102(6):2606-38.
38. Clougherty JE, Eisen EA, Slade MD, Kawachi I, Cullen MR. Gender and sex differences in job status and hypertension. *Occ Environ Med*. 2011;68(1):16-23.
39. Clougherty JE, Eisen EA, Slade MD, Kawachi I, Cullen MR. Workplace status and risk of hypertension among hourly and salaried aluminum manufacturing employees. *Soc Sci Med*. 2009;68(2):304-13.

40. 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(2):304-10.
41. Faraway JJ. Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models. Boca Raton: CRC Press; 2016.
42. Quam L, Ellis LB, Venus P, Clouse J, Taylor CG, Leatherman S. Using claims data for epidemiologic research: the concordance of claims-based criteria with the medical record and patient survey for identifying a hypertensive population. *Med Care*. 1993;31(6):498-507.
43. Fowles JB, Fowler EJ, Craft C. Validation of claims diagnoses and self-reported conditions compared with medical records for selected chronic diseases. *J Ambul Care Manag*. 1998;21(1):24-34.
44. Jiang L, Zhang B, Smith ML, Lorden AL, Radcliff TA, Lorig K, Howell BL, Whitelaw N, Ory MG. Concordance between self-reports and Medicare claims among participants in a national study of chronic disease self-management program. *Front Public Health*. 2015;3:222.
45. Cullen MR, Vegso S, Cantley L, Galusha D, Rabinowitz P, Taiwo O, Fiellin M, Wennberg D, Iennaco J, Slade MD, Sircar K. Use of medical insurance claims data for occupational health research. *J Occup Environ Med*. 2006;48(10):1054-61.
46. 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;92:105-113.
47. Mojtabai R. Use of specialty substance abuse and mental health services in adults with substance use disorders in the community. *Drug Alcohol Depen*. 2005;78(3):345-54.
48. Gary FA. Stigma: Barrier to mental health care among ethnic minorities. *Issues Ment Health N*. 2005;26(10):979-99.
49. Yeh M, McCabe K, Hurlburt M, Hough R, Hazen A, Culver S, Garland A, Landsverk J. Referral sources, diagnoses, and service types of youth in public outpatient mental health care: A focus on ethnic minorities. *J Behav Health Ser R*. 2002;29(1):45-60.
50. Wells K, Klap R, Koike A, Sherbourne C. Ethnic disparities in unmet need for alcoholism, drug abuse, and mental health care. *Am J Psychiat*. 2001;158(12):2027-32.
51. Wang PS, Lane M, Olfson M, Pincus HA, Wells KB, Kessler RC. Twelve-month use of mental health services in the United States: results from the National Comorbidity Survey Replication. *Arch Gen Psychiat*. 2005;62(6):629-40.
52. Pescosolido BA, Gardner CB, Lubell KM. How people get into mental health services: Stories of choice, coercion and "muddling through" from "first-timers." *Soc Sci Med*. 1998;46(2):275-86.
53. Pescosolido BA, Martin JK, Long JS, Medina TR, Phelan JC, Link BG. "A disease like any other"? A decade of change in public reactions to schizophrenia, depression, and alcohol dependence. *Am J Psychiat*. 2010;167(11):1321-30.

Chapter 2: Workplace gender composition and treatment for depression among men and women in the U.S. aluminum industry

2.1 Abstract

Workers in male-dominated industries and occupations often experience considerable work-related stress, yet few studies have considered the health implications of workplace gender composition. Using data from the American Manufacturing Cohort Study (AMC), we summarized the association between workplace gender composition and treatment for depression among blue-collar workers at 32 U.S. aluminum plants from 2003 - 2013. We created a repeated, binary measure of treatment for depression for each year of follow-up using medical claims for outpatient depression-related visits. We modeled annual treatment for depression as a function of time-varying workplace gender composition and covariates using generalized additive models (GAM). We used g-computation with fitted GAMs to estimate risk differences that characterize the association between depression treatment and workplace gender composition under hypothetical interventions on gender composition as compared with the observed data. The study sample included 5,279 women and 24,124 men. Among women, the number of workers treated for depression per 1,000 was decreased when women comprised at least 20% (RD = -3.95; 95% CI -7.18, -0.72) or 30% of the workforce (-11.7; -20.5, -2.88) versus the observed data. We observed similar decreases among male workers at 20% women (-6.4; -8.65, -4.15) and 30% women (-14.5; -17.7, -11.2). Modest increases in the percent women employed were associated with decreases in the number of workers treated for depression. Our findings motivate continued examination of the association between workplace gender composition and the social context of workplaces for worker health.

2.2 Introduction

Women's labor force participation in the U.S. rose steadily in the latter part of the 20th century.¹⁻⁵ This has been attributed to factors such as growth in women's wages; elimination of policies that prohibited married women from working (i.e. "marriage bars"); growth in the clerical sector; and labor-saving household technologies.⁶⁻⁹ However, women's inroads have been far from equal across industries and occupations.¹⁰ Whereas women now comprise the majority of workers in some industries (i.e. education and healthcare), they remain substantially underrepresented relative to their share of total employment in industry sectors such as agriculture, transportation and utilities, and manufacturing.^{2,3,11}

The causes of occupational sex segregation in the U.S. labor force have been extensively studied and are generally understood to reflect both supply- and demand-side processes driven by the "sex-typing" of occupations.^{10,12-15} Regardless of its causes, occupational sex segregation appears to have substantial social and economic consequences.^{11,16} The gap between men's and women's wages is frequently attributed to occupational sex segregation,^{4,14,16-22} and the greater women's share of employment, the less likely an employer is to offer fringe benefits.^{23,24} Moreover, women employed within predominantly male industries and occupations are more likely to experience social isolation;^{25,26} gender discrimination and sexual harassment;^{11,27-29} increased scrutiny of their job performance;^{30,31} job insecurity and lack of control over work;^{32,33} work-family conflict;^{13,34} and decreased job satisfaction.³⁵⁻³⁷ There is some evidence that men in gender-balanced work groups experience greater job satisfaction than men in male-only work groups,³⁷ but otherwise research remains ambiguous with respect to the effects of workplace gender composition on men's wellbeing.

Despite its clear implications for worker well-being, the evidence-to-date regarding the consequences of occupational sex segregation for health-related outcomes remains decidedly limited. There is some evidence for increased rates of sickness absence among workers in female- or male-dominated occupations as compared with workers in gender neutral occupations,³⁸⁻⁴⁰ although this may be attributable to selection of absence-prone workers into gender segregated occupations.^{41,42} At least one study finds increased risk for myocardial infarction among workers in occupations with male predominance.⁴³ There is also some evidence for increased psychiatric morbidity associated with aspects of the work environment – including coworker interactions, psychological demand, and physical demand –within occupations where men predominate.^{4,44-46}

With these limitations of the extant literature in mind, we summarize the association between workplace gender composition and treatment for depression among workers employed by a single aluminum manufacturer across 32 U.S. plants in male-predominated blue-collar jobs. Unlike past studies – which frequently rely on data at the level of industries and occupations^{11,47} – our analysis employs a precise measure of gender composition within individual plants. We hypothesized, given consistent evidence that women in male-dominated work settings are more likely to experience work-related stress, that the percent women employed within plants would be inversely associated with the risk of treatment depression among female blue-collar workers. As there is relatively less evidence regarding the implications of workplace feminization for male workers, we had no *a priori* expectation regarding the implications of the workplace gender composition for male workers.

2.3 Methods

Study Population and Design

Using data from the American Manufacturing Cohort Study (AMC), we conducted a retrospective cohort study of blue-collar workers employed by a single firm at one of 32 U.S. aluminum plants between 2003 and 2013. Individual workers' records from company personnel files and medical claims were deterministically linked using a unique, encrypted identifier. Complete medical claims data were available for workers enrolled in their local preferred provider organization (PPO) health insurance plan, which were identical with respect to coverage, including psychiatric services.⁴⁸ We further restricted our cohort to workers hired after January 1, 1975 who were between the ages of 18 and 65 at the start of follow-up. For each worker, follow-up ranged between one and 11 years, and extended from start of the study period in 2003 or the first year they became eligible for their local PPO plan through their last year of eligibility or the end of the study period in 2013.

Plant-Level Gender Composition

Using company personnel files, we created a time-varying measure of workplace gender composition. We calculated the percent women employed at each plant for each year of follow-up, and we included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculation. To avoid including plants where production operations had ceased, we excluded years of follow-up in which the size of the workforce fell below 50 employees.

Treatment for Depression

We created a repeated, binary outcome measure of treatment for depression using medical claims data. We identified depression-related outpatient visits with diagnostic codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311 from the International Classification of Diseases, Ninth Revision (ICD-9). Next, we created a time-varying indicator variable which equaled one for every year in which a worker registered at least one depression-related outpatient visit, and zero otherwise.

Covariates

Basic demographic characteristics (gender, age, race/ethnicity), plant, and calendar year were derived from company personnel files. We created categorical variables for gender, race/ethnicity (Black, Hispanic, white, and other) and a set of indicator variables for plant and calendar year.

Statistical Analyses

We characterized the association between workplace gender composition (i.e. percent women) and treatment for depression using g-computation.^{49,50} This approach is an extension of regression-based standardization that involves using fitted models to predict the risk of treated depression at specific exposure levels. Although g-computation is often implemented in order to identify causal effects, it has several advantages in non-causal settings such as ours. These include straightforward estimation of additive-scale parameters (i.e. risk differences), and estimation of population average measures of association, rather than within covariate sub-groups as with traditional regression methods.

Our analysis proceeded in the following stages: first, we used generalized additive models (GAM) – a semi-parametric extension of generalized linear models – to model yearly treatment for depression as a function of the plant-level gender composition and covariates. Because GAMs relax the assumption of a linear dose-response otherwise imposed by GLMs, they are ideally suited for capturing both linear and non-linear relationships between response variables and continuous exposure variables such as ours. For all models, we adjusted for individual-level confounders (baseline age, sex, and race/ethnicity) that could plausibly affect both selection into more or less feminized workplaces and subsequent depression. We additionally included plant fixed effects to address confounding by geography and time-invariant plant-level characteristics (i.e. union status, process type) and a set of fixed effects for calendar year to account for secular trends. We specified a logit link and used cubic smoothing splines⁵¹ for baseline age and plant-level gender composition to capture potential nonlinear relationships for all analyses.

Next, we used fitted GAMs to predict the probability of treated depression in the observed data and under three intervention scenarios. For the first intervention scenario, all plants employed at least 10 percent women for all years of follow-up: all observations below this threshold were re-assigned to equal 10 percent but assumed their original value otherwise. For the second and third intervention scenarios, all plants employed at least 20 and 30 percent women, respectively, for all years of follow-up. Each intervention corresponds to a scenario in which all plants committed to maintaining a minimum percentage of employed women throughout the study period. Percentages were selected based on the observed data, and correspond approximately to the first quartile, mean, and third quartile of the percent women employed across all person-years. The 30 percent threshold corresponds to the percentage of women employed in the U.S. manufacturing as of 2017 (approximately 29%)².

Finally, we used the fitted GAMs to calculate risk differences by taking the difference between the predicted risk under each respective intervention scenario and the risk predicted from the observed data. We examined risk differences for each intervention scenario separately among male and female workers to account for potential differences in the prevalence of mood disorders, propensity to utilize healthcare services, and in response to changes in gender composition. We estimated 95% confidence intervals with a cluster bootstrap with 1,000 repetitions, resampling at the level of the plant to account for non-independence of outcomes among workers within plants.

Sensitivity Analyses

The study population included workers hired before and after the study period commenced in 2003. The anticipated inverse association between percent women and treatment for depression may reflect an average decrease in the number of workers using depression-related outpatient services in response to feminization of the workplace. Alternatively, an inverse association could arise if workers hired after the start of follow-up were systematically less likely to use mental healthcare services. To assess the plausibility of this alternative explanation, we examined the association between plant-level gender composition and treatment for depression separately among workers hired prior to the start of follow-up (i.e. prevalent hires) and workers hired after the start of follow-up (i.e. incident hires). Additional sensitivity analyses are described in the supplemental materials.

Statistical analyses were performed with R version 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria). This study was approved by the Institutional Review Boards at the University of California, Berkeley and at Stanford University.

2.4 Results

The study population included 5,279 women and 24,124 men. Female workers were treated for depression approximately twice as often as male workers (Table 1). Slightly less than half of workers ($N = 12,499$, 42.5%) were hired after the start of follow-up 2003. The majority of workers were white, although incident hires were more likely to be non-white. (Table 1 and Table 1 in the Supplemental Materials) The percent women employed across all plants included in our study increased throughout follow-up – most notably throughout the first half of the study period – from a minimum of 17.0% in 2003 to a maximum of 21.4% in 2009 (Figure 1). The median percent women employed was 15.5 (IQR 10.8 – 31.3). The minimum percent women employed across all plants and years of follow-up was 4.3 and the maximum percent women employed was 65.7 (Table 2 in the Supplemental Materials). Fitted GAMs suggested an inverse linear association, wherein the log-odds of treatment for depression decreased as the percent women employed within plants increased.

Main Analysis

Among women, we observed decreases in the number of workers that would have been treated for depression each year, under hypothetical scenarios where women comprised at least 20 percent (RD = -3.95 per 1,000; 95% CI -7.18, -0.72) and 30 percent (RD = -11.7 per 1,000; 95% CI -20.5, -2.88) of the workforce as compared with the observed data. Among men, results were entirely consistent with those observed among women. The intervention scenario wherein women comprised at least 20 percent of the workforce was associated with 6.4 fewer male blue-collar workers treated for depression per 1,000 within a given study year (95% CI -8.65, -4.15),

and the intervention scenario in which women comprised at least 30 percent of the workforce was associated with 14.5 fewer male blue-collar workers treated for depression per 1,000 within a given study year (95% CI -17.7, -11.2). We observed minimal changes in the use of depression-related outpatient services under the hypothetical intervention scenario in which women comprised at least 10 percent of the workforce across all plants throughout the study period among either male or female blue-collar workers (Figure 2 and Table 3 in the Supplemental Materials).

Sensitivity Analyses

Among prevalent hires, we still observed evidence that the risk of treatment for depression decreased under the hypothetical scenario in which women comprised at least 20 percent (RD = -6.2; 95% CI -8.47, -3.97) or 30 percent (RD = -14.4; 95% CI -18.2, -10.6) of the workforce as compared with the observed data. Among incident hires, we also observed decreased risk of treatment for depression when women comprised at least 20 percent (RD = -0.33; 95% CI -2.08, 1.4) or 30 percent (RD = -8.74; 95% CI -12.5, -4.98) of the workforce (Figure 3 and Table 4 in the Supplemental Materials).

2.5 Discussion

The gender composition of industries, occupations, and workplaces is an important expression of social structure. Although its implications for workplace inequality are well-studied, relatively fewer studies have examined its implications for worker health. For the present study, we characterize the association between workplace gender composition and treatment for depression among blue-collar workers employed by a single U.S. aluminum firm. To our knowledge, this is one of the first studies to characterize the association between workplace gender composition and treatment for depression among workers in the United States. Our analysis employs precise estimates of workplace gender composition rather than relying on estimates at the level of industry or occupation, as is typical in the extant literature. We summarize the association between workplace gender composition and treatment for depression using g-computation, a flexible modeling approach that allows us to summarize the risk for treated depression under specific levels of our exposure of interest.

Consistent with our study hypothesis, we observed an inverse association between plant-level gender composition and risk of treatment for depression among female blue-collar workers. These findings are supported by past research, which finds that women employed in occupations with male predominance are more likely to experience psychosocial stressors including diminished job satisfaction and antagonistic interactions with male coworkers. To the extent that feminization of the workforce mitigates any of these stressors, the well-being of female workers – and their use of outpatient depression-related services – could plausibly improve in response. We observed – entirely consistent with our results for blue-collar women – that the number of male blue-collar workers treated for depression decreased when women comprised at least 20 or 30 percent of the workforce. These results are perhaps counterintuitive since the decline in wages and prestige associated with the feminization of historically male-dominated workplaces could provoke stress, anxiety, or depression among male workers.

Our findings are, however, supported past research, which finds decreased risk for mortality, morbidity, and psychiatric morbidity among men living in countries or U.S. states with higher levels of gender equality.⁵²⁻⁵⁶ We note that as blue-collar men comprised the majority (82%) of

workers in our study population, the largest absolute decreases in the number of workers treated for depression (and the largest savings for the employer) associated with the feminization of the workplace will be realized among male workers, not female workers. Among both male and female workers, we observed very little evidence of any change in the use of depression-related services at the 10 percent threshold, likely because this intervention represents a very small deviation from the observed data, which was used as the reference for all calculated measures of association.

An alternative explanation for the observed inverse association between the percent women and treatment for depression is that changes in the plant-level gender composition coincide with the hiring of new workers who are systematically less likely to use depression-related outpatient services. To assess this alternative explanation, we examined the association between plant-level gender composition and treatment for depression among incident and prevalent hires. We observed decreased risk of treated depression among both incident and prevalent hires for the 20 and 30 percent thresholds. The results for prevalent hires in particular are consistent with the scenario in which workers decrease the frequency with which they are treated for depression in response to increases in the percent women employed at their workplaces.

Limitations

Measures of association estimated using g-computation can be interpreted as causal effects only when a set of assumptions – including exchangeability and consistency – are met.⁵⁷ We do not feel that these assumptions are satisfied in the present study, and therefore our results are more appropriately interpreted as associations rather than as causal effects.

With respect to exchangeability, we were only able to control for a limited number of individual-level characteristics as is typical of occupational studies. However, there may be residual confounding by unmeasured individual-level characteristics (i.e. prior work history). Although we included a set of fixed effects to control for confounding by time-invariant plant- and area-level characteristics, we were unable to differentiate changes in plant-level gender composition from coincident but unobserved changes in organizational culture or institutional practices relevant workers' utilization of depression-related services. Interpretation of our findings is further complicated by non-consistency of the exposure. Changes in workplace gender composition could arise through the termination of male workers, hiring of female workers, or some combination thereof.⁵⁸ These three scenarios could have substantively different implications for workers' underlying mental health and propensity to seek care for depression.

Finally, our outcome of interest is defined using medical claims data, which conflate treatment seeking with underlying disease status. Our outcome measure does not capture untreated depression or treatment received outside of the worker's PPO network. Moreover, absent information on workers' past history of mental illness, we cannot differentiate new onset and preexisting depression. Nevertheless, given the prodromal and oftentimes episodic nature of depressive disorders, we believe our outcome measure is a meaningful measure of clinically important depression sufficiently serious to prompt the worker to seek outpatient treatment.

2.6 Conclusion

We summarized the association between workplace gender composition and treatment for depression among blue-collar men and women employed by a single U.S. aluminum firm from 2003 – 2013. We found evidence of an inverse association between the percent women

employed and treatment for depression in both male and female blue-collar workers. We observed the greatest decreases in risk when at least 30 percent of the workforce is female. Our findings among female workers are supported by past research, which suggests that occupational sex segregation may be a considerable source of stress for women employed male-dominated industries and occupations. As blue-collar men comprised the majority of workers in our study population, our results further suggest that the largest absolute decreases in treatment for depression associated with the feminization of the workplace occur among male workers. Overall, our findings underscore the importance of the social context within workplaces for employee health and motivate continued examination of the association between workplace gender composition and worker health across varied industry sectors and occupations.

Table 1. Characteristics of the hourly workforce at 32 U.S. aluminum plants, 2003 – 2013

	All Workers (N = 29,403)	Male Workers (N = 24,124)	Female Workers (N = 5,279)
Baseline Age – Median (IQR) ^b	34.8 (27.9 – 43.6)	33.8 (27.4 – 42.2)	40.3 (32.0 – 47.8)
Race – N (%)			
White	20,988 (71.3)	17,561 (72.8)	3,427 (64.9)
Black	3,456 (11.8)	2,585 (10.7)	871 (16.5)
Hispanic	3,587 (12.2)	2,839 (11.7)	748 (14.2)
Other	1,372 (4.7)	1,139 (4.7)	233 (4.4)
Incident Hires ^b	12,499 (42.5)	10,053 (41.7)	2,446 (46.3)
Plant-level gender composition – Median (IQR) ^c	15.5 (10.8 – 31.3)	14.3 (10.5 – 19.3)	35.2 (18.3 – 38.4)
Person-years of follow-up – N	173,363	29,901	143,462
Person-years with treatment for depression – N (%) ^d	9,636 (5.6)	2,819 (9.4)	6,817 (4.8)

- a.** Baseline age was calculated at the start of the study period on January 1, 2003 for prevalent hires, and at first hire date for incident hires.
- b.** Incident hires include all hourly workers hired after the start of follow-up (in 2003 or afterwards).
- c.** Plant-level gender composition refers to the proportion of women (both hourly and salaried) employed within each plant during each year of follow-up. We included workers on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. Descriptive statistics reflect the distribution of the percent women pooled across all person-years of follow-up.
- d.** We identified depression-related outpatient visits using primary outpatient diagnostic ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

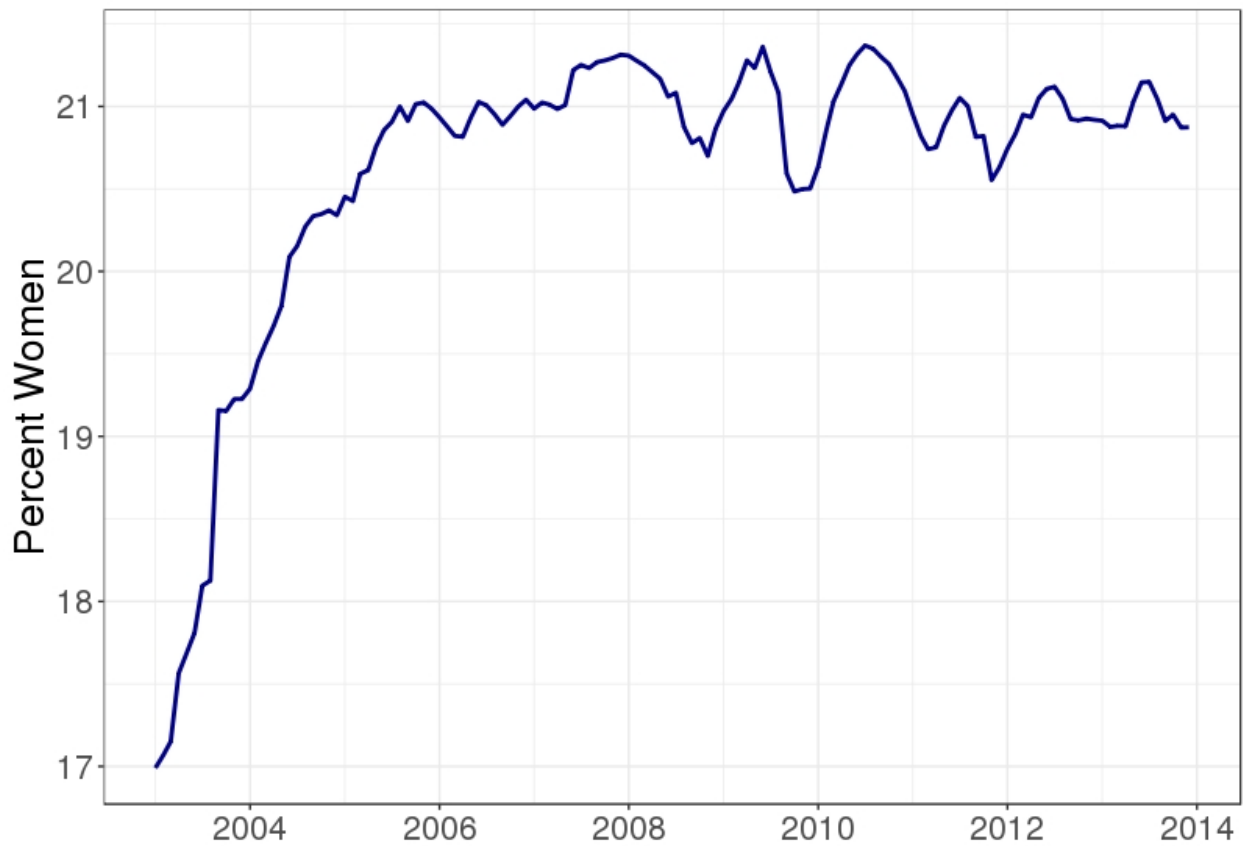


Figure 1. Percent women employed across all 32 U.S. plants from 2003 – 2013. Company personnel files provided complete enumeration of the size of the workforce by plant throughout the study period, as well as basic worker demographics. Using these data, we calculated the number of active workers, the number of active female workers, and the percentage of women employed at each plant for each month between 2003 and 2013. We included both hourly and salaried workers in our calculations of the plant-level gender-composition, and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations.

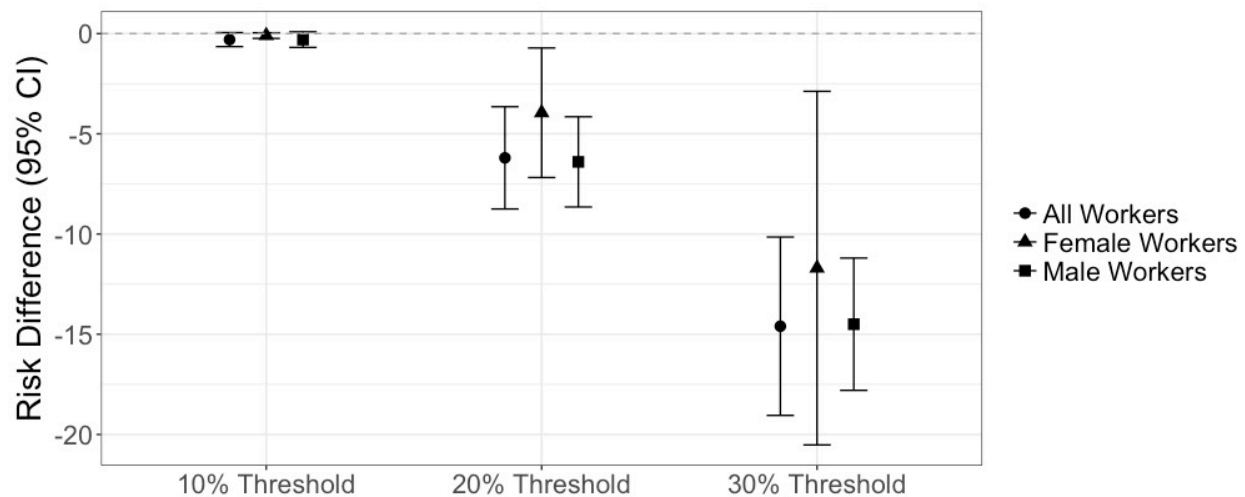


Figure 2. We used generalized additive models (GAM) with a logit link to model the risk of treatment for depression as a function of the plant-level gender composition and covariates (age at the start of follow-up, race, and sex). All models included a set of controls for plant and calendar year to account for geographic and temporal variation, respectively. We used g-computation to summarize the population average association between the plant-level gender composition and treatment for depression under three hypothetical intervention scenarios for all workers, and then separately among female and male workers. Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plants employed at least 10, 20, or 30 percent women for all years of follow-up. All observations below the specified threshold were re-assigned to equal 10, 20, or 30 percent, and assumed their original, observed value otherwise. We calculated risk differences (RDs) by contrasting the risk of the outcome under each hypothetical intervention scenario versus the risk calculated from the observed data. All risk differences reported correspond to the difference in the number of workers treated for depression per 1,000 within a given study year.

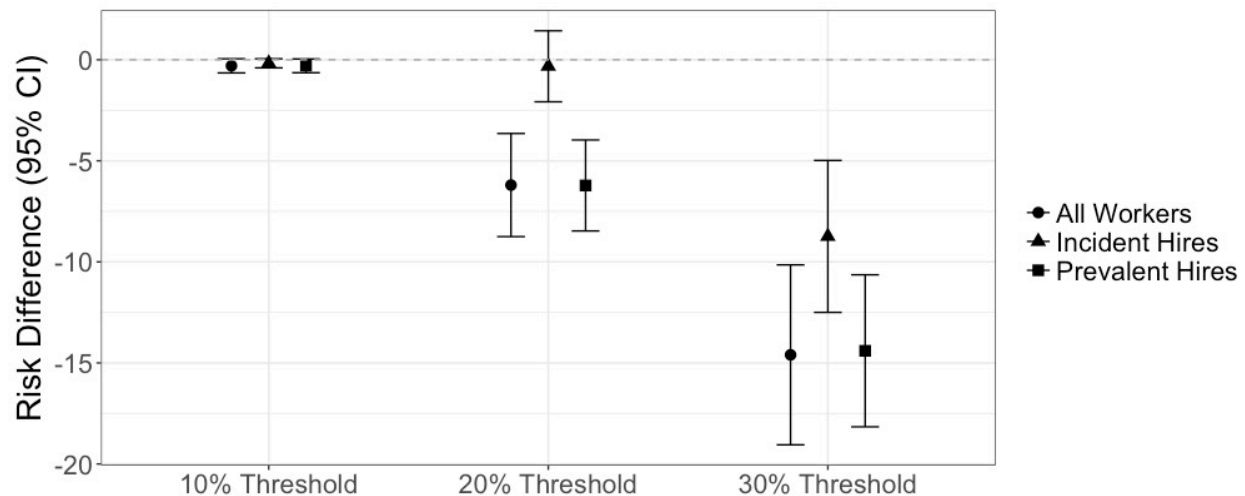


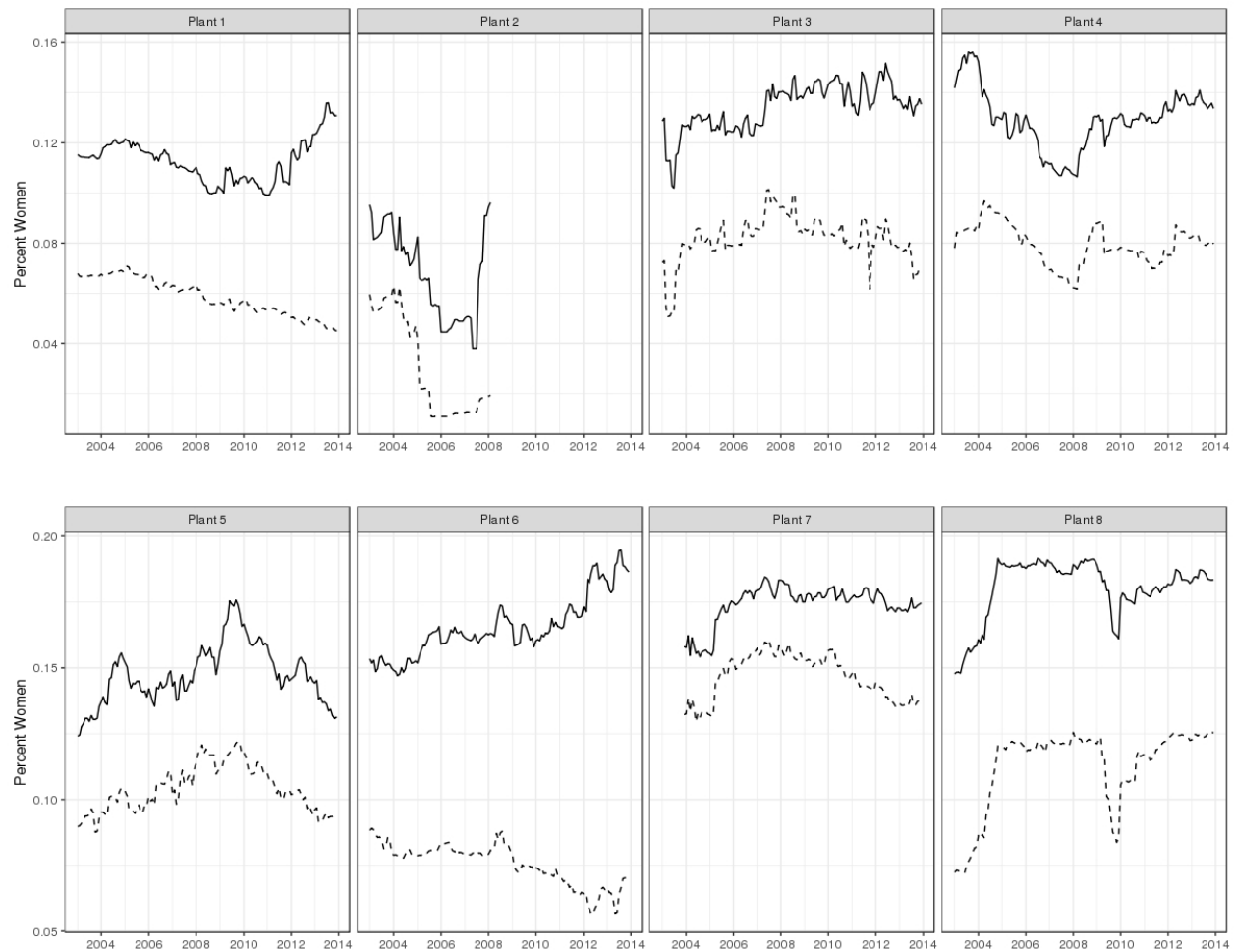
Figure 3. We used generalized additive models (GAM) with a logit link to model the risk of treatment for depression as a function of the plant-level gender composition and covariates (age at the start of follow-up, race, and sex). All models included a set of controls for plant and calendar year to account for geographic and temporal variation, respectively. We used g-computation to summarize the population average association between the plant-level gender composition and treatment for depression under three hypothetical intervention scenarios for all workers, and then separately among workers hired before the start of follow-up in 2003 (i.e. prevalent hires) and those hired after the start of follow-up (i.e. incident hires). Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plants employed at least 10, 20, or 30 percent women for all years of follow-up. All observations below the specified threshold were re-assigned to equal 10, 20, or 30 percent, and assumed their original, observed value otherwise. We calculated risk differences (RDs) by contrasting the risk of the outcome under each hypothetical intervention scenario versus the risk calculated from the observed data. All risk differences reported correspond to the difference in the number of workers treated for depression per 1,000 within a given study year.

2.8 Supplemental Materials

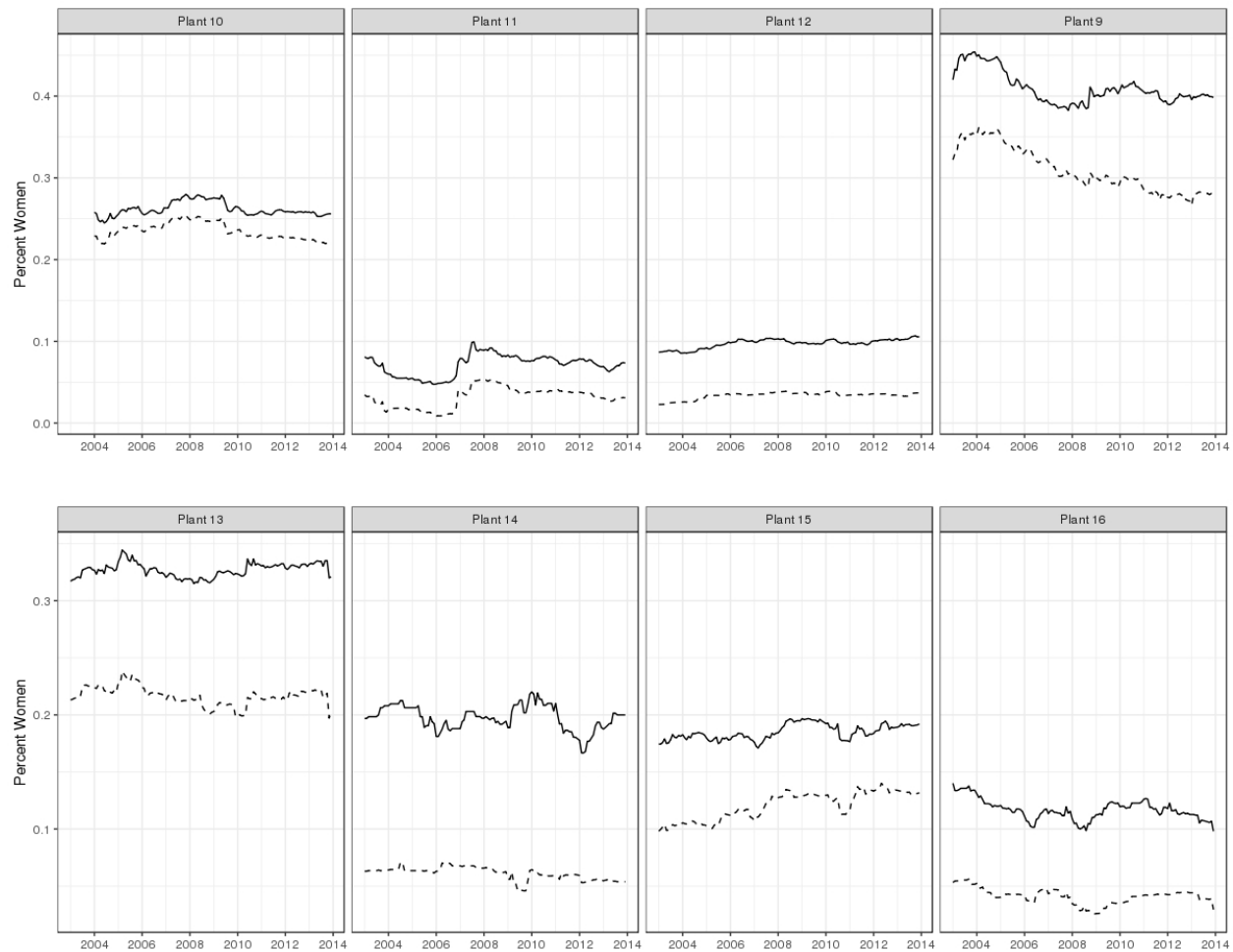
To examine the validity of our analytic approach, we conducted the following additional sensitivity analyses.

First, we repeated our main analysis using percent blue-collar women rather than the overall percent women as our independent variable. Our study population is restricted to male and female blue-collar workers at 32 U.S. aluminum manufacturing plants, and consistent with previous analyses of these data, we classified all hourly workers as blue-collar. However, our calculation of the plant-level gender composition includes both blue- and white-collar workers. Our rationale for including white-collar women in our calculation of the workplace gender composition is that the presence of additional women in the workplace could lead to changes in workplace culture - including decreased social isolation and improved morale – that could translate to improvements in the worker mental health. However, our analysis is restricted to workers in blue-collar jobs as our substantive interest is in the experiences of men and women in jobs with a historic and present-day male predominance. We find that white-collar women comprised a small minority of the active workforce across the U.S. plants included in our analysis (approximately 5.0%), and the percent women and the percent blue-collar women employed appear to covary within plants throughout the study period (Web Figure 1). Further, we find results consistent with those of our main analysis when we examined the association between percent blue-collar women and treatment for depression (Tables 2 and 5 in the Supplemental Materials).

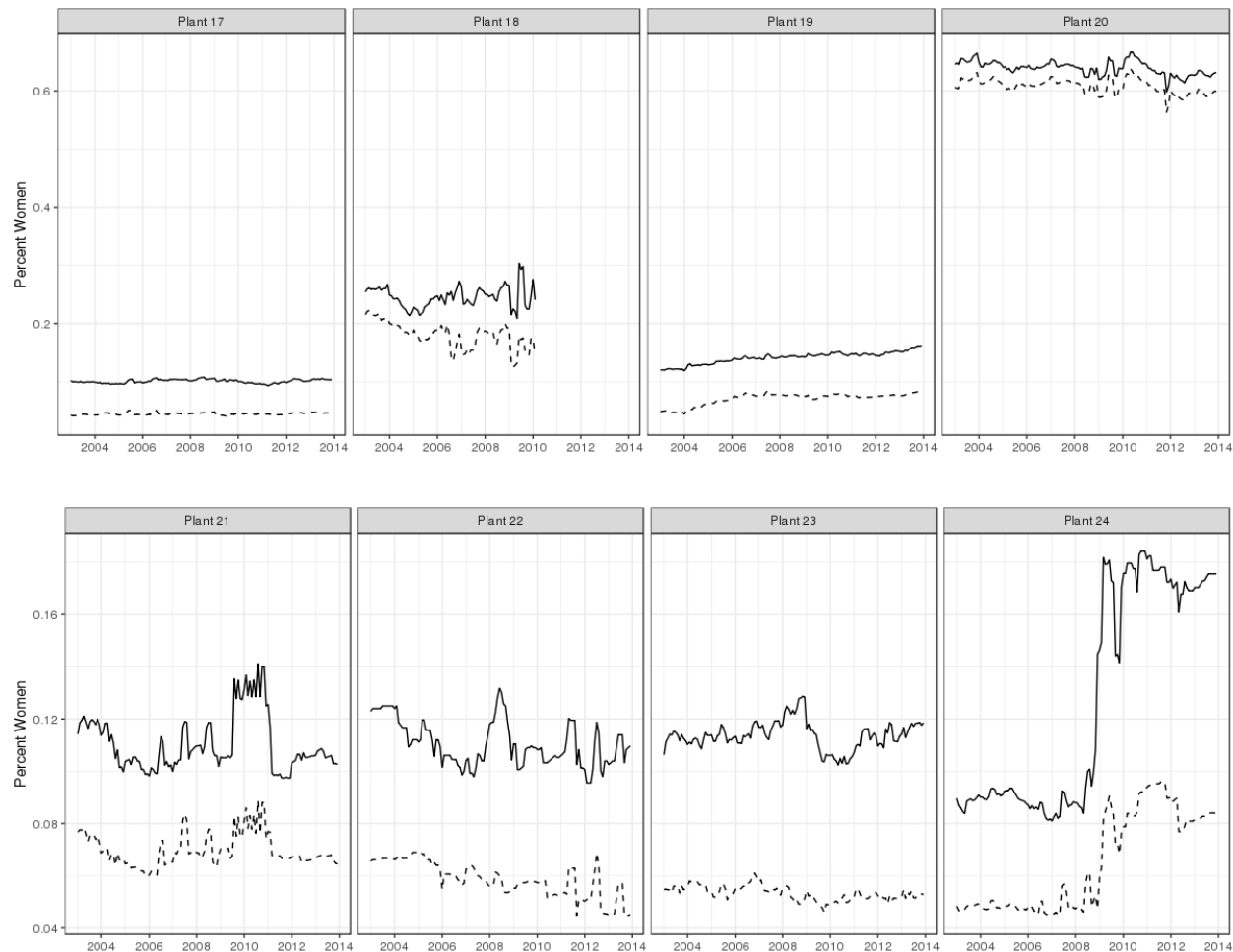
Second, the study data included monthly data on insurance eligibility. Our main analysis includes – for a given worker – any year in which they were enrolled and insured for at least one month. This partial annual eligibility is a potential source of bias because we are by axiom less likely to observe treatment for depression in a worker who is eligible for only part of the year. Partial annual eligibility is a potential source of bias if it occurs with greater frequency at plants depending on the percent women employed at that plant. To assess potential bias due to partial annual insurance eligibility, we repeated our main analysis by limiting our dataset to include only those person-years in which a given worker was continuously insured and eligible for all 12 months. The results from this sensitivity analysis were also consistent with those of our main analysis (Tables 2 and 6 in the Supplemental Materials).



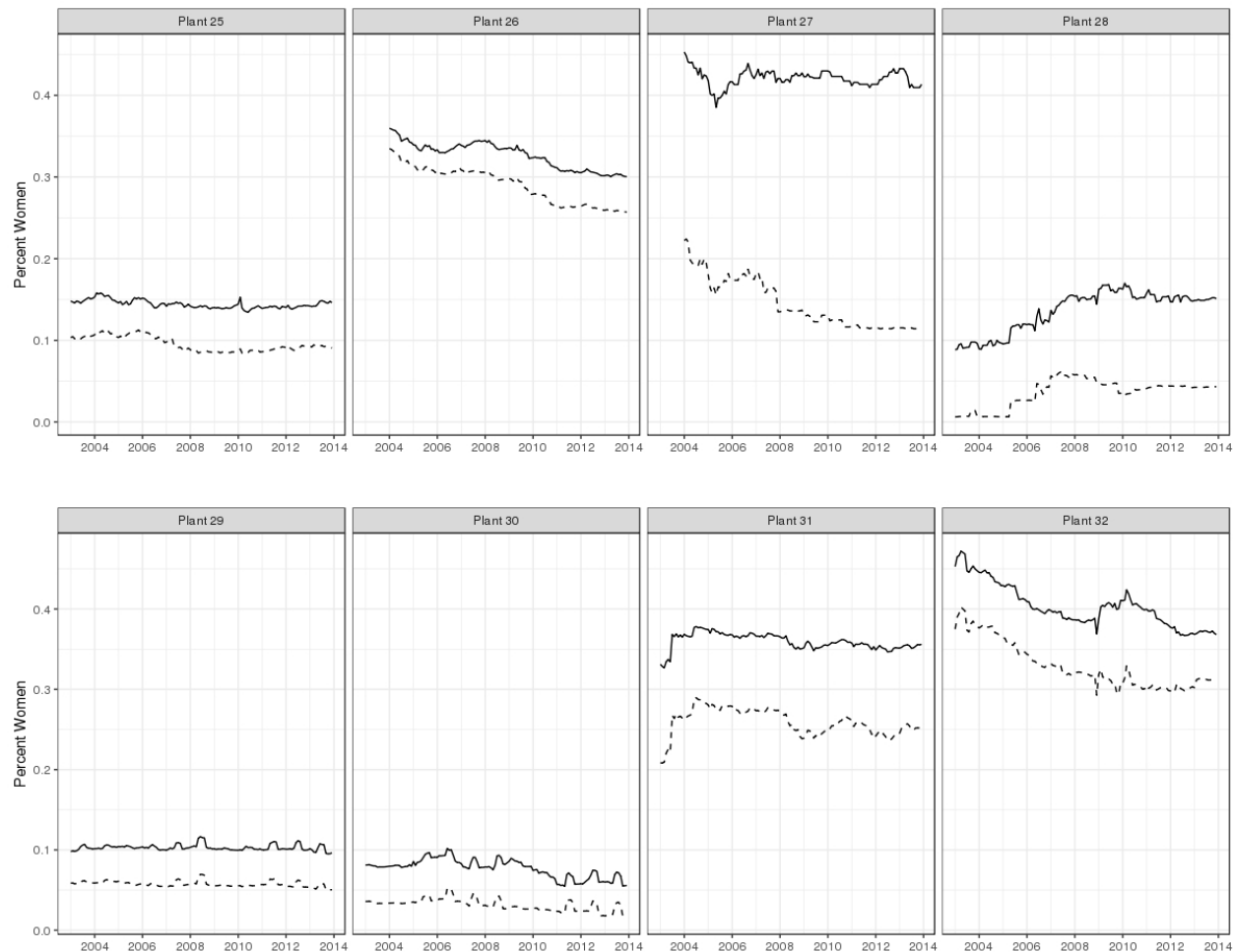
Supplemental Figure 1. Percent women employed within each of the 32 U.S. plant locations from 2003 – 2013. Company personnel files provided complete enumeration of the size of the workforce by plant location from month-to-month, as well as basic worker demographic details, including gender. Using these data, we calculated the number of active workers, the number of active female workers, and the proportion of women employed at each plant location for each month between January 2003 and December 2013. We included both hourly and salaried workers in our calculation of the percent women and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. We excluded years of follow-up for any plant location where fewer than 50 workers were employed. To calculate the monthly proportion blue-collar women employed at each plant location, we divided the number of active hourly female workers by the total number of active workers employed at each plant location each month.



Supplemental Figure 1 (Continued). Percent women employed within each of the 32 U.S. plant locations from 2003 – 2013. Company personnel files provided complete enumeration of the size of the workforce by plant location from month-to-month, as well as basic worker demographic details, including gender. Using these data, we calculated the number of active workers, the number of active female workers, and the proportion of women employed at each plant location for each month between January 2003 and December 2013. We included both hourly and salaried workers in our calculation of the percent women and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. We excluded years of follow-up for any plant location where fewer than 50 workers were employed. To calculate the monthly proportion blue-collar women employed at each plant location, we divided the number of active hourly female workers by the total number of active workers employed at each plant location each month.



Supplemental Figure 1 (Continued). Percent women employed within each of the 32 U.S. plant locations from 2003 – 2013. Company personnel files provided complete enumeration of the size of the workforce by plant location from month-to-month, as well as basic worker demographic details, including gender. Using these data, we calculated the number of active workers, the number of active female workers, and the proportion of women employed at each plant location for each month between January 2003 and December 2013. We included both hourly and salaried workers in our calculation of the percent women and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. We excluded years of follow-up for any plant location where fewer than 50 workers were employed. To calculate the monthly proportion blue-collar women employed at each plant location, we divided the number of active hourly female workers by the total number of active workers employed at each plant location each month.



Supplemental Figure 1 (Continued). Percent women employed within each of the 32 U.S. plant locations from 2003 – 2013. Company personnel files provided complete enumeration of the size of the workforce by plant location from month-to-month, as well as basic worker demographic details, including gender. Using these data, we calculated the number of active workers, the number of active female workers, and the proportion of women employed at each plant location for each month between January 2003 and December 2013. We included both hourly and salaried workers in our calculation of the percent women and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. We excluded years of follow-up for any plant location where fewer than 50 workers were employed. To calculate the monthly proportion blue-collar women employed at each plant location, we divided the number of active hourly female workers by the total number of active workers employed at each plant location each month.

Supplemental Table 1. Characteristics of the hourly workforce by hire date at 32 U.S. aluminum plants, 2003 – 2013

	All Workers (N = 29,403)	Incident Hires ^a (N = 12,499)	Prevalent Hires ^a (N = 16,904)
Baseline Age – Median (IQR) ^b	34.8 (27.9 – 43.6)	34.2 (26.3 – 43.5)	35.2 (29.0 – 43.6)
Race – N (%)			
White	20,988 (71.3)	7,737 (61.9)	13,251 (78.4)
Black	3,456 (11.8)	1,519 (12.2)	1,937 (11.5)
Hispanic	3,587 (12.2)	2,372 (19.0)	1,215 (7.2)
Other	1,372 (4.7)	871 (7.0)	501 (3.0)
Women – N (%)	5,279 (18.0)	2,446 (19.6)	2,833
Plant-level gender composition – Median (IQR) ^c	15.5 (10.8 – 31.3)	18.7 (11.2 – 35.2)	14.7 (10.5 – 19.4)
Person-years of follow-up – N	173,363	50,837	122,526
Person-years with treatment for depression – N (%) ^d	9,636 (5.6)	3,173 (6.2)	6,463 (5.3)

a. Incident hires include all hourly workers hired after the start of follow-up (in 2003 or afterwards); prevalent hires include all hourly workers hired prior to 2003.

b. Baseline age was calculated at the start of the study period on January 1, 2003 for prevalent hires, and at first hire date for incident hires.

c. Plant-level gender composition refers to the proportion of women (both hourly and salaried) employed within each plant-location during each year of follow-up. We included workers on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. Descriptive statistics reflect the distribution of the percent women pooled across all person-years of follow-up.

d. Reflects the total number of person-years over the course of follow-up in which a given worker had at least one depression-related outpatient visit. We identified depression-related outpatient visits using primary outpatient diagnostic ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

Supplemental Table 2. Median, minimum, and maximum proportion women and blue-collar women employed at each of the 32 U.S. plant locations, 2003 – 2013

Plant Number	Proportion Women ^a			Proportion Blue-Collar Women ^b		
	Median	Minimum	Maximum	Median	Minimum	Maximum
1	0.11	0.10	0.14	0.06	0.04	0.07
2	0.11	0.04	0.12	0.02	0.01	0.06
3	0.14	0.10	0.15	0.08	0.05	0.10
4	0.13	0.11	0.16	0.08	0.06	0.10
5	0.15	0.12	0.18	0.08	0.06	0.10
6	0.16	0.15	0.19	0.10	0.09	0.12
7	0.18	0.15	0.18	0.08	0.06	0.09
8	0.18	0.15	0.19	0.12	0.07	0.13
9	0.40	0.38	0.45	0.30	0.27	0.36
10	0.26	0.24	0.28	0.23	0.22	0.25
11	0.07	0.05	0.10	0.03	0.01	0.05
12	0.10	0.09	0.11	0.03	0.02	0.04
13	0.30	0.32	0.34	0.22	0.20	0.24
14	0.20	0.17	0.22	0.06	0.05	0.07
15	0.18	0.17	0.20	0.13	0.10	0.14
16	0.12	0.10	0.14	0.04	0.03	0.06
17	0.10	0.09	0.11	0.04	0.04	0.04
18	0.28	0.21	0.37	0.22	0.12	0.32
19	0.14	0.12	0.16	0.08	0.04	0.09
20	0.64	0.60	0.67	0.61	0.56	0.64
21	0.11	0.10	0.14	0.07	0.06	0.09
22	0.11	0.10	0.13	0.06	0.04	0.07
23	0.11	0.11	0.13	0.05	0.05	0.06
24	0.09	0.08	0.18	0.05	0.04	0.10
25	0.14	0.13	0.16	0.09	0.08	0.11
26	0.33	0.30	0.36	0.09	0.08	0.11
27	0.42	0.39	0.45	0.14	0.11	0.22
28	0.15	0.09	0.17	0.04	0.01	0.06
29	0.10	0.10	0.12	0.06	0.05	0.07
30	0.08	0.05	0.10	0.03	0.02	0.05
31	0.36	0.33	0.38	0.26	0.21	0.29
32	0.40	0.37	0.47	0.32	0.29	0.40

a. Company personnel files provided complete enumeration of the size of the workforce by plant location from month-to-month, as well as basic worker demographic details, including gender. Using these data, we calculated the number of active workers, the number of active female workers, and the proportion of women employed at each plant location for each month between January 2003 and December 2013. We included both hourly and salaried workers in our calculation of the percent women, and included active workers as well as those on leave of absence, family medical leave, short-term disability, and long-term disability in our calculations. We excluded years of follow-up for any plant location where fewer than 50 workers were employed.

b. To calculate the monthly proportion blue-collar women employed at each plant location, we divided the number of active hourly female workers by the total number of active workers employed at each plant location each month.

Supplemental Table 3. Association between plant-level gender composition and treatment for depression under three hypothetical intervention scenarios ^{a,b}

	All Workers (N = 29,403)		Female Workers (N = 5,279)		Male Workers (N = 24,124)	
	Risk Difference ^c (95% CI)	Risk Ratio (95% CI)	Risk Difference ^c (95% CI)	Risk Ratio (95% CI)	Risk Difference ^c (95% CI)	Risk Ratio (95% CI)
Observed	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
10% Threshold ^d	- 0.30 (- 0.65, 0.05)	1.00 (0.99, 1.00)	- 0.10 (- 0.24, 0.04)	1.00 (0.99, 1.00)	- 0.30 (- 0.69, 0.09)	0.99 (0.98, 1.00)
20% Threshold ^e	- 6.20 (- 8.75, - 3.65)	0.89 (0.83, 0.95)	- 3.95 (- 7.18, - 0.72)	0.96 (0.92, 0.99)	- 6.40 (- 8.65, - 4.15)	0.87 (0.81, 0.92)
30% Threshold ^f	- 14.6 (- 19.0, - 10.2)	0.74 (0.64, 0.83)	- 11.7 (- 20.5, - 2.88)	0.88 (0.79, 0.97)	- 14.5 (- 17.8, - 11.2)	0.70 (0.63, 0.76)

a. We used generalized additive models (GAM) with a logit link to model the risk of depression-related outpatient visits as a function of the plant-level gender composition and covariates (age at the start of follow-up, race, and sex). We used g-computation to summarize the marginal association between the plant-level gender composition and depression-related outpatient visits under three hypothetical intervention scenarios.

b. Depression-related outpatient visits were defined using ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

c. All risk differences reported correspond to the decrease in the number of person-years in which at least one depression-related outpatient visit occurred per 1,000.

d. Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 10 percent women for all years of follow-up. All observations below this threshold were re-assigned to equal ten percent, and assumed their original, observed value otherwise. We calculated measures of association (RD and RR) by contrasting the risk of the outcome under this intervention scenario versus the risk calculated from the observed data.

e. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 20 percent women for all years of follow-up.

f. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 30 percent women for all years of follow-up.

Supplemental Table 4. Association between plant-level gender composition and treatment for depression among all workers, incident and prevalent hires ^{a,b}

	All Workers (N = 29,403)		Incident Hires ^c (N = 12,499)		Prevalent Hires ^c (N = 16,904)	
	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)
Observed	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
10% Threshold ^e	- 0.30 (- 0.65, 0.05)	1.00 (0.99, 1.00)	- 0.17 (- 0.40, 0.05)	1.00 (0.99, 1.00)	- 0.30 (- 0.64, 0.04)	0.99 (0.98, 1.00)
20% Threshold ^f	- 6.20 (- 8.75, - 3.65)	0.89 (0.83, 0.95)	- 0.33 (- 2.08, 1.43)	0.95 (0.92, 0.98)	- 6.22 (- 8.47, - 3.97)	0.88 (0.83, 0.94)
30% Threshold ^g	- 14.6 (- 19.0, - 10.2)	0.74 (0.64, 0.83)	- 8.74 (- 12.5, - 4.98)	0.86 (0.80, 0.92)	- 14.4 (- 18.2, - 10.6)	0.73 (0.64, 0.81)

a. We used generalized additive models (GAM) with a logit link to model the risk of depression-related outpatient visits as a function of the plant-level gender composition and covariates (age at the start of follow-up, race, and sex). We used g-computation to summarize the marginal association between the plant-level gender composition and depression-related outpatient visits under three hypothetical intervention scenarios.

b. Depression-related outpatient visits were defined using ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

c. Incident hires include all hourly workers hired after the start of follow-up (in 2003 or afterwards); and prevalent hires include all hourly workers hired prior to the start of follow-up. **d.** All risk differences reported correspond to the decrease in the number of person-years in which at least one depression-related outpatient occurred per 1,000.

e. Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 10 percent women for all years of follow-up. All observations below this threshold were re-assigned to equal ten percent, and assumed their original, observed value otherwise. We calculated measures of association (RD and RR) by contrasting the risk of the outcome under this intervention scenario versus the risk calculated from the observed data.

f. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 20 percent women for all years of follow-up.

g. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 30 percent women for all years of follow-up.

Supplemental Table 5. Association between percent blue-collar women and treatment for depression under three hypothetical intervention scenarios ^{a,b}

	All Workers (N = 29,403)		Female Workers (N = 5,279)		Male Workers (N = 24,124)	
	Risk Difference ^b (95% CI)	Risk Ratio (95% CI)	Risk Difference ^b (95% CI)	Risk Ratio (95% CI)	Risk Difference ^b (95% CI)	Risk Ratio (95% CI)
Observed	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
10% Threshold ^c	0.37 (0.17 – 0.56)	1.01 (1.00, 1.01)	3.62 (2.60, 4.64)	1.04 (1.03, 1.05)	- 0.10 (-0.54, 0.34)	0.99 (0.98, 1.01)
20% Threshold ^d	- 2.00 (- 3.02, - 0.98)	0.96 (0.94, 0.97)	4.22 (3.00, 5.44)	1.04 (1.03, 1.05)	- 2.46 (-3.83, - 1.09)	0.95 (0.92, 0.98)
30% Threshold ^e	- 15.4 (- 19.0, - 11.8)	0.72 (0.66, 0.78)	- 16.0 (- 20.0, -12.0)	0.83 (0.79, 0.87)	- 14.3 (- 17.2, -11.4)	0.70 (0.65, 0.75)

a. We used generalized additive models (GAM) with a logit link to model the risk of depression-related outpatient visits as a function of the percent blue-collar women employed at the plant-level and covariates (age at the start of follow-up, race, and sex). We used g-computation to summarize the marginal association between the plant-level gender composition and depression-related outpatient visits under three hypothetical intervention scenarios.

b. Depression-related outpatient visits were defined using ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

c. All risk differences reported correspond to the decrease in the number of person-years in which at least one depression-related outpatient occurred per 1,000.

d. Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 10 percent blue-collar women for all years of follow-up. All observations below this threshold were re-assigned to equal ten percent, and assumed their original, observed value otherwise. We calculated measures of association (RD and RR) by contrasting the risk of the outcome under this intervention scenario versus the risk calculated from the observed data.

e. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 20 percent blue-collar women for all years of follow-up.

f. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 30 percent blue-collar women for all years of follow-up.

Supplemental Table 6. Association between plant-level gender composition and treatment for depression restricted to person-years with completed PPO eligibility.^{a,b,c}

	All Workers (N = 29,403)		Female Workers (N = 5,279)		Male Workers (N = 24,124)	
	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)	Risk Difference ^d (95% CI)	Risk Ratio (95% CI)
Observed	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
10% Threshold^e	- 0.33 (- 0.71, 0.06)	0.99 (0.98, 1.00)	- 0.09 (- 0.23, 0.04)	1.00 (0.99, 1.00)	- 0.40 (- 0.88, 0.07)	0.99 (0.98, 1.00)
20% Threshold^f	- 6.70 (- 9.46, - 3.94)	0.88 (0.82, 0.94)	- 3.85 (- 7.59, - 0.11)	0.96 (0.92, 1.00)	- 7.67 (- 10.5, - 4.87)	0.84 (0.78, 0.91)
30% Threshold^g	- 15.7 (- 20.4, - 11.0)	0.72 (0.63, 0.82)	- 11.4 (- 22.1, - 0.74)	0.88 (0.77, 0.99)	- 17.2 (- 21.1, - 13.3)	0.65 (0.57, 0.73)

a. We restricted our follow-up to those person years in which workers were eligible for their local PPO insurance for all 12 months of the year.

b. Depression-related outpatient visits were defined using ICD-9 codes 293.84, 296.2 – 296.3, 300.00 – 300.02, 309 and 311.

c. We used generalized additive models (GAM) with a logit link to model the risk of depression-related outpatient visits as a function of the plant-level gender composition and depression-related outpatient visits under three hypothetical intervention scenarios.

d. All risk differences reported correspond to the decrease in the number of person-years in which at least one depression-related outpatient occurred per 1,000.

e. Using fitted GAMs, we estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 10 percent women for all years of follow-up. All observations below this threshold were re-assigned to equal ten percent, and assumed their original, observed value otherwise. We calculated measures of association (RD and RR) by contrasting the risk of the outcome under this intervention scenario versus the risk calculated from the observed data.

f. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 20 percent women for all years of follow-up.

g. We estimated the risk that at least one depression-related outpatient visit occurred within a given person-year under the hypothetical intervention wherein all plant locations employed at least 30 percent women for all years of follow-up.

2.9 References

1. Fullerton Jr HN. Labor force participation: 75 years of change, 1950-98 and 1998-2025. *Mon Labor Rev.* 1999;122:3.
2. U.S. Bureau of Labor Statistics. Women in the labor force: a databook. Available from: <https://www.bls.gov/opub/reports/womens-databook/2016/home.htm>. Accessed April 2019.
3. U.S. Bureau of Labor Statistics. Spotlight on Statistics: Women at work. Available from: <https://www.bls.gov/spotlight/2017/women-at-work/home.htm>. Accessed April 2019
4. Gardiner M, Tiggemann M. Gender differences in leadership style, job stress and mental health in male-and female-dominated industries. *J Occup Organ Psych.* 1999;72(3):301-15.
5. Blau FD. Trends in the well-being of American women, 1970-1995. NBER Working Paper 6206. 1997.
6. Costa DL. From Mill Town to Board Room: The Rise of Women's Paid Labor. *J Econ Perspect.* 2000;14(4):101-22.
7. Bailey MJ. "Momma's Got the Pill": How Anthony Comstock and Griswold v. Connecticut Shaped US Childbearing. *Am Econ Rev.* 2010;100(1):98-129.
8. Bailey MJ. More Power to the Pill: The Impact of Contraceptive Freedom on Women's Life Cycle Labor Supply. *Q J Econ.* 2006;121(1):289-320.
9. Goldin C. A grand gender convergence: its last chapter. *Am Econ Rev.* 2014;104(4):1-30.
10. Levanon A, Grusky DB. The persistence of extreme gender segregation in the twenty-first century. *Am J Sociol.* 2016;122(2):573-619.
11. Reskin BF, McBrier DB, Kmec JA. The determinants and consequences of workplace sex and race composition. *Annu Rev Sociol* 1999;25(1):335-61.
12. Gorman EH. Gender stereotypes, same-gender preferences, and organizational variation in the hiring of women: Evidence from law firms. *Am Sociol Rev.* 2005;70(4):702-28.
13. Hochschild AR, Machung A. The second shift: working families and the revolution at home. New York: Penguin Books; 2015.
14. England P, Farkas G, Kilbourne BS, Dou T. Explaining occupational sex segregation and wages: Findings from a model with fixed effects. *Am Sociol Rev.* 1988;53(4):544-58.
15. Okamoto D, England P. Is there a supply side to occupational sex segregation? *Sociol Perspect.* 1999;42(4):557-82.
16. Reskin BF, Bielby DD. A sociological perspective on gender and career outcomes. *J Econo Perspect.* 2005;19(1):71-86.
17. Groshen EL. The structure of the female/male wage differential: Is it who you are, what you do, or where you work? *J Hum Resour.* 1987;26(3):457-72.
18. England P. Comparable worth: Theories and evidence. London: Routledge; 2017.
19. Blau FD, Kahn LM. The gender wage gap: Extent, trends, and explanations. *J Econ Lit.* 2017;55(3):789-865.
20. Millward N, Woodland S. Gender segregation and male/female wage differences. *Gender Work Organ.* 1995;2(3):125-39.
21. Bender KA, Donohue SM, Heywood JS. Job satisfaction and gender segregation. *Oxford Econ Pap.* 2005;57(3):479-96.
22. England P. Wage appreciation and depreciation: A test of neoclassical economic explanations of occupational sex segregation. *Soc Forces* 1984;62(3):726-49.
23. Petersen T, Morgan LA. Separate and unequal: Occupation-establishment sex segregation and the gender wage gap. *Am J Sociol.* 1995;101(2):329-65.
24. Knoke D. Cui bono? Employee benefit packages. *Am Behav Sci.* 1994;37(7):963-78.

25. Aries E. Interaction patterns and themes of male, female, and mixed groups. *Small Group Behav.* 1976;7(1):7-18.
26. Carlock CJ, Martin PY. Sex composition and the intensive group experience. *Soc Work.* 1977;22(1):27-32.
27. Bobbitt-Zeher D. Gender discrimination at work: Connecting gender stereotypes, institutional policies, and gender composition of workplace. *Gender Soc.* 2011;25(6):764-86.
28. Burstein P. Attacking sex discrimination in the labor market: A study in law and politics. *Soc Forces.* 1989;67(3):641-65.
29. Gruber JE. The impact of male work environments and organizational policies on women's experiences of sexual harassment. *Gender Soc.* 1998;12(3):301-20.
30. Taylor SE. A categorization approach to stereotyping. In: Hamilton, DL ed. *Cognitive Processes in Stereotyping and Intergroup Behavior*. Mahwah, New Jersey: Lawrence Erlbaum Associates; 1981. p. 83-114.
31. Sackett PR, DuBois CL, Noe AW. Tokenism in performance evaluation: The effects of work group representation on male-female and White-Black differences in performance ratings. *J Appl Psychol.* 1991;76(2):263-7.
32. Gruber JE, Bjorn L. Blue-collar blues: The sexual harassment of women autoworkers. *Work Occupation.* 1982;9(3):271-98.
33. Harrell WA. Perceived risk of occupational injury: Control over pace of work and blue-collar versus white-collar work. *Percept Motor Skill.* 1990;70(3_Suppl):1351-9.
34. Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm SH, Wegman D, Sctock SR, de Grosbois S. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med.* 2003;43(6):618-29.
35. Loscocco KA, Spitze G. Working conditions, social support, and the well-being of female and male factory workers. *J Health Soc Behav.* 1990;31(4):313-27.
36. Blalock HM. *Toward a theory of minority-group relations*. New York, NY: Wiley; 1970.
37. Fields DL, Blum TC. Employee satisfaction in work groups with different gender composition. *Journal of Organ Behav.* 1997;18(2):181-96.
38. Alexanderson K, Leijon M, Åkerlind I, Rydh H, Bjurulf P. Epidemiology of sickness absence in a Swedish county in 1985, 1986 and 1987: A three year longitudinal study with focus on gender, age and occupation. *Scand J Soc Med.* 1994;22(1):27-34.
39. Hensing G, Alexanderson K, Åkerlind I, Bjurulf P. Sick-leave due to minor psychiatric morbidity: role of sex integration. *Soc Psych Psych Epid.* 1995;30(1):39-43.
40. Evans O, Steptoe A. The contribution of gender-role orientation, work factors and home stressors to psychological well-being and sickness absence in male-and female-dominated occupational groups. *Soc Sci Med.* 2002;54(4):481-92.
41. Mastekaasa A. Sickness absence in female-and male-dominated occupations and workplaces. *Soc Sci Med.* 2005;60(10):2261-72.
42. Melsom AM, Mastekaasa A. Gender, occupational gender segregation and sickness absence: Longitudinal evidence. *Acta Sociol.* 2018;61(3):227-45.
43. Ostlin P, Alfredsson L, Hammar N, Reuterwall C. Myocardial infarction in male and female dominated occupations. *Occup Environ Med.* 1998;55(9):642-44.
44. Josephson M, Pernold G, Ahlberg-Hultén G, Härenstam A, Theorell T, Vingård E, Waldenström M, Wigaeus Hjelm E. Differences in the association between psychosocial work conditions and physical work load in female-and male-dominated occupations. *Am Ind Hyg Assoc J.* 1999;60(5):673-78.
45. Bond MA, Punnett L, Pyle JL, Cazeca D, Cooperman M. Gendered work conditions, health, and work outcomes. *J Occup Health Psych.* 2004;9(1):28-45.

46. Bergman B, Carlsson SG, Wright I. Women's work experiences and health in a male-dominated industry: A longitudinal study. *J Occup Environ Med.* 1996;38(7):663-72.
47. Baron JN, Bielby WT. Organizational barriers to gender equality: Sex segregation of jobs and opportunities. In: Rossi, A ed. *Gender and the Life Course*. Piscataway, New Jersey: Transaction Publisher; 1985. p. 233-51.
48. Einav L, Finkelstein A, Pascu I, Cullen MR. How general are risk preferences? Choices under uncertainty in different domains. *Am Econ Rev.* 2012;102(6):2606-38.
49. Ahern J, Hubbard A, Galea S. Estimating the effects of potential public health interventions on population disease burden: a step-by-step illustration of causal inference methods. *Am J Epidemiol.* 2009;169(9):1140-47.
50. Snowden JM, Rose S, Mortimer KM. Implementation of G-computation on a simulated data set: demonstration of a causal inference technique. *Am J Epidemiol.* 2011;173(7):731-38.
51. Hastie TJ, Tibshirani R. Generalized additive models. *Stat Sci.* 1986;1(3):297-318.
52. Van de Velde S, Huijts T, Bracke P, Bambra C. Macro-level gender equality and depression in men and women in Europe. *Sociol Health Ill.* 2013;35(5):682-98.
53. Torsheim T, Ravens-Sieberer U, Hetland J, Välimaa R, Danielson M, Overpeck M. Cross-national variation of gender differences in adolescent subjective health in Europe and North America. *Soc Sci Med.* 2006;62(4):815-27.
54. Stanistreet D, Bambra C, Scott-Samuel A. Is patriarchy the source of men's higher mortality? *J Epidemiol Commun H.* 2005;59(10):873-6.
55. Kawachi I, Kennedy BP, Gupta V, Prothrow-Stith D. Women's status and the health of women and men: a view from the States. *Soc Sci Med.* 1999;48(1):21-32.
56. Cullen MR, Baiocchi M, Eggleston K, Loftus P, Fuchs V. The weaker sex? Vulnerable men and women's resilience to socio-economic disadvantage. *SSM-Pop Health.* 2016;2:512-24.
57. Hernán MA. Beyond exchangeability: the other conditions for causal inference in medical research. *Stat Methods Med Res.* 2011;21(1):3-5.
58. Cole SR, Frangakis CE. The consistency statement in causal inference: a definition or an assumption? *Epidemiology.* 2009;20(1):3-5.

Chapter 3: Layoffs and the mental health and safety of remaining workers: A quasi-experimental study of the U.S. aluminum industry

3.1 Abstract

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. We examined the effects of layoffs on mental healthcare utilization and injury risk among workers at 30 U.S. 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 three-month period one year previously, accounting for secular trends with control plants. Our study population included 15,502 workers and seven layoff events between 2003 and 2012. Layoffs were associated with decreases in reported injuries (-0.006, 95% CI -0.013, 0.001), and increased probability of outpatient visits (0.010, 95% CI 0.003, 0.017) and prescriptions (0.014, 95% CI -0.0006, 0.027) for mental health. Among men, injury risk decreased more substantially (-0.010, 95% CI -0.018, -0.001) and among women the increase in outpatient visits was more pronounced (0.017, 95% CI 0.003, 0.031). Increased prescription utilization appeared attributable primarily to opioids (0.016 95% CI 0.005 – 0.027). Our results indicate an association between layoffs and remaining workers' mental health and safety. However, decreased injury may reflect changes in reporting practices, and changes mental healthcare utilization may reflect changes in care-seeking. Future research on concordance of service utilization and underlying health and safety may yield valuable insight into the experiences employed workers in the wake of layoffs.

3.2 Introduction

The consequences of socioeconomic shocks such as plant closures, downsizing, and layoffs for workers are well-characterized. Job displacement, for example, has been linked with prolonged periods of subsequent unemployment, diminished earning, 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,^{8,10,11} and drug and alcohol abuse.¹²⁻¹⁴

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.¹⁵ Remaining workers may experience greater job insecurity in the wake of layoffs, especially in the context of recessions when labor markets are relatively weak and other employment opportunities may be limited.¹⁶ Layoffs and the resultant job insecurity may additionally serve to weaken remaining workers' organizational commitment, increase work related stress, and decrease job satisfaction.¹⁷⁻¹⁹

Remaining workers may also experience psychiatric distress in the wake of layoffs due to guilt or remorse for their terminated coworkers.¹⁵ Research on the mental health effects of the Great Recession among continuously employed U.S. workers found that rates of mental health-related outpatient visits and prescriptions increased most among workers at plants where mass layoffs had occurred.²⁰ 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.²¹⁻²³ Moreover, multi-skilling, job-reassignment, and associated management problems may increase injury risk.²⁴ 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.²⁵

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 aluminum manufacturer at one of 30 U.S. plants between 2003 and 2013. Using a difference-in-differences approach, we estimated the association between layoff and remaining workers' mental healthcare utilization and injury risk. We hypothesized 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 utilization among remaining workers.

3.3 Methods

For the present analysis, we used data from the American Manufacturing Cohort Study (AMC), which included detailed, longitudinal health and employment records for workers employed by a single U.S. aluminum manufacturer followed from January 1, 2003 through December 31, 2012. The AMC Study data included a range of administrative datasets – including personnel files, the company payroll database, the occupational injury management system, and medical insurance claims – that were 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 U.S. plants between January 1, 2003 and December 31, 2012. 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 (i.e. treated plants), we retained only the quarter in which the layoff event occurred and the same three-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 utilization and injury risk.²⁶⁻³⁰ Second, upon inspecting the data we noted that many layoff events identified were preceded by substantial, but smaller, reductions in the size of the workforce. However, for all plant locations 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 three months of the layoff quarter and all three months of the reference quarter. For workers at control plants, we retained all worker-quarters pairs that corresponded to the layoff and reference quarters at treated plants.

Outcome Assessment

Our outcomes of interest were injury and two measures of mental healthcare utilization. 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).³¹

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, Ninth Revisions (ICD-9). 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.^{32,33}

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 gender, race-ethnicity (Black, Hispanic, white, other), and categories of birth year and hire year.

Statistical Analyses

We used a difference-in-differences (DID) approach³⁴ 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 among workers at plants where no layoffs occurred (i.e. control plants) from the change in the probability each outcome among workers at treated plants. Any changes that occurred in injury risk and mental healthcare utilization at control plants presumably resulted only from secular trends. Under the assumptions that secular trends were parallel among workers at treated and control plants and that statistical models were correctly specified, the resulting DID estimator corresponded to the change in each outcome 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 three-month period (i.e. quarter). The variable I_{st} is an indicator for whether a layoff event occurred at plant location s during the three-month period t . We estimated the following regression equation using generalized estimating equations (GEE) 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 location and B_t represents fixed effects for each of the fourteen study quarters. The coefficient β therefore corresponded to our estimate of interest, the difference in the probability of the outcome of interest attributable to layoffs. This specification is a common generalization of the most basic DID setup (with two time periods and two groups).

³⁵ We subsequently added a vector of individual-level X_{ist} covariates to the model, which included gender, race/ethnicity, and categories of birth year, and hire year. We hypothesized that male and female workers may have responded differently to layoffs with respect to mental healthcare utilization and injury risk, and we therefore ran analyses stratified by worker gender. All analyses were conducted with R, version 3.3.2 (R Foundation for Statistical Computing, Vienna, Austria).

Sensitivity Analyses

We repeated our main analysis restricted to control quarters where there was no more than a 7.5% percent change in the size of the workforce. This threshold corresponded to the largest change in the reference quarters of treated plants. We conducted a separate analysis for each prescription type (antidepressants, anxiolytics, sleep aids, opiates); visit type (depressive disorders, anxiety, substance use); and injury type (first aid, OSHA-reportable). Because news of earlier layoffs may have affected worker behavior during subsequent layoffs, we examined each layoff event separately. Finally, we implemented a negative exposure controls analysis³⁶ 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 would provide evidence that our main results were not due to time trends.

3.4 Results

Between January 2003 and December 2012, we identified seven layoff events at eight of 30 U.S. plants. Treated plants were located in all four regions of the U.S. 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 United States. Additional details of layoff events are summarized in the supplemental materials (Table 1 and Figure 1 in the Supplemental Materials).

Our study population included 15,502 workers, of whom 4,158 were employed at a plant location that experienced at least one layoff event (i.e. 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).

Estimated association between layoffs and worker mental health and safety

We found that layoff events were associated with *decreased* injury reports (-0.006, 95% CI -0.013, 0.001). Layoff events were associated with an increase in the probability of both outpatient visits (0.010, 95% CI 0.003, 0.017) and prescriptions (0.014, 95% CI -0.0006, 0.027) related to mental health. Our analysis suggested that male and female workers responded differently to layoffs. Among men, we observed a more substantial decrease in reported injuries (-0.010, 95% CI -0.018, -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, 0.031) (Figure 3). As anticipated with a DID design, unadjusted and adjusted analyses yielded similar estimates (Tables 2 and 3 in the Supplemental Materials).

Sensitivity Analyses

Our analysis with restricted control quarters yielded results similar to those we observed in our main analysis with all control quarters included (Tables 2 and 4 in the Supplemental Materials). We analyzed the association between layoffs and subtypes of injury, outpatient visit, and prescription (Figure 3). Results suggest that the increase in outpatient visits associated with layoffs occurs primarily through increases in depression-related visits (0.007, 95% CI 0.001, 0.012) and anxiety-related visits (0.005, 95% CI 0.0004 – 0.009). Results suggested further that the observed increase in prescriptions occurs primarily through an increase in the probability of

opioid prescriptions (0.016 95% CI 0.005 – 0.027). The observed decrease in reported injuries was not clearly attributable to either injuries requiring first aid or OSHA-recordable events (Table 5 in the Supplemental Materials). Our analysis of each treatment period separately did not suggest any trends over time (Table 6 in the Supplemental Materials).

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 (Table 7 in the Supplemental Materials).

3.5 Discussion

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 U.S. plants between 2003 and 2013. We used a quasi-experimental DID approach. Under the assumption that secular trends were parallel among workers at treated and control plants and that statistical models were correctly specified, the resulting DID estimate corresponded to the change in each outcome attributable to the layoff event itself.

Consistent with our hypothesis, we found modest increases in mental healthcare utilization (both outpatient visits and prescriptions) during layoffs. By contrast, we found that layoffs were associated with a slight *decrease* in the probability of reported injury. Our main results were robust to several sensitivity analyses, including multivariate adjustment and negative exposure controls analysis.

Results of our stratified analysis indicated that the reduction in injury was more pronounced among male workers, with an observed 1% decrease in the probability of reported injury during layoffs. 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 to which they are less familiar and ill-suited.²¹⁻²³ One explanation for our findings is that male workers who survived layoffs became hypervigilant in the context of layoffs due to perceived job insecurity.³⁷ Alternatively, it may be that injury risk remains the same or even increases, but plants experience a lapse in reporting.

Our stratified analysis also indicated a more pronounced increase in mental healthcare utilization among female workers. We observed a 1.7% increase in the probability of a mental health-related outpatient visit during layoffs among female workers. This finding is fairly consistent with the literature, as higher prevalence of affective disorders and utilization of healthcare services for mental health is consistently observed among women as compared with men.^{38,39}

Our analysis of outcome sub-categories suggested the observed increase mental health-related outpatient visits was due primarily to an increase in depression- 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 utilization of related healthcare service.

By contrast, the observed increase in mental health-related prescriptions seemed 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 population⁴⁰ 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 failed to report injuries that occur during layoffs but subsequently sought 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 perhaps workers seek and receive prescriptions for opioids 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 utilization were 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 behaviors over time with respect to injury reporting and mental healthcare utilization in anticipation of layoffs. We anticipate that such behavior changes would attenuate the estimated associations between layoff events and our outcomes of interest. We further noted that several layoff events 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 utilization and reported injuries. Changes in mental healthcare utilization 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.

3.6 Conclusion

We examined the impact of layoffs on remaining workers. We found that recorded injuries *decreased* during layoffs, whereas utilization of outpatient visits and prescriptions for mental health increased as hypothesized. We observed the largest decrease in injuries among male workers, and the largest increase in prescriptions among women. The increase in prescriptions appears attributable largely to increases in opioid prescriptions during layoffs, a finding which is seemingly inconsistent with apparent decreases in recorded injuries. Overall, our results suggest that layoffs do lead to changes in mental healthcare utilization 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 utilization may reflect true underlying psychiatric distress, moral hazard, or some combination thereof. Future research

on the concordance of service utilization and workers' underlying health and safety may yield valuable insight into the experiences of workers who remain employed after substantial layoffs.

Table 1. Demographic characteristics of workers at treated and control plants ^a

	Treated Plants (N = 4,158)	Control Plants (N = 11,344)
Men – N (%)	3,078 (74.0)	9,491 (83.7)
Race/Ethnicity – N (%)		
White	3,019 (72.6)	8,442 (74.4)
Black	737 (17.7)	1,027 (9.1)
Hispanic	275 (6.6)	1,379 (12.2)
Other	127 (3.1)	496 (4.4)
Birth Year ^b		
Before 1953	1,025 (24.7)	2,692 (23.7)
1953 – 1959	1,114 (26.8)	2,863 (25.2)
1960 – 1967	867 (20.9)	2,612 (23.0)
After 1968	1,154 (27.8)	3,184 (28.1)
Hire Year ^b		
Before 2000	803 (19.3)	4,723 (41.6)
2000 – 2002	2,363 (56.8)	3,088 (27.2)
After 2002	994 (23.9)	3,540 (31.2)

- a. Study data include 30 U.S. plants. The eight treated U.S. 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.
- b. Quartiles were defined based on the distribution of birth year among all workers at treated and control plants
- c. Tertiles were defined based on the distribution of hire year among all workers at treated and control plants

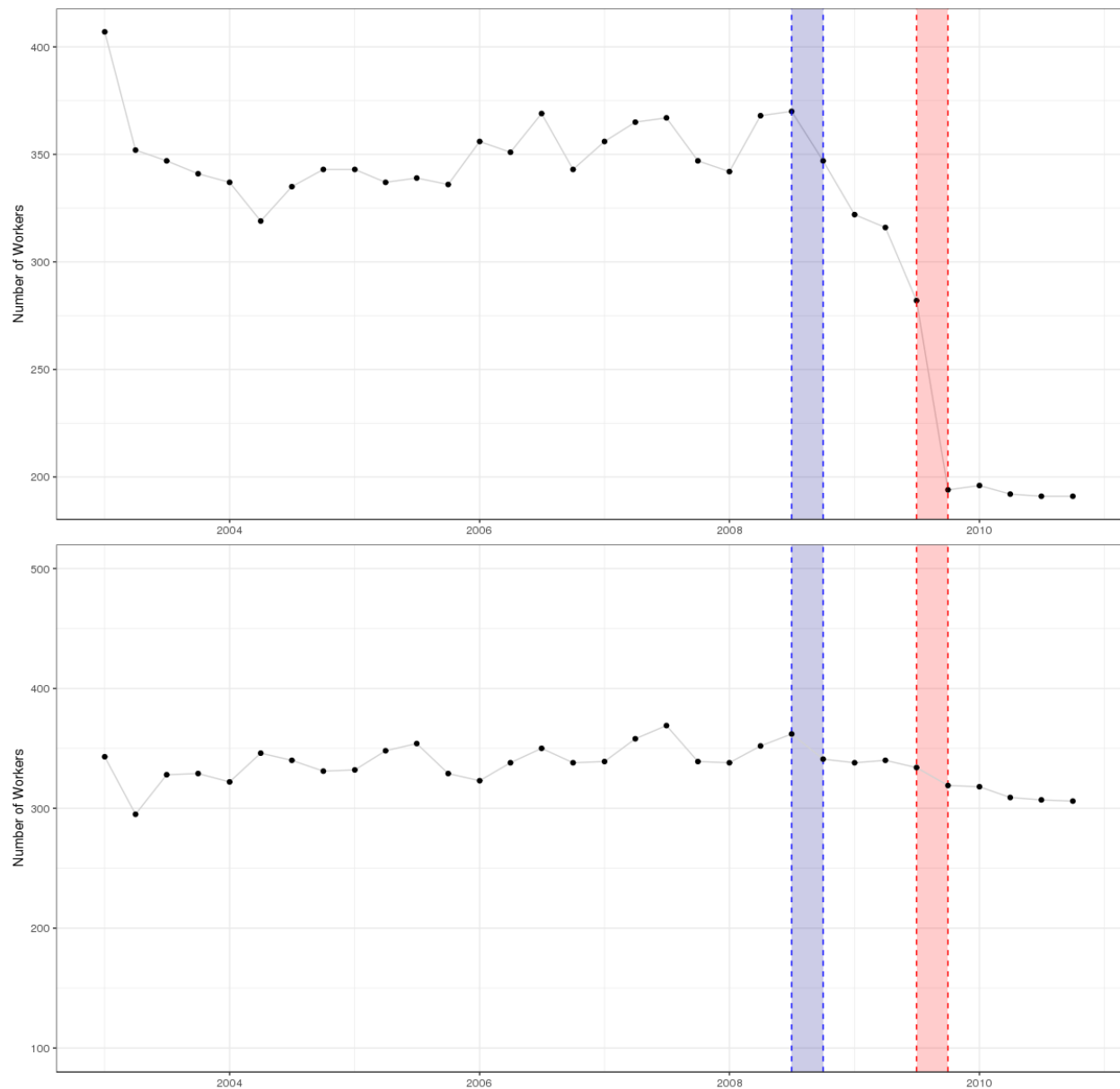


Figure 1. Workforce size throughout the study period at a treated and control plant. We plot the number of hourly workers on the company payroll at a plant located in the Northeastern U.S. where layoffs occurred between July and September of 2009 (top panel) and the number of hourly workers on the company payroll at a plant located in the Northeastern U.S. 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 three-month period from the previous year, which serves as the reference quarter in our analysis.

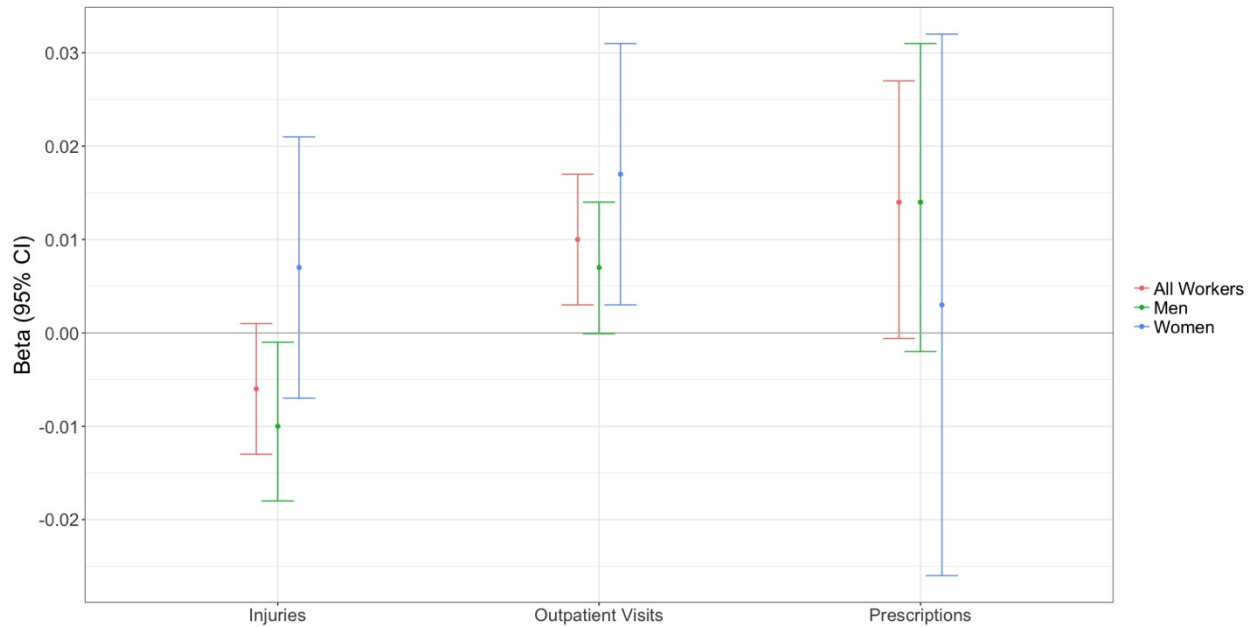


Figure 2. Difference-in-differences estimates for the effect of layoffs on injury risk and mental healthcare utilization. We used generalized estimating equations (GEE) with the identity link were used to estimate the marginal (population-average) effects of layoffs on the probability of each outcome 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 which equaled 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 ($N = 2,933$). We characterized injuries with a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time). We characterized outpatient visits related to mental health with a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Outpatient visits for mental health were identified using ICD-9 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 characterized prescriptions related to mental health with an indicator variable which 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.

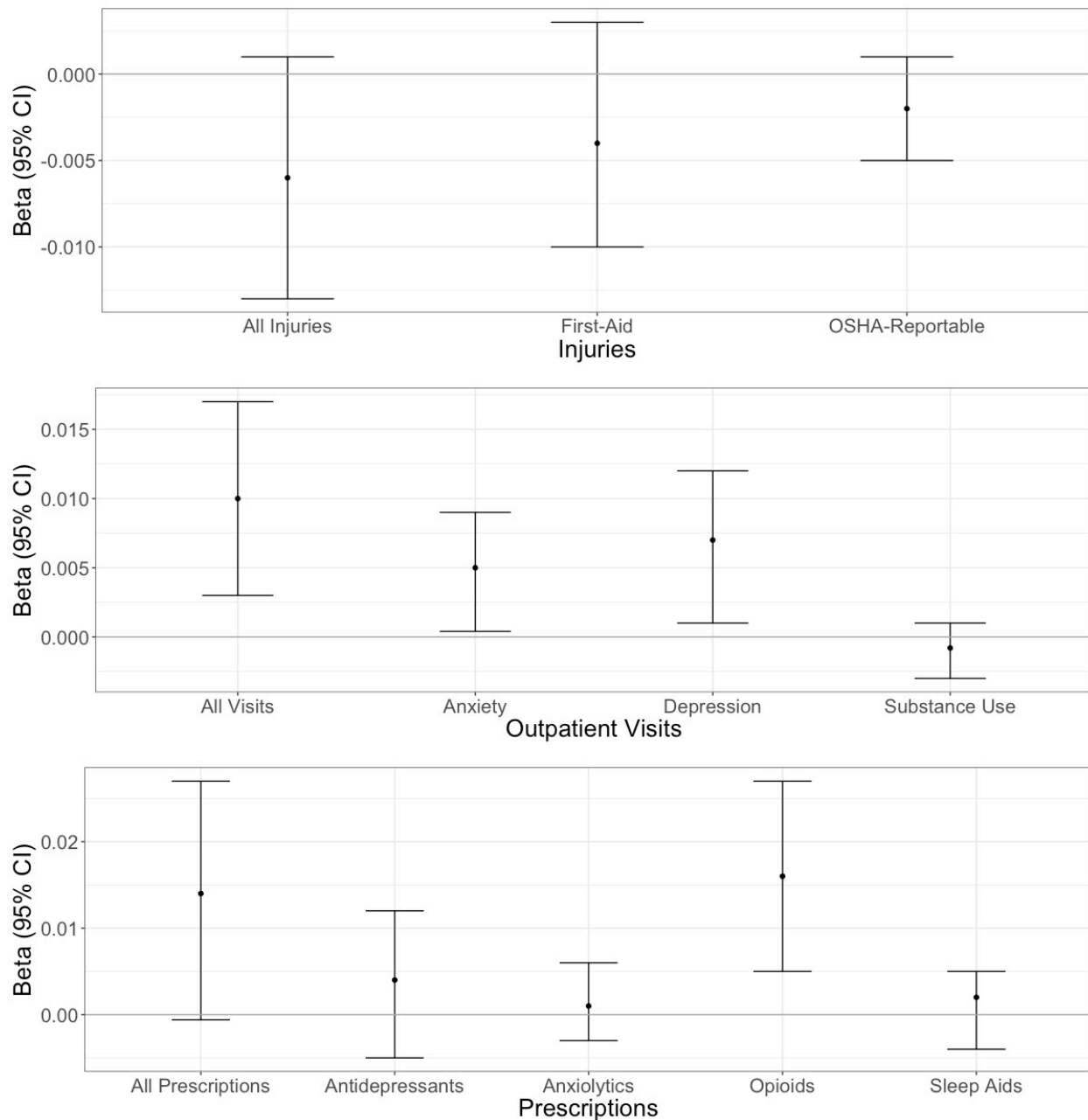
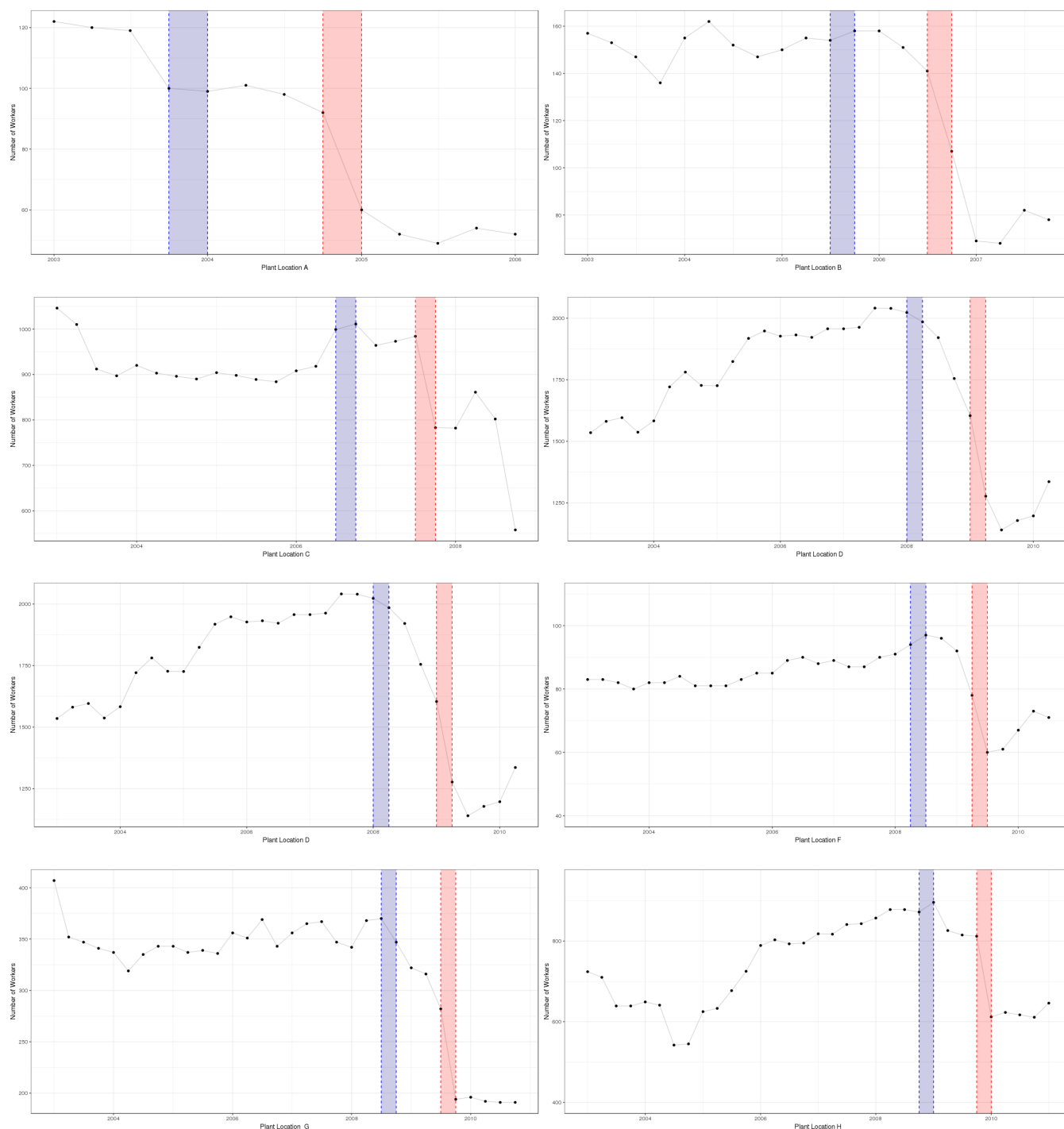


Figure 3. Differences-in-differences estimates for the effect of layoffs by sub-categories of injuries, outpatient visits, and prescriptions. We used generalized estimating equations (GEE) with the identity link were used to estimate the marginal (population-average) effects of layoffs on the probability 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 which equaled one in the treated plants during the quarter of layoffs and was zero otherwise. We separately analyzed the effect of layoffs on all injuries; injuries requiring first-aid; and Occupational Safety and Health Administration (OSHA) recordable events (**top panel**). We separately analyzed 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 analyzed the effect of layoffs on all prescriptions, prescribed antidepressants, prescribed anxiolytics, prescribed sleep aids, and prescribed opioids (**bottom panel**).

3.8 Supplementary Materials



Supplemental Figure 1. We plot the number of hourly workers on the company payroll at each of the eight plant locations where a layoff event occurred within the study period. We defined a layoff event as a reduction in the size of the hourly workforce by 20% or more within a three-month period. The red dotted lines demarcate the quarter in which the layoffs occurred at the treated plant, and the blue dotted lines demarcate the same three-month period from the previous year, which serves as the reference quarter in our analysis.

Supplemental Table 1. Characteristics of eight treated U.S. plant locations

Plant Location	Layoff Quarter		Reference Quarter		U.S Region
	Change in Hourly Workforce Size ^a	Date ^b	Change in Hourly Workforce Size ^a	Date ^b	
A (BAD)	- 34.78%	2004-01-01	- 1.00%	2003-01-01	South
B (LVY)	- 24.11%	2006-07-01	+ 2.60%	2005-07-01	South
C (ROK)	- 20.43%	2007-07-01	+ 1.20%	2006-07-01	South
D (WMH)	- 20.38%	2009-01-01	- 1.88%	2008-01-01	Midwest
E (CDL)	- 21.08%	2009-04-01	+ 2.03%	2008-04-01	West
F (KNK)	- 23.08%	2009-04-01	+ 3.20%	2008-04-01	Northeast
G (MSY)	- 31.21%	2009-07-01	- 6.26%	2008-07-01	Northeast
H (HVH)	- 24.63%	2009-10-01	+ 2.75%	2008-10-01	South

a. Change in the size of the hourly workforce for a given quarter calculated as $(\text{workers}_{t+1} - \text{workers}_t) / \text{workers}_t \times 100$

b. Date corresponds to the first day of each quarter.

Supplemental Table 2. Differences-in-differences estimates for the effect of layoffs on injury risk and mental healthcare utilization ^{a, b}

Outcome	All Workers (N = 15,502) β (95% CI)	Male Workers (N = 12,569) β (95% CI)	Female Workers (N = 2,933) β (95% CI)
Injuries ^e	-0.006 (-0.013, 0.001)	-0.010 (-0.018, -0.001)	0.007 (-0.007, 0.021)
Outpatient Visits ^f	0.010 (0.003, 0.017)	0.007 (-0.0001, 0.014)	0.017 (0.003, 0.031)
Prescriptions ^g	0.014 (-0.0006, 0.027)	0.014 (-0.002, 0.031)	0.003 (-0.026, 0.032)

- a.** We used generalized estimating equations (GEE) with the identity link were used 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.
- b.** All models included fixed effects for plant location, quarter, and an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise.
- c.** Analysis of outcome of interest is restricted to male workers (N = 12,569).
- d.** Analysis of outcomes of interest is restricted to female workers (N = 2,933).
- e.** The outcome is a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time).
- f.** The outcome is a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Outpatient visits for mental health were identified using ICD-9 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).
- g.** The outcome is a quarterly indicator variable which 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.

Supplemental Table 3. Multivariate-adjusted estimates for the effect of layoffs on remaining workers (N = 15,502) ^{a, b}

Outcome	All Workers (N = 15,502) ^c β (95% CI)	Male Workers (N = 12,569) ^d β (95% CI)	Female Workers (N = 2,933) ^e β (95% CI)
Injuries ^f	-0.005 (-0.012, 0.002)	-0.009 (-0.017, -0.0003)	0.008 (-0.006, 0.021)
Outpatient Visits ^g	0.010 (0.004, 0.017)	0.008 (0.0005, 0.015)	0.018 (0.004, 0.032)
Prescriptions ^h	0.012 (-0.002, 0.026)	0.014 (-0.003, 0.030)	0.003 (-0.025, 0.032)

- a.** We used generalized estimating equations (GEE) with the identity link were used 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.
- b.** All models included fixed effects for plant location, quarter, an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise, and are adjusted for sex, race/ethnicity (Black, Hispanic, white, other), quartiles of birth year (before 1953, 1953 – 1959, 1960 – 1967, after 1968) and tertiles of hire year (before 2000, 2000 – 2002, after 2002).
- c.** Includes all hourly workers who were on the payroll and insured by the company PPO for all three months of at least one layoff quarter and the associated reference quarter.
- d.** Analysis of outcome of interest is restricted to male workers (N = 12,569).
- e.** Analysis of outcomes of interest is restricted to female workers (N = 2,933).
- f.** Outcome is a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time).
- g.** Outcome is a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Visits for mental health were identified using ICD-9 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).
- h.** The outcome is a quarterly indicator variable which 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.

Supplemental Table 4. Differences-in-differences estimates for the effect of layoffs with restricted control quarters (N = 14,666) ^{a, b}

Outcome	All Workers (N = 14,666) ^c β (95% CI)
Injuries ^d	-0.048 (-0.012, 0.003)
Outpatient Visits ^e	0.010 (0.003, 0.017)
Prescriptions ^f	0.012 (-0.002, 0.026)

- a. We used generalized estimating equations (GEE) with the identity link were used 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.
- b. All models included fixed effects for plant location, quarter, an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise.
- c. Analysis is restricted to control quarters to those where there was no more than a 7.5% percent change in the size of the workforce, a threshold that corresponds to the largest change in the reference quarters of the treated plants.
- d. Outcome is a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time).
- e. Outcome is a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Visits for mental health were identified using ICD-9 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).
- f. The outcome is a quarterly indicator variable which 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.

Supplemental Table 5. Differences-in-differences analysis by outcome sub-categories ^{a, b}

Outcome	All Workers (N = 15,502) ^c β (95% CI)
Injuries ^d	
All injuries	-0.006 (-0.013, 0.001)
Injuries requiring first-aid	-0.004 (-0.010, 0.003)
OSHA-reportable injuries	-0.002 (-0.005, 0.001)
Outpatient Visits ^e	
All outpatient visits	0.010 (0.003, 0.017)
Depression-related outpatient visit	0.007 (0.001, 0.012)
Anxiety-related outpatient visits	0.005 (0.0004, 0.009)
Outpatient visits for substance use	-0.0008 (-0.003, 0.001)
Prescriptions ^f	
All prescriptions	0.014 (-0.0006, 0.027)
Prescribed antidepressants	0.004 (-0.005, 0.012)
Prescribed anxiolytics	0.001 (-0.003, 0.006)
Prescribed sleep aids	0.0002 (-0.004, 0.005)
Prescribed opioids	0.016 (0.005 – 0.027)

- a. We used generalized estimating equations (GEE) with the identity link were used 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.
- b. All models included fixed effects for plant location, quarter, and an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise.
- c. Includes all hourly workers who were on the payroll and insured by the company PPO for all three months of at least one layoff quarter and the associated reference quarter.
- d. Separate analyses examined the effect of layoffs on all injuries; injuries requiring first-aid; and Occupational Safety and Health Administration (OSHA) recordable events.
- e. Separate analyses examined 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).
- f. Separate analyses examined the effect of layoffs on all prescriptions, prescribed antidepressants, prescribed anxiolytics, prescribed sleep aids, and prescribed opioids.

Supplemental Table 6. Differences-in-differences estimates for the effect of layoffs for each treatment period ^{a, b}

Plant Location	Dates of Layoffs ^c	Workers ^d (N)	Injuries ^e β (95% CI)	Outpatient Visits ^f β (95% CI)	Prescriptions ^g β (95% CI)
A	Oct. 1, 2004 – Dec. 31, 2004	8,568	-0.020 (-0.070, 0.031)	0.020 (-0.016, 0.056)	0.036 (-0.042, 0.114)
B	July 1, 2006 – Sept. 31, 2006	7,675	0.015 (-0.022, 0.052)	0.018 (-0.011, 0.049)	0.045 (-0.040, 0.130)
C	July 1, 2007 – Sept 31, 2007	9,035	-0.026 (-0.064, 0.012)	0.002 (-0.016, 0.019)	0.002 (-0.044, 0.048)
D	Jan. 1, 2009 – Mar. 31, 2007	10,801	-0.003 (-0.013, 0.007)	0.010 (-0.004, 0.024)	0.009 (-0.012, 0.029)
E, F	April 1, 2009 – June 31, 2009	8,912	-0.037 (-0.085, 0.010)	-0.003 (-0.027, 0.021)	-0.016 (-0.063, 0.032)
G	July 1, 2009 – Sept 31, 2009	8,398	-0.044 (-0.090, 0.003)	0.020 (-0.016, 0.055)	0.013 (-0.028, 0.054)
H	Oct. 1, 2009 – Dec. 31, 2009	8,054	-0.008 (-0.032, 0.015)	-0.003 (-0.022, 0.016)	-0.033 (-0.070, 0.003)

a. We used generalized estimating equations (GEE) with the identity link were used 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.

b. All models included fixed effects for plant location, quarter, and an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise. For each layoff quarter, the reference quarter is the same three-month period from one year earlier.

c. Number of workers on the payroll and enrolled in the company PPO plan for all three months of the layoff quarter and reference quarter for each individual treatment period.

d. The outcome is a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time).

e. The outcome is a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Outpatient visits for mental health were identified using ICD-9 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).

f. The outcome is a quarterly indicator variable which 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.

Supplemental Table 7. Negative exposure controls analysis for the effect of layoffs on injury risk and mental healthcare utilization (N = 11,351) ^{a, b, c}

Outcome	All Workers (N = 14,666) ^d ß (95% CI)
Injuries ^e	0.0009 (-0.005, 0.007)
Outpatient Visits ^f	0.0009 (-0.005, 0.007)
Prescriptions ^g	0.0025 (-0.010, 0.014)

- a. We used generalized estimating equations (GEE) with the identity link were used 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.
- b. All models included fixed effects for plant location, quarter, an indicator variable which equaled one in the treated plants during the quarter of layoffs and was zero otherwise.
- c. For the negative exposure control analysis, we randomly selected eight new plants that did not experience a layoff event within our study period and assigned the dates of the layoff events to the eight randomly selected control plants.
- d. Includes all hourly workers who were on the payroll and insured by the company PPO for all three months of at least one layoff quarter and the associated reference quarter.
- e. Outcome is a quarterly indicator variable which equals one if an injury occurred and is zero otherwise. Injuries included first aid events as well as Occupational Health and Safety Administration (OSHA) recordable events (medical treatment, restricted work, and lost work time).
- f. Outcome is a quarterly indicator variable which equals one if a mental health-related outpatient visit occurred and is zero otherwise. Visits for mental health were identified using ICD-9 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).
- g. The outcome is a quarterly indicator variable which 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.

3.9 References

1. Ruhm CJ. Are workers permanently scarred by job displacements? *Am Econ Rev.* 1991;81(1):319-24.
2. Jacobson LS, LaLonde RJ, Sullivan DG. Earnings losses of displaced workers. *Am Econ Rev.* 1993;83(4):685-709.
3. Farber HS. What do we know about job loss in the United States? Evidence from the Displaced Workers Survey, 1984-2004. *J Econ Perspect.* 2005;29(2):13-29.
4. Fallick BC. A review of the recent empirical literature on displaced workers. *ILR Rev.* 1996;50(1):5-16.
5. Strully KW. Job loss and health in the US labor market. *Demography.* 2009;46(2):221-246.
6. Catalano R, Dooley D. The health effects of economic instability: A test of the economic stress hypothesis. In: John J, Schwefel D, Zöllner H eds. *Influence of Economic Stability on Health.* Berlin, Germany: Springer; 1981. p. 225-62.
7. Korpi T. Accumulating disadvantage. Longitudinal analyses of unemployment and physical health in representative samples of the Swedish population. *Eur Sociol Rev.* 2001;17(3):255-73.
8. Montgomery SM, Cook DG, Bartley MJ, Wadsworth M. Unemployment pre-dates symptoms of depression and anxiety resulting in medical consultation in young men. *Int J Epidemiol.* 1999;28(1):95-100.
9. Wadsworth ME, 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(10):1491-9.
10. Dooley D, Catalano R, Wilson G. Depression and unemployment: panel findings from the Epidemiologic Catchment Area study. *Am J Commun Psychol.* 1994;22(6):745-765.
11. Kessler RC. The effects of stressful life events on depression. *Annu Rev Psychol.* 1997;48(1):191-214.
12. Kivimäki M, Honkonen T, Wahlbeck K, Elovainio M, Pentti J, Klaukka T, Virtanen M, Vahtera J. Organisational downsizing and increased use of psychotropic drugs among employees who remain in employment. *J Epidemiol Commun Health.* 2007;61(2):154-8.
13. Pelfrene E, Vlerick P, Moreau M, Mak RP, Kornitzer M, De Backer G. 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(2):433-442.
14. Sikora P, Moore S, Greenberg E, Grunberg L. Downsizing and alcohol use: A cross-lagged longitudinal examination of the spillover hypothesis. *Work Stress.* 2008;22(1):51-68.
15. Brockner J, Davy J, Carter C. Layoffs, self-esteem, and survivor guilt: Motivational, affective, and attitudinal consequences. *Org Behav Hum Dec.* 1985;36(2):229-44.
16. Hamad R, Modrek S, Cullen MR. The effects of job insecurity on health care utilization: findings from a panel of US workers. *Health Serv Res.* 2016;51(3):1052-1073.
17. Ashford SJ, Lee C, Bobko P. Content, cause, and consequences of job insecurity: A theory-based measure and substantive test. *Acad Manage J.* 1989;32(4):803-29.
18. Davy JA, Kinicki AJ, Scheck CL. Developing and testing a model of survivor responses to layoffs. *J Vocat Behav.* 1991;38(3):302-317.
19. Modrek S, Cullen MR. Job insecurity during recessions: effects on survivors' work stress. *BMC Public Health.* 2013;13(1):929.
20. 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(2):304-10.
21. 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):1-44.
22. Cappelli P. *Change at work.* New York: Oxford University Press; 1997.
23. Tang TL-P, Fuller RM. Corporate downsizing: What managers can do to lessen the negative effects of layoffs. *SAM Adv Manage J.* 1995;60(4):12-31.

24. Quinlan M, Bohle P. Contingent work and occupational safety. In: Barling J, Frone MR Eds. *The Psychology of Workplace Safety*. Washington, DC: American Psychological Association; 2004. p. 81-105.
25. Probst TM, Brubaker TL. The effects of job insecurity on employee safety outcomes: Cross-sectional and longitudinal explorations. *J Occup Health Psych*. 2001;6(2):139-59.
26. Harmatz MG, Well AD, Overtree CE, Kawamura KY, Rosal M, Ockene IS. Seasonal variation of depression and other moods: a longitudinal approach. *J Biol Rhythm*. 2000;15(4):344-50.
27. Maes M, Meltzer HY, Suy E, De Meyer F. Seasonality in severity of depression: relationships to suicide and homicide occurrence. *Acta Psychiatr Scand*. 1993;88(3):156-161.
28. Oyane NM, Bjelland I, Pallesen S, Holsten F, Bjorvatn B. Seasonality is associated with anxiety and depression: the Hordaland health study. *J Affect Disorders*. 2008;105(1-3):147-55.
29. Vegso S, Cantley L, Slade M, Taiwo O, Sircar K, Rabinowitz P, Fiellin M, Russi M, Cullen MR. Extended work hours and risk of acute occupational injury: A case-crossover study of workers in manufacturing. *Am J Ind Med*. 2007;50(8):597-603.
30. Wehr TA, Rosenthal NE. Seasonality and affective illness. *Am J Psychiat*. 1989;146(7):829.
31. Tessier-Sherman B, Cantley LF, Galusha D, Slade MD, Taiwo OA, Cullen MR. Occupational injury risk by sex in a manufacturing cohort. *Occup Environ Med*. 2014;71(9):605-10.
32. 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.
33. Kozman D, Graziul C, Gibbons R, Alexander GC. Association between unemployment rates and prescription drug utilization in the United States, 2007–2010. *BMC Health Serv Res*. 2012;12(1):435.
34. Angrist JD, Kreuger AB. Empirical strategies in labor economics. In: Ashenfelter O, Card D eds. *Handbook of Labor Economics*. San Diego, CA: North Holland; 2011. p 1277-1366.
35. Bertrand M, Duflo E, Mullainathan S. How much should we trust differences-in-differences estimates? *Q J Econ*. 2004;119(1):249-75.
36. Lipsitch M, Tchetgen ET, Cohen T. Negative controls: a tool for detecting confounding and bias in observational studies. *Epidemiology*. 2010;21(3):383-88.
37. Catalano R, Dooley D. Does economic change provoke or uncover behavioral disorder: A preliminary test. In: Ferman LA, Gordus JP eds. *Mental Health and the Economy*. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research; 1979. p. 321-46.
38. Mojtabai R. Use of specialty substance abuse and mental health services in adults with substance use disorders in the community. *Drug Alcohol Depen*. 2005;78(3):345-54.
39. Kessler RC. Epidemiology of women and depression. *J Affect Disorders*. 2003;74(1):5-13.
40. 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(5):457-61.

4. CONCLUSION

Work is among the most fundamental determinants of adult health and well-being, and specific aspects of workplaces have the potential to be either harmful or health-promoting. Blue-collar jobs are typically characterized by stressors including exposure to physical hazards, variable work schedules, and by monotonous, repetitive, and physically demanding work tasks. Moreover, the net effect of secular trends in the U.S. economy over the past four decades – including declines in manufacturing, computerization and automation, and the weakened collective bargaining power of unions – is that blue-collar jobs are increasingly precarious.

The extant literature indicates that women in blue-collar jobs face additional work-related stressors, including sexual harassment and discrimination; social isolation; decreased job satisfaction; and greater work-life conflict. And indeed, by all accounts these are hardships that characterize the experiences of women in present-day working-class, male-dominated jobs. An in-depth account of the experiences of women employed in two Chicago-area Ford motor plants published in the *New York Times Magazine* in 2017 details an entrenched culture of sexual harassment – one in which women regularly endure lewd and sexually explicit comments, sexual assault, and face inaction or open hostility when the offenders are reported. More recently, in an opinion piece in the *New York Times*, a former nuclear site guard recounts her experiences of harassment and the subsequent retaliation she experienced after reporting an assault, which resulted in demotion and ultimately in her termination.

Despite first-hand accounts such as these, the existing academic literature on blue-collar work and depression largely fail to consider the experiences of female workers.⁶³⁻⁶⁵ This leaves unanswered important questions regarding the magnitude of the association between the work environment and depression among blue-collar female workers, and the specific mechanisms by which aspects of blue-collar jobs may uniquely predispose female workers to depression. In response, this dissertation is focused on the implications aspects of the work environment for the mental health of blue-collar women in the American Manufacturing Cohort (AMC) study.

The first chapter examines the risk for treated depression and frequency of depression-related utilization by occupational class and gender. I find that blue-collar workers are more likely to be treated for depression within study period than white-collar workers, and that blue-collar women are most likely to be treated for depression as compared with white-collar men. This finding implies a unique susceptibility to depression among women in blue-collar jobs. By contrast, in the analysis of depression-related service utilization, blue-collar men and women utilize depression-related services less frequently than their white-collar counterparts. In this insured population, these findings may reflect additional barriers to mental healthcare utilization among blue-collar workers including increased stigma or less permissive norms around mental healthcare utilization; provider behavior; temporal inflexibility; blue-collar workers' greater sensitivity mental healthcare costs. As many of these barriers are potentially modifiable, future public health research may aim to identify the predominant mechanisms that explain systematic differences in mental healthcare utilization by occupational class that I have observed.

The second chapter summarizes the association between the workplace gender composition and treatment for depression by occupational class. The results suggest an inverse association between the percent women employed at the plant level and individual risk of treatment for depression in both male and female blue-collar workers. The greatest decreases in risk were

observed when at least 30 percent of the workforce was female. Consistent with these results, past research suggests that occupational sex segregation may be a considerable source of stress for women employed male-dominated industries and occupations. As blue-collar men comprise the majority of workers in the study population, these results further suggest that the largest absolute decreases in treatment for depression associated with the feminization of the workplace will occur among male workers.

The third and final chapter examines the effects of layoff events on mental healthcare utilization and injury risk among blue-collar men and women. I find that injuries *decrease* during layoffs, whereas use of outpatient visits and prescriptions for mental health increase. The largest decrease in injuries occurred among male workers, and the largest increase in prescriptions occurred among women. The increase in prescriptions appears attributable largely to increases in opioid prescriptions during layoffs among those who remain at work, a finding which is seemingly inconsistent with apparent decreases in recorded injuries. Apparent decreases in injuries may reflect real changes in injury risk, or changes in reporting practices. Similarly, changes in mental healthcare utilization may reflect true underlying psychiatric distress, moral hazard, or some combination thereof.

Collectively, these findings suggest that men and women in blue-collar jobs have fundamentally different work experiences, and this includes measurable and consistent differences in risk for depression, use of mental healthcare services, and injury. The salience of factors such as occupational class, the workplace gender composition, and the advent of large-scale layoffs underscores the importance of the social context within workplaces for worker health, safety, and well-being. Of course, there are several aspects of the work environment – including working hours and scheduling practices, measures of physical and psychological job demand, remuneration and fringe benefits – that are likely to affect worker health but are not considered here. Similarly, although these analyses examine how depression varies by occupational class and gender, examination of additional axes of stratification – for example race/ethnicity and income – would surely yield new insights regarding the complex relationship between work and mental health. This naturally motivates continued examination of aspects of the work environment and the implications for health across subgroups and in varied industry sectors and occupations so that worker health may be better protected and promoted.