

The Frequency and Economic Impact of Musculoskeletal Disorders for California Firefighters

Trends and Outcomes Over the Past Decade

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Preface

Musculoskeletal disorders (MSDs) are the most common type of occupational injury or illness suffered by firefighters, and so there is considerable interest among policymakers and stakeholders about how best to monitor, prevent and treat firefighter MSDs. A 2010 RAND study on MSDs in California firefighters confirmed that firefighters experience MSDs at a significantly elevated rate compared to other workers, even compared to workers in other high-risk jobs. Firefighters were more likely than other comparable workers to experience lost time due to an MSD, but the economic consequences of MSDs were, on average, more moderate for firefighters than for workers in similar occupations.

The 2010 RAND study examined injury dates from 2000 through 2007. A number of developments since that time call for more current evidence on the frequency, severity, and consequences of firefighter MSDs. The severity of recent wildfire seasons underscores the importance of a healthy firefighting workforce, and awareness of the psychiatric burden borne by public safety workers exposed to traumatic events has grown in recent years. Meanwhile, California undertook a major set of workers' compensation reforms with the enactment, in 2012, of Senate Bill (SB) 863, which modified the permanent disability rating system and benefit levels.

In response to these developments, the California Commission on Health and Safety and Workers' Compensation (CHSWC) commissioned RAND to update the analyses from the 2010 RAND study and consider the impacts of the 2013 workers' compensation reforms and the economic shocks of the late 2000s on outcomes for firefighters with MSDs. This study's findings will be of interest to policymakers in California and other states, and to other audiences concerned with the occupational health and safety of firefighters.

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Summary

Firefighters play a vital role in protecting the public while facing exceptional hazards to their own health and safety. Smoke inhalation, burns, and traumatic injury are just a few of the serious risks posed by active firefighting. Yet the strenuous physical demands of firefighting can take a less visible toll on the human body, with this wear and tear that increases the risk of back injury, joint pain or other forms of musculoskeletal disorders (MSDs). In fact, musculoskeletal disorders (MSDs) are the most common type of occupational injury or illness suffered by firefighters, and so there is considerable interest among policymakers and stakeholders about how best to monitor, prevent and treat firefighter MSDs.

An earlier RAND study on MSDs in California firefighters confirmed that firefighters experience MSDs at a significantly elevated rate compared to other workers, even compared to workers in other high-risk jobs (Seabury and McLaren 2010). Firefighters were more likely than other comparable workers to experience lost time due to an MSD, but the economic consequences of MSDs were, on average, more moderate for firefighters than for workers in similar occupations. MSDs in older firefighters (aged 55 or above at injury) had earnings and employment losses comparable to private-sector workers, however. The report also examined the effect of medical reforms enacted in 2003 and 2004 and found no adverse impact on firefighters.

The 2010 RAND study examined injury dates from 2000 through 2007. A number of developments since that time call for more current evidence on the frequency, severity, and consequences of firefighter MSDs. The severity of recent wildfire seasons underscores the importance of a healthy firefighting workforce, and awareness of the psychiatric burden borne by public safety workers exposed to traumatic events has grown in recent years. Meanwhile, California undertook a major set of workers' compensation reforms with the enactment, in 2012, of Senate Bill (SB) 863. In addition to medical delivery reforms and other changes, SB 863 modified the permanent disability rating system and benefit levels. Permanent disability benefits were increased, but compensation for secondary or *add-on* psychiatric impairments was restricted. On injuries occurring in 2013 or later, compensation for add-on psychiatric impairments was allowed only for victims of a violent act or catastrophic injury, raising concern about access to benefits for firefighters who might witness non-violent traumatic events yet fail to meet the new requirements. Besides these workers' compensation reforms, the economic landscape in California has changed substantially since the previous RAND study. The 2008-2009 Great Recession caused significant economic hardship, and injured and disabled workers appeared to be particularly hard hit; analysis of workers injured between 2005-2015 suggests at best a partial recovery in injured workers' labor market outcomes. While declines in post-injury earnings were widespread, but the impact on public safety workers has not specifically been examined (Dworsky et al., 2018).

Study Objectives

In this study we update the analyses from the 2010 RAND study and consider the impacts of the 2013 workers' compensation reforms and the economic shocks of the late 2000s on outcomes for firefighters with MSDs. DIR requested that we address a wide range of specific research

questions on various aspects of firefighters' injury risk and outcomes in the workers' compensation system, from case mix and economic consequences to permanent disability rating, medical treatment patterns, and the incidence of comorbid psychiatric conditions. A full list of these research questions is presented in Chapter 1. We grouped these questions together into five chapters by topic:

- Characterize recent trends in MSD claim rates and case mix among firefighters
- Describe the economic consequences of MSDs
- Estimate the prevalence of psychiatric comorbidities among firefighters with MSDs
- Estimate the effects of disability rating reforms enacted in SB 863
- Assess the effect of caps on chiropractic, occupational therapy, and physical medicine visits

We analyzed administrative data from the California workers' compensation system linked to data on earnings for workers injured between 2005-2015, with some additional analyses to tailor the results to the new reforms and to take advantage of data resources that were unavailable previously. Where necessary, or to provide context, we supplement the analysis using outside data from the published literature or national data. As in our earlier study, we identified a comparison group of workers in similar occupations to provide a benchmark for firefighter outcomes and to determine whether any changes over time uniquely affected firefighters or reflected broader systemic changes. We compare firefighters to three groups of workers in broadly occupations: police, other public-sector workers, and private-sector workers with job demands that resemble firefighting (including occupations related to health and safety, transportation, and heavy installation and maintenance). While many of the concerns examined here have relevance throughout the California labor force, the present report is focused narrowly on firefighters with MSDs; broader questions about the consequences of MSDs across the entire labor force, or about other health and safety risks faced by firefighters, were beyond the scope of our study.

Findings

The following sections of this summary highlights major findings from each of these five chapters.

Firefighters Continue to Face Elevated Risk of Work-Related Musculoskeletal Disorders, Especially Injuries to the Lower Extremities and Trunk

In Chapter 3 of this report, we use data from the California Workers' Compensation Information System (WCIS) to compare the frequency and types of workplace injuries experienced by firefighters to those of workers in other occupations. There are several reasons that we expect injuries to firefighters to differ from those to other workers. Part of that is the intense and demanding nature of the work, which is risky and more likely to result in injury. But firefighters, as well as police officers, other public safety workers and, to a lesser extent, other public sector workers more generally, benefit from both special benefits that offer additional compensation for workplace injuries and from additional job security that could make it easier to file injury claims. Thus, we compare the composition of injury claims for firefighters to a range of occupations including police officers, other public sector workers, private sector workers

generally and a group of private sector occupations specifically chosen because they have a relatively similar set of requirements as firefighters.

As expected, firefighter injury rates are high compared to other workers. Between 2005-2017, the firefighter injury rate ranges from just under 200 per 1,000 workers to more than 250 per 1,000. Injury rates for police officers are similar though slightly lower, while the overall rate for all workers ranges from 35 to 50 per 1,000 workers. While the rate of occupational injuries throughout the US labor force has declined steadily, we found no discernible trend for firefighters or police officers. Firefighters also have the highest share of injuries that are musculoskeletal in nature, with 47% of injuries involving MSDs compared to 38% for police officers, 42% for other public sector workers, 37% in our private sector comparison group with similar job requirements to firefighters and 42% for other private sector workers. This confirms that MSDs are a particular source of concern for firefighters.

In other analyses, we compare different types and characteristics of firefighter injuries. Firefighters have an elevated risk of MSDs across the full life cycle, with over half of firefighter injuries at ages 40-49 involving MSDs. By comparison, just 39% of injuries in our private sector comparison group involve MSDs. Compared to other occupations, injuries to firefighters are less likely to involve the upper extremities and significantly more likely to involve lower extremities or the trunk. Strains are the modal cause of injury for firefighters; burns are significantly more common among firefighters than other workers but still represent a small share of injuries (6%) in comparison to MSDs. In short,

Overall, the injury distribution for firefighters is different than for workers in other jobs, including the private sector comparison group that was selected because the job demands are similar overall. This is at least suggestive evidence that the differences in types of injury cannot be explained entirely by differences in job demands or physical factors. One possible explanation is that the nature of firefighting influences claim-filing behavior in ways that change the injury mix. This does not necessarily mean job security or injury compensation, as we expect these to be similar between firefighters, police officers and other public employees. However, one hypothesis might be that staffing requirements for firefighters that require them to be able to perform all potential duties could lead to higher injury claiming than in occupations where modified work is more readily available. Sorting through the different factors that drive injury composition is ultimately beyond the scope of this report; research on claim-filing behavior across occupations (perhaps including a review of accident reports) would be helpful.

Earnings Losses for Firefighters Worsened After the Great Recession of 2008-2009, Yet the Economic Consequences of Musculoskeletal Disorders for Firefighters Remain Less Severe than for Workers in Similar Occupations

We also examined post-injury earnings and employment for firefighters, using methods developed in previous RAND studies to compare injured worker outcomes to a control group of similar workers without an injury. In the second year after injury, injured firefighters earned 95 percent of what they would have earned in the absence of the injury. As in our 2010 study, firefighters with musculoskeletal disorders appear to have less severe economic consequences from their injuries than do workers in similar occupations. Post-injury earnings relative to in the second year after injury were sharply lower in comparable occupations: 88 percent for police, 85 percent for other public-sector workers, and 87 percent for private-sector workers. These differences in earnings are mirrored closely by differences in the proportion of injured workers

who continue to work for the employer where the injury occurred, or the *at-injury employer*. In most occupations, employment at the at-injury employer is well below the overall employment rate, indicating that injury can lead to increased job separations or career changes even for workers who remain employed. For firefighters, in contrast, at-injury employment two years after injury is 95 percent of the level that would have been expected in the absence of injury--very close to the overall level of employment (at any employer). This is an unusual pattern of post-injury outcomes, both because at-injury employment is nearly as high as overall employment and because it is much higher than observed in comparison occupations. Fire departments appear to do better than other employers—even public-sector employers—at retaining injured workers.

Turning to trends in outcomes over time, we find that labor market outcomes for firefighters declined following the Great Recession of 2008-2009. This decline in outcomes was not unique to firefighters: we also saw worsening post-injury outcomes for similar occupations, a pattern consistent with previous RAND research showing widespread impacts of the Great Recession throughout the workers' compensation system. That said, it is surprising to see this decline in outcomes among firefighters because we would have expected the exceptionally high post-injury job retention among firefighters and their status as critical public safety personnel to have protected them from the slack labor market conditions facing private-sector workers. These trends in system-wide outcomes have not yet been adequately explained.¹

DEU Ratings and Statutory Permanent Disability Benefits Rose for Firefighters After SB 863 Implementation

Based on their standard ratings, firefighters with permanently disabling musculoskeletal disorders who were rated at the Disability Evaluation Unit (DEU) appeared to have similar impairment severity to police and other comparison occupations with the same type of rating. Firefighters had slightly higher final ratings than comparable occupations prior to SB 863, however. Firefighters have relatively high occupational adjustments, and their slightly older age at injury may also result in more favorable adjustments under the current disability rating schedule. Other aspects of the rating process, such as the frequency with which apportionment is recommended and the use of alternative rating procedures, were not dramatically different between firefighters and other occupations.

Implementation of SB 863 was followed by higher final ratings for firefighters with musculoskeletal disorders who received Summary ratings (typically performed for workers without legal representation at the request of a workers' compensation judge). It is somewhat surprising, however, that the average final rating did not increase on Consult ratings (performed at the request of a party to the case, typically when the worker has legal representation). The only provision of SB 863 that would tend to reduce ratings was the elimination of psychiatric add-on impairments, and we saw that psychiatric impairments were rated in fewer than 1 in 100 musculoskeletal disorder cases for firefighters prior to SB 863. Our results hint at an alternative mechanism that may have operated independently of SB 863, which was an increase in the frequency of apportionment to non-occupational cause. We did not have a sufficient sample size

¹ RAND is examining these questions in ongoing work under the Wage Loss Monitoring Study.

of firefighters with consult ratings to examine differences between occupations, but similar changes in the frequency of apportionment on Consult ratings were apparent across most occupations examined.

These findings suggest that increased apportionment among Consult ratings may have offset some of the rating increases anticipated under SB 863. However, a broader analysis of occupations not included in this study (and less comparable to firefighters) would be needed to produce informative estimates about the frequency of apportionment. More systematic validation of apportionment information in DEU ratings data—which was well beyond the scope of this report—is needed to confirm these suggestive findings. DEU ratings data for consult ratings do not contain reliable information about how apportionment affects ratings (such as the percent apportioned by impairment or the rating before apportionment), and so we cannot attribute the differences in SB 863 impacts between consult and summary ratings to apportionment without further investigation. Notwithstanding the somewhat muted benefit increases that we observed on consult ratings, statutory benefits were substantially higher across all occupations and rating types examined thanks to the increase in the weekly maximum implemented under SB 863.

Firefighters with Musculoskeletal Disorders Rarely Receive Treatment or Permanent Disability Benefits for PTSD or Other Psychiatric Conditions

We examined diagnosis codes on medical services and prescriptions billed to workers' compensation to identify MSD injuries with comorbid psychiatric conditions. These data indicate that firefighters and police have similar rates of psychiatric comorbidities, but incidence rates for public safety workers are substantially lower than rates observed among other public-sector workers or comparable private-sector workers. We do find evidence that psychiatric comorbidities are associated with worse labor market outcomes compared to musculoskeletal disorders without such comorbidities. This finding was anticipated given previous evidence on earnings losses for workers with permanent disability due to psychiatric impairments (Dworsky et al., 2016). We do not, however, find strong evidence that the incremental losses associated with psychiatric comorbidities vary across occupations.

Taken together, these findings do not provide evidence that Post-Traumatic Stress Disorder (PTSD) or other psychiatric comorbidities are a more serious concern for firefighters than for workers in other similar occupations. Two important limitations of this work need to be added, however. First, we rely on medical claims to identify psychiatric disorders, and we observe only medical care provided through the workers' compensation system. Because public-sector workers are likely to have access to high-quality health insurance outside of workers' compensation, we cannot rule out the possibility that workers are seeking treatment for psychiatric conditions outside the workers' compensation system, either through group health or without any reimbursement from insurance at all. A second, and more troubling, caveat is that mental health stigma could also lead to the patterns observed in these data. Stigma is widely recognized as a barrier to diagnosis and treatment of PTSD and mental disorders more generally among public-safety workers, but the scope of this study did not encompass measurement of firefighter mental health independently of care provided through workers' compensation.

We Did Not Find Evidence that Treatment Caps on Chiropractors, Occupational Therapy, and Physical Medicine Had a Substantial Impact on Most Workers

The workers' compensation system is designed to provide injured workers with necessary medical care. There is concern among stakeholders that some policies used to control costs have interfered with workers' ability to access needed care, however. Senate Bill 228, enacted in 2003, sought to control medical spending growth through a number of policy levers, including the establishment of treatment caps on chiropractic and physical medicine. Evidence remains limited on the impacts of the SB 228 treatment caps on patterns of care or worker outcomes, and so CHSWC requested that we study this issue. We ask what proportion of workers with and without musculoskeletal disorders have sufficiently high utilization of the capped services to potentially be affected by the caps, and whether we see a larger-than-expected number of workers stopping treatment when they reach the cap. We do not find clear evidence that the SB 228 treatment caps pose a particularly strong barrier to receipt of the types of care subject to the caps. We note that, without a comparison group not subject to the treatment caps, it is not possible to credibly evaluate impacts of the treatment caps on patient outcomes. However, the lack of evidence that workers are substantially constrained by the treatment caps suggests that other, more harmful consequences of the treatment caps may not be a significant concern.

Policy Implications and Priorities for Future Research

For firefighters, as for other groups of injured workers, the weak recovery of labor market outcomes from the Great Recession is worrisome. The findings of this report, as with other analyses for broader groups of workers, highlights the need to understand how and why the Great Recession had such lasting effects on post-injury outcomes.

Our analysis of disability ratings indicated that SB 863 has been effective in raising final ratings and statutory benefits for both firefighters and for comparable groups of workers. The rating changes and the increase in the statutory maximum in SB 863 appear to have been particularly favorable for firefighters, likely due to the high proportion of firefighters who earn above the pre-SB 863 maximum weekly wage and due to the prevalence of knee impairments, which received the second-largest possible increase in final ratings from changes to the formula used to calculate ratings. We did, however, notice an uptick in the frequency with which apportionment was recommended on Consult ratings. While this trend was not notably different for firefighters than for other comparable occupations, it would be valuable to investigate changes in apportionment frequency more carefully and to collect additional data capable of illuminating the impacts of apportionment on ratings since SB 863 took effect. This may require substantial additional data collection beyond DEU, but clearer evidence on the role that apportionment plays in the disability rating system would likely be welcomed by policymakers and stakeholders.

Finally, while we are concerned about the impact of mental health stigma on our analysis of PTSD and psychiatric comorbidities, somewhat different methods and additional data collection are necessary to understand the implications of our findings that these public safety workers are far less likely to receive treatment for psychiatric conditions in the workers' compensation system. Data from the workers' compensation system also cannot speak to the incidence of PTSD or mental distress among workers who do not file claims for a workplace injury. The potential for stigma suggests a need to go beyond claims data and use complementary approaches to

assess firefighters' and police officers' mental health, potentially including surveys or analysis of group health claims.

Abbreviations

AB	Assembly Bill
ACOEM	American College of Occupational and Environmental Medicine
AMA	American Medical Association
ASC	ambulatory surgery center
BLS	Bureau of Labor Statistics
CHSWC	Commission on Health and Safety and Workers' Compensation
CWCI	California Workers' Compensation Institute
DEU	Disability Evaluation Unit
DWC	Division of Workers' Compensation
DIR	California Department of Industrial Relations
DOT	Dictionary of Occupational Titles
EDD	Employment Development Department
FROI	First Report of Injury
FTE	Full-Time Equivalent
IBR	independent bill review
ICD	International Classification of Diseases
IMR	independent medical review
JCN	Jurisdiction Claim Number
LC	Labor Code
MMI	maximum medical improvement
MPN	medical provider network
MSD	musculoskeletal disorder
MTUS	Medical Treatment Utilization Schedule
OES	Occupational Employment Statistics
OT	occupational therapy
O*NET	Occupational Information Network

PD	permanent disability
PPD	permanent partial disability
PT	Physical Therapy
PTSD	Post-Traumatic Stress Disorder
RBRVS	Resource-Based Relative Value Scale
QME	qualified medical examiner
SB	Senate Bill
SOC	Standard Occupational Classification
SROI	Subsequent Report of Injury
SSN	Social Security Number
TTD	temporary total disability
UI	Unemployment Insurance
WCAB	Workers' Compensation Appeals Board
WCIRB	Workers' Compensation Insurance Rating Bureau
WCIS	Workers' Compensation Information System

1. Introduction

Firefighters play a vital role in protecting the public interest, often being forced to place their own lives at risk in order to protect the health and safety of others. Firefighting is one of the most dangerous occupations in the U.S. in terms of workplace injury risk. The Bureau of Labor Statistics reports that in 2017 there were approximately 508 nonfatal injuries per 10,000 full-time equivalent (FTE) firefighters. This is more than five times the rate of 89.4 injuries per 10,000 FTEs that workers face, on average, in the private sector.² In California, the risks of firefighting have become even more salient in the past few years, with the record wildfires and resulting deaths that have occurred.

The health risks facing firefighters go beyond just burns, automobile crashes and other forms of acute trauma, however. Firefighters are widely believed to face an elevated risk of cancer due to exposure to smoke and other hazardous materials. Additionally, the strenuous nature of the work and the rigorous physical demands can take a toll on the human body. This leads to physical wear and tear that increases the risk of back injury, joint pain or other forms of musculoskeletal disorders, particularly for older workers.

As is the case with most occupations, musculoskeletal disorders (MSDs) are the most common type of occupational injury or illness suffered by firefighters. There is concern that the strenuous physical demands of firefighting could put workers at greater risk of work loss and disability as a result of an MSD. Moreover, rigorous job requirements often dictate that even a relatively minor work restriction prevents someone from performing the full range of activities required of an active-duty firefighter. Thus, MSD injury risk can make it more difficult or costly to maintain a fully-staffed fire departments capable of protecting the public at the optimal level. This has led to considerable interest among policymakers and stakeholders about how to best monitor, prevent and treat firefighter MSDs.

A 2010 study by the RAND Corporation studied the frequency and economic consequences of work-related MSDs among firefighters compared to other workers in the public and private sectors (Seabury and McLaren, 2010). The prior study found that firefighters experienced MSDs at a significantly elevated rate compared to other workers, even compared to workers in other high-risk jobs such as police or corrections. Moreover, firefighters were more likely than other workers to experience lost time due to an MSD, especially at older ages. However, the economic impact of MSDs—back injuries in particular—was found to be more moderate on average for firefighters than for other employees in most cases. The only real exception was for firefighters age 55 years and older; older firefighters experienced earnings and employment losses as bad, on average, as those of workers in private-sector occupations. The report also evaluated the effect of medical reforms on outcomes for California firefighters and found no evidence of an adverse impact.

² Source: Bureau of Labor Statistics, Survey of Occupational Illnesses and Injuries. Available from <https://data.bls.gov/gqt/InitialPage> (accessed June 19, 2019).

A Changing Landscape

The 2010 RAND study examined injury dates from 2000 through 2007. There have been a number of developments over the past decade that could have impacted the economic outlook for injured California firefighters. From a policy standpoint, chief among these was the enactment of significant workers' compensation reform in 2012 with California Senate Bill (SB) 863. This bill was passed in response to the fact that employer costs and premiums were rising even though the earlier 2004 reforms had led to a dramatic cut in PPD benefits for disabled workers (Seabury et al., 2010). SB 863 represented an effort to restore some of the lost benefits while slowing the growth of employer costs by attempting to control medical costs.

Benefits were increased by modifying the disability rating formula and increasing the weekly maximum benefit. Additionally, a \$120 million Return to Work Fund was established to make supplemental payments to disabled workers with disproportionately high earnings loss, and it became operational in 2015. To contain medical spending, the law established several processes related to dispute resolution (including independent medical review [IMR] and independent bill review [IBR]) and made changes to the qualified medical examiner (QME) process and the regulation of medical provider networks (MPNs). Reimbursement for medical services shifted dramatically with the adoption of the Resource-Based Relative Value Scale (RBRVS), as well as changes to facility fees for ambulatory surgery centers (ASCs) and payment for spinal hardware. The physician fee schedule took effect on January 1, 2014, as did elimination of overpayments for certain spinal implant procedures that arose from duplicate reimbursement for spinal hardware. Updates to multiple sections of the Medical Treatment Utilization Schedule (MTUS), which defines treatment guidelines for providers in the workers' compensation system, also took effect in 2014 and may have changed patterns of care provision for workers injured in 2014 and later. These changes could have impacted employment outcomes for injured California firefighters if it made the medical treatment process more efficient and evidence based, and it could have reduced the long-term economic burden of injuries by increasing disability benefits.³

In addition to legislative changes to the workers' compensation system, the economic landscape in California has experienced significant changes since the previous RAND study. The 2008-2009 Great Recession caused significant economic hardship, and injured and disabled workers appeared to be particularly hard hit. An earlier RAND study found that permanently disabled workers had lost earnings that increased sharply during the Great Recession of 2008–2009, with little sign of recovery through 2012 (Dworsky et al., 2016). Even after adjusting for

³ While SB 863 was the most significant legislative change to the California workers' compensation system in recent years, there have been some smaller changes. The 2014 Assembly Bill (AB) 1035 modified the presumption in certain cancer cases for public safety employees, particularly firefighters, to extend the statute of limitations and make compensation more attainable. However, this only affects a relatively minor number of death cases (DIR, 2014 (Department of Industrial Relations 2014). In 2015, Assembly Bill (AB) 1124 provided for a prescription medication formulary to be established. And in 2016, two bills were passed that targeted medical provider fraud, medical case management, and delays in medical treatment. However, while these reforms have the potential to improve worker outcomes and contain costs, their implications for California firefighters with MSDs should be relatively minor.

changes in the types of workers filing for benefits, the study found that the economic outcomes for similar injured workers were systematically worse after the recession than before the recession. The pain caused by the recession was significant and widespread, but it is unknown the extent to which these findings are representative of the experience of injured firefighters in California.

In addition to system and economic changes, there have been other factors that could impact both the frequency and severity of California firefighters. Wildfires not only place firefighter lives at risk, but they potentially have the secondary effect of increasing the burden on department staffing and increasing overtime, exposing workers to greater risk of nonfatal injury and illness. There is also a greater awareness of the perils of post-traumatic stress and other psychological disorders that can affect the victims of traumatic events, which are particularly germane to workers in high-risk occupations like firefighters. All of these raise the question as to whether the frequency, severity and economic consequences of firefighter injuries have changed, and whether the workers' compensation benefit system has kept up in terms of ensuring benefit adequacy.

Study Goals and Objectives

In this study we update the analyses from the 2010 RAND study and provide new insight into the impact of the 2013 workers' compensation reforms and the economic shocks of the late 2000s on outcomes for firefighters with MSDs compared to other injured workers. There are 10 specific research objectives for this study, all responding to specific questions raised by CHSWC:

1. Estimate the percentage of firefighter injuries that are musculoskeletal as compared to other types of job related injuries;
2. Test for any correlation between MSDs and reporting of PTSD or other types of psychological injury;
3. Estimate whether return to work rates for firefighters with MSDs differ from rates for injured workers in other job classifications;
4. Estimate the impact of work related MSDs on the employment and earnings of firefighters compared to other injured workers;
5. Test whether reforms introduced by SB 863 impacted the earnings losses or disability benefits of firefighters with permanent disabling MSDs;
6. Evaluate the percentage of MSD claims that also include PTSD and other psychological injury reporting;
7. Empirically assess, of MSD claims, what percentage is ultimately determined compensable under workers' compensation;
8. Of MSDs determined compensable, assess how many are subject to causal apportionment to non job related causes for firefighters compared to other workers;
9. Estimate how often the cap on physical therapy visits is binding for firefighters with MSDs and, to the extent possible, determine whether or not the cap appears to impact treatment or recovery; and

10. Assess how often a work-related MSD is the result of a cumulative injury for firefighters compared to other workers.

Following the approach from the prior work, we accomplish this primarily through the analysis of administrative data from the California workers' compensation system linked to data on earnings for injured workers, with some additional analyses to tailor the results to the new reforms and to take advantage of data resources that were unavailable previously. Where necessary, or to provide context, we supplement the analysis using outside data from the published literature or national data.

Outline of Report and Overview of Analysis Samples

This report is organized as follows. In Chapter 2 we offer some background information on the injury risk of firefighters compared to other occupations, including a comparison of MSD risk. In Chapter 3 we use California administrative data from the workers' compensation system to decompose the composition of injuries for California firefighters over the past decade. In Chapter 4 we use injury data linked to earnings to assess the economic impact of MSDs and other injuries to California firefighters, and how this varied over the Great Recession. In Chapter 5 we assess the rate of psychiatric co-morbidities for CA firefighters with MSDs and other types of injuries, using workers' compensation medical data. Chapter 6 addresses some medical-legal issues, including benefit changes and changes in the disability rating system, and how they affected firefighters in California. Chapter 7 then assesses the extent to which California firefighters are restricted by the caps on physical therapy visits introduced in the early 2000s. Finally, in Chapter 8 we discuss the policy implications of our findings.

Our research questions vary widely with respect to the volume of data necessary to produce informative estimates. Although it would have been ideal to use a single research sample across all parts of the report, the number of injured firefighters appearing in all datasets was limited compared to the total number of injured firefighters, and we opted instead to define four different analytic samples with complete records on the variables specifically required to address each chapter's research questions. Differences in these samples are highlighted in Table 1.1; we defer detailed discussion of data sources and methods to the relevant chapters, and additional details on sample construction are presented in Appendix A.

Chapter 3 uses only occupation descriptions, worker demographics and injury characteristics from the First Report of Injury (FROI), a form submitted to the Workers' Compensation Information System capturing information known at or shortly after the claim is initially filed. Chapter 4, on labor market outcomes, additionally required a successful link between FROI data and earnings records from the Employment Development Department (EDD). Chapters 5 and 7, which focus on psychiatric comorbidities and medical treatment patterns, required successful linkage to medical bill data. For analyses in Chapter 5 examining earnings losses for workers with psychiatric comorbidities, we also required a linkage to the earnings data used in Chapter 4. Finally, in Chapter 6, we used data on workers who had permanent disability evaluations performed by the Disability Evaluation Unit, and who were successfully linked to the FROI.

Table 1.1: Overview of Analytic Samples Used in Report

Chapter	Analytic sample	Injury Years Available in Sample
3	Complete records cases from First Reports of Injury submitted by claim administrators with reliable reporting	2005-2018
4	Cases used in Chapter 3 with linkage to EDD earnings data	2005-2015
5, 7	Cases used in Chapter 3 with linkage to medical bill data	2007-2016
5	Cases used in Chapter 3 with linkage to medical bill data and EDD earnings records	2007-2015
6	Cases with permanent disability rated at Disability Evaluation Unit and linkage to FROI	2005-2015

As suggested by the varying injury date ranges in Table 1.1, datasets that were important for certain analyses were not available over the full range of injury dates for which we examined injury rates and case mix (2005-2018). Analysis of earnings, diagnoses, and medical treatment outcomes require a follow-up period of several years after injury, making it infeasible to include the latest possible injury years in these analyses. Disability evaluations also may not be performed for many years after injury, leading to similar limitations in our ability to examine permanent disability ratings for the most recent injury years. We felt the value of providing the most current available data on case mix and injury rate trends outweighed potential drawbacks of using different analysis samples. Additional details on sample construction are presented in Appendix A.

2. Background on Work-related Musculoskeletal Disorder Risk for Firefighters Compared to Workers in Other Occupations

Before we proceed to our empirical examination of the types and severity of injuries experienced by California firefighters, we first provide some background information. We begin by discussing the definition of an MSD, which is broad and not always consistent across settings. We then describe some institutional factors relevant to public safety employees, particularly with regards to disability compensation that could impact our findings. We then discuss previous work and offer a few descriptive statistics using national data to describe the overall MSD risk for firefighters and to look for any trends since the previous RAND study.

What is a Musculoskeletal Disorder?

As noted in Seabury and McLaren (2010), a fundamental challenge with studying MSDs is the lack of consensus as to precisely what constitutes an MSD. They are generally recognized to encompass a broad set of conditions that affect muscles, joints and connective tissues. The Bureau of Labor Statistics (BLS) offers the following definition of musculoskeletal disorders:

Musculoskeletal disorders (MSDs) include cases where the nature of the injury or illness is pinched nerve; herniated disc; meniscus tear; sprains, strains, tears; hernia (traumatic and nontraumatic); pain, swelling, and numbness; carpal or tarsal tunnel syndrome; Raynaud's syndrome or phenomenon; musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is overexertion and bodily reaction, unspecified; overexertion involving outside sources; repetitive motion involving microtasks; other and multiple exertions or bodily reactions; and rubbed, abraded, or jarred by vibration. (Source: Bureau of Labor Statistics, U.S. Department of Labor, *Survey of Occupational Injuries and Illnesses*)

However, not all definitions are so precise; the National Fire Protection Agency (NFPA) includes MSDs in a category that characterizes injuries as “strains, sprains, or muscular pain.” The academic literature displays similar variation. Some conditions such as osteoarthritis and low back pain are almost always included. However, in some cases carpal tunnel syndrome is excluded while in others it is included. Similarly, some definitions include disorders involving lower extremities while others limit MSDs to only disorders affecting upper extremities.⁴

The prior RAND study was particularly challenged in terms of its ability to identify MSDs because of the primary data source used. Seabury and McLaren used administrative data from the California Disability Evaluation Unit (DEU) that characterized injuries solely based on the part of body, with no other refinements (a common limitation of data from state workers' compensation systems). In this study, we have greater ability to identify specific types of injury because of advances in data collection that have occurred in recent years. We discuss our exact approach and data in more detail in the next chapter, but generally speaking we take two approaches to identifying MSDs. The first is based on the injury description listed in the first

⁴ For examples of papers using these different definitions, see Punnet and Wegman (2004), Power et al. (2006), Huisstede et al. (2006) or Dunning et al. (2010).

reports of injury (FROI) codes that are reported to the state, and the second is based on the listed ICD-9-CM diagnosis codes contained in the medical billing data. The ICD-9 codes have the advantage of providing more precise clinical detail about the nature of injury and an individual's physical condition. ICD-9 codes, which are reported on medical bills, can also be used to identify conditions that emerge over time but that may not have been immediately apparent at the date of injury. However, due to incomplete reporting and the possibility of "rule-out" diagnoses appearing in the billing records, the FROI injury codes provide a more complete, if less detailed, accounting of the nature of injury. We ultimately rely on the FROI injury codes as our primary definition of MSDs largely because they are available for a much larger analysis sample spanning all years from 2005-2018, whereas medical claims are not available in all years and are missing for a non-trivial proportion of cases even in years when they are available. Furthermore, the proportion of WCIS claims without medical records varies over time, making the medical data a less reliable source for analyzing trends in case mix. We characterize differences between the two approaches to defining MSDs (FROI vs. ICD) in Appendix A.

One final complicating factor in this issue is the somewhat ambiguous distinction between a musculoskeletal "disorder" versus an "injury." We tend to think of an injury as an acute event with a discrete time of occurrence and clear causality, while a disorder is something that can be acute or can develop over time and could be due to multiple causes. The workers' compensation system does cover both acute injuries and chronic disorders, as long as they arise at or due to the nature of one's work. However, in the case of chronic conditions, causality can be difficult to establish, and the true date of injury can be unclear. In some empirical analyses, we will distinguish between acute and chronic conditions, but in general we use the term "disorders" to encompass any and all MSDs that occur in the system.

Injury Compensation for Public Safety Employees in California

In addition to facing a higher risk of injury at work, firefighters and other public safety employees are also unique in that they receive special compensation measures not available to most private sector workers. These include both extra indemnity benefits during recovery from injury as well as disability retirement benefits, both of which could help alleviate the economic burden of injury. We briefly describe these here, with more detail provided in earlier RAND studies (c.f., Latourette, Loughran and Seabury, 2008).

The vast majority of workers in the US who experience a work-related injury or illness are eligible for medical and indemnity benefits from their employer as specified by the governing states' workers' compensation laws. These typically include full coverage of medical costs and partial coverage of lost wages. Indemnity benefits vary depending on whether the injury is permanent or temporary, as well as according to other factors such as the type of injury and/or the worker's age or occupation.

While most workers' compensation benefits are formulaic, the indemnity benefits offered to public safety employees are often more generous, and this is particularly true for public safety employees. Most state workers' compensation programs provide weekly TTD benefits that are equal to two-thirds of pre-injury weekly earnings, subject to a cap (e.g., two-thirds of weekly wages up to \$500 per week). An important aspect of workers' compensation benefits is that they are tax-free at the state and local level, although some states (e.g. Ohio) do set benefits as a fixed fraction of after-tax earnings.

Many public employees receive negotiated benefits called salary continuance, which replaces a higher portion of wages for some limited period of time after an injury. Because it is a negotiated benefit, there is no uniform formula for salary continuance (one example that has been used in the past is a worker receiving 80% of pre-injury salary for the duration of their injury). These benefits are paid over and above workers' compensation benefits, often with permanent benefits being paid through the workers' compensation system if a worker is unable to return to work.⁵

Public safety employees often receive higher temporary disability benefits even greater than salary continuance due to state legislative action. California Labor Code §4850 (LC §4850) provides police officers, firefighters and other specified safety personnel with full salary replacement, tax free, for up to one year following to a work-related injury.⁶ Thus, in many cases injured safety personnel actually make more money while recovering from injury than they do while working. Permanent disability benefits are not directly supplemented, but public pension programs often have special provisions for safety personnel that make them eligible for generous service-related disability retirement packages.

The reasons for offering generous injury compensation packages for firefighters and other safety personnel seem clear. As noted above, these workers are routinely asked to put their lives at risk to protect the public, and we might be concerned that workers would be less willing to take on these risks if they knew it would lead to significant future economic hardships for themselves or their families. On the other hand, there is concern that these policies can lead to abuse and raise costs. A 2018 investigative report published by the *Los Angeles Times* showed high rates of medical and sick leave among police officers and firefighters close to retirement age, amounting to hundreds of millions of dollars in paid time off.⁷ What is particularly noteworthy for this study is that a large share of the conditions being compensated were MSDs that are more likely due to cumulative trauma, as opposed to the more acute risks associated with public safety work.

In addition to receiving higher benefits, public safety employees are also often covered for certain chronic illnesses that are not usually considered work-related in the private sectors. The difference is rooted in differences in the legal presumption regarding workplace causality. Typically, workers have to prove that chronic illnesses are job related in order to receive compensation, which can be difficult because most injuries develop over time and it is difficult for any given individual to prove their illness is work-related barring relatively uncommon circumstances (e.g., developing mesothelioma after being exposed to asbestos at work). However, for firefighters and other public safety employees, certain diseases are often presumed

⁵ There is nothing to prevent salary continuance can be negotiated for private employees as well, but anecdotally these tend to be offered in the public sector where unions are far more prevalent.

⁶ Public safety employees are not necessarily the only public workers offered special benefits. While less generous, public school teachers in California are also granted special benefits; Section 44984 of the Education Code (ED 44984) requires that any certificated employee injured at work be given their full salary, tax-free, for 60 workdays (Cal. Ed. Code § 44984(d)).

⁷ See <https://www.latimes.com/local/california/la-me-drop-20180203-htmllstory.html>, accessed February 4, 2019.

to be work-related, including heart disease, respiratory disease and certain types of cancer. These presumptions are most likely offered because of concern that public safety employees are routinely exposed to risk factors for these diseases in their work, though there has not been a great deal of scientific study to verify this (LaTourette, Loughran and Seabury, 2008). California has presumptions in place for all three of these health conditions for both police officers and firefighters.

These differences in the design of injury compensation programs between public safety employees and other workers have practical implications for our study. As discussed in more detail later in the report, we measure the economic consequences of workplace injuries by comparing the reported earnings of injured workers to the earnings of similar, uninjured workers. Salary continuance may show up as earnings in our data; although LC §4850 benefits should be reported to DIR as employer paid benefits, our previous study found that some claims administrators incorrectly report these benefits to EDD as wage income. Workers' compensation benefits, meanwhile, should never be counted as wage and salary income. Thus, comparing workers eligible for LC §4850 compensation to other workers could make it look as if injured firefighters and other safety employees were actively working after an injury even if they were actually out of work due to temporary disability. This form of measurement error would make the relative experience of non-safety personnel look worse by comparison than it really is. As we discuss in Chapter 3, we address this issue in part by including police officers (who are also eligible for §4850 benefits) as a comparison group. As we discuss in Chapter 4, we also conduct some sensitivity analyses on our earnings loss estimates to guard against misreporting of §4850 benefits as income.

In addition to affecting our estimates of economic consequences, the differences in benefits could also impact our frequency estimates by changing reporting practices. The availability of presumptions for heart disease, lung disease or cancer makes it possible that we observe workers' compensation claims for these conditions but not for workers in other occupations. Moreover, the fact that benefits are higher could induce firefighters to report injuries that they otherwise would not in order to file a claim and receive benefits, or it could induce them to engage in riskier behaviors that resulted in more injuries.⁸ Both of these effects could combine to make it look as if the relative risk of experiencing one of these conditions for safety personnel compared to other workers is greater than it really is.

This last point raises a general issue of the need to distinguish between true injury rates and reported injury rates. From a public health perspective, we are most interested in the injury rate, the true rate at which employees experience workplace injuries. But because of reporting incentives (or disincentives) on the part of workers and employers, in part due to compensation mechanisms, job security and other factors, the reported injury rate will generally be lower than

⁸ Workers increasing their propensity to file claims as benefits increase is referred to in the economics literature as "claims reporting moral hazard" while workers increasing their risk-taking and experiencing more injuries is referred to as "risk bearing moral hazard" (Butler and Worrall, 1991). Both are theoretically feasible, but generally speaking the former is considered to be more relevant empirically. Cite: Butler, Richard J., and John D. Worrall. "Claims reporting and risk bearing moral hazard in workers' compensation." *Journal of Risk and Insurance* (1991): 191-204.

the true injury rate.⁹ In our empirical work we are not able to distinguish differences in injury reporting across occupations, so differences in reporting rate implicitly reflect the net difference in true injury rates and injury reporting.

Existing Evidence on Firefighter Injury Risk

Unsurprisingly, given the important and high-risk nature of the job, there have been a number of previous epidemiological studies of firefighter injury risk. Our goal here is not to provide a full accounting of the existing literature, but rather to present a general overview of existing work and give some context to compare to our analysis of workers' compensation data. We focus exclusively on studies of nonfatal injury risk, because that is the subject of our empirical work.¹⁰

The previous RAND study used injury and illness data for California collected by the BLS for years 2003-2007 and observed a number of differences in injury rates for firefighters compared to police officers and workers in the private sector (Seabury and McLaren, 2010). These included that firefighter injury rates were higher overall than private sector workers but lower than police. However, in terms of MSDs, firefighter injury rates were higher than those for police officers or private sector workers. They also found important differences between firefighters and private sector workers by age. Overall, firefighter injury rates increased somewhat at older ages while they declined on average for private sector workers. In terms of MSDs, however, the rate of MSD injuries for firefighters 55 and older was more than double that of the youngest firefighters and more than ten times greater than that of the same age group for private-sector workers.

Other studies provide more detailed breakdowns of the nature and cause of firefighter injuries. The NFPA publishes a regular series on firefighter injuries using data reported to them by individual fire agencies from their survey NFPA Survey of Fire Departments for U.S. Fire Experience. With these data, (Haynes and Molis 2017) report that in 2015 there were over 68,000 line of duty firefighter injuries, about 43% of which occurred during fireground operations, 21% occurred at non-fire emergencies, 6% travelling to or from an incident, 11% during training and the rest during other on-duty activities. About 56% of firefighter injuries were classified as strains and sprains, including 53% of fireground injuries and 60% of injuries at non-fire emergencies. The second most common type of injury was wound, contusion or muscular pain (15%). Burns accounted for 3% of injuries, while respiratory distress accounted for 4% of injuries. Approximately 17% of injuries resulted in days away from work.

⁹ In theory, the reported injury rate could be higher than the true injury rate if there is significant reporting fraud, but we are unaware of any estimates suggesting that the number of fraudulent injuries is high enough to significantly impact the injury rate. Previous work generally concludes that true injury rates are significantly higher than reported rates (cf., Boden and Ozonoff, 2008;) Cite: Boden, L.I. and Ozonoff, A.L., 2008. Capture-recapture estimates of nonfatal workplace injuries and illnesses. *Annals of epidemiology*, 18(6), pp.500-506.

¹⁰ For information on firefighter fatalities, see the National Fire Protection Association's annual report *Firefighter Fatalities in the United States* available at: <https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/Firefighter-fatalities-in-the-United-States> (accessed on February 20, 2019).

There has been less work focused on injuries associated with woodland firefighting, which is a growing concern in California. Using data from the Department of the Interior from 2003-2007, (Britton et al. 2013) identified slips or falls as the most common type of nonfatal injury, followed by injuries involving equipment or machinery.¹¹ By comparison, Haynes and Molis (2016) identified slips or falls as the most common cause of fireground injuries while overexertion was the second most common. Similar to firefighter injuries generally, (Purchio 2017) found that about half of woodland firefighter injuries were sprains and strains. (Semmens et al. 2016) found that time spent in woodland firefighting was associated with elevated rates of hypertension. In general, it appears that woodland firefighting is similar to urban firefighting, in the sense that injury rates are elevated compared to non-firefighter occupations but MSDs are still the most common type of injury.

One of the most noteworthy stylized facts to emerge from the previous studies on firefighter injuries is that while burns and some of the other, more extreme, traumatic injuries one might associate with fires are certainly more common among firefighters than other workers, they still make up a relatively small share of injuries overall. More generally, it appears that while the injury rate of firefighters is significantly higher on average than that of other workers, the types of injuries they experience are broadly similar (Kurlick n.d.). This highlights the importance of focusing on firefighter MSDs, because they are common, frequent and costly to workers and employers.

¹¹ Cite: Britton, Carla, Charles F. Lynch, Marizen Ramirez, James Torner, Christopher Buresh, and Corinne Peek-Asa. "Epidemiology of injuries to wildland firefighters." *The American journal of emergency medicine* 31, no. 2 (2013): 339-345.

3. Recent Trends in Injury Rates and Composition Among California Firefighters

In this chapter we use data from the California workers' compensation system to examine trends in firefighter injuries between 2005 and 2018. Specifically, we look at the share of injuries reported that are MSDs compared to other types of injuries, for firefighters compared to workers overall and workers in similar occupations. Following the earlier RAND report, we also look at differences in the types of injuries for firefighters and other workers by age.

Data Sources

Our data for this project combine several administrative databases, all of which have been used for prior RAND studies (c.f. (M. Dworsky, Rennane, and Broten 2018; M. Dworsky et al. 2016).¹² The 2010 RAND study focused on permanent disability claims from the California Disability Evaluation Unit. These data were limited for several ways, including limited information on the nature of the injury and the restriction to permanent disabilities, which represent only a small portion of workplace injuries. In this study, we use data on permanent, temporary and medical only claims from the Workers' Compensation Information System (WCIS), a richer and more comprehensive data source with more information on the nature and circumstances of injuries.

The WCIS was first introduced by legislation in 1993, but was not implemented until 2001. The database is made up of information on individual workers' compensation claims submitted to DIR from claims administrators using the Electronic Data Interchange (EDI) formats developed by the International Association of Industrial Accident Boards and Commissions (IAIABC). In 2001, DIR began collecting EDI versions of the First Report of Injury (FROI), and Subsequent Reports of Injury (SROI). In 2007, DIR also began collecting transaction-level data on health care utilization billed under the workers compensation claims, including medical billing codes for procedures and diagnoses. Claims administrators are required to report detailed information on the type of injury, the body part injured and some circumstances surrounding the injury. They are also required to report at least annually on medical and indemnity benefits paid, including payments for temporary and permanent benefits. In this section, we focus our analysis on the FROI and SROI because they are reported more completely (in the Appendix we describe some supplemental analyses using the medical billing data). We now describe the variables extracted and use from each of these reports in more detail.

First Reports of Injury (FROI)

The First Report of Injury (FROI) must be submitted to WCIS within ten days of the claim administrator's knowledge of the claim. The FROI includes detailed information on the injured worker, employer, and the injury. Key information on the FROI that is particularly relevant for

¹² Our discussion of these data sources draws heavily on Dworsky, Rennane, and Broten, (2018).

this study includes the date of injury, worker demographics including age and sex, occupation, weekly wage, class code, industry and location. Additionally, information is recorded about the type of injury, including the nature, cause, and body part of injury.

After a FROI is filed, each new claim is assigned a jurisdiction claim number (JCN), a unique administrative identifier used to link all files across the lifetime of the claim. While reporting was considered an issue in the early days of the WCIS, the most recently available data indicates that over 90 percent of claims are reported to the WCIS as a FROI (California Department of Industrial Relations, 2017). While we do miss some injuries, the WCIS represents the only public source of individual-level claims data in California that captures all parts of the system including self-insured employers and, critically for our purposes, public-sector entities.

WCIS Subsequent Reports of Injury (SROI)

Reporting requirements for a Subsequent Report of Injury (SROI) state that it must be filed within 15 days of a change to benefit or claim status. Individual SROI are assigned to a claim using the same JCN as the FROI, allowing information to be linked and compiled at the claim level. SROI data provide transaction-level information on indemnity payments and lost time, which allow the WCIS to be used to monitor benefit receipt and payment levels. Additionally, the SROI data include information about the timing of important events on a claim such as maximum medical improvement, end date of temporary total disability payments, date and receipt of permanent partial disability payments, return to work (if applicable) and claim closure.

In theory, combining data from the FROI and SROI should provide complete injury and benefit information over the length of a claim. Unfortunately, compliance with reporting standards remains imperfect, and the data reported on the SROI are significantly less complete than the data reported to the FROI. Data collected by DIR on SROI reporting indicated that it was only about two-thirds complete (California Department of Industrial Relations 2017). The implications of this incomplete reporting for our study are mixed. On the one hand, much of the information about the type of injury that we use to identify MSDs are selected from the FROI. However, information on injury severity (e.g., medical only or lost-time, temporary or permanent disability) are only determined from the SROI. Where appropriate, and discussed in more detail below, we conduct analyses to assess the representativeness of claims with valid information from the SROI and apply analytic weights to allow us to produce consistent estimates as if we had a representative sample.

Weighting

To adjust for non-reporting to the SROI and make our estimates representative of all claims reported to the WCIS, we calculated sampling weights so that our analysis sample matches the full WCIS in terms of occupation, injury date, age, region, and whether the employer's workers' compensation policy is self-administered. Self-administration is far more common among public-sector employers and is also associated with less complete reporting.

Specifically, we construct these weights by partitioning our data into mutually exclusive categories defined by occupation (Active Firefighters, Public Sector, Active Police, Rest of WCIS), period of injury (2005-2009, 2010-2012, 2013+), gender, age (15-year bins), region (Southern California vs. rest-of-California), and self-administered status. Weights are defined as the ratio of counts in these categories for all observations with complete cases to counts with complete cases who pass the claim administrator screen. All statistics reported in this chapter are

computed using these weights, unless otherwise noted. Additional details on the weighting procedures is provided in the Appendix.

Other Data

While the WCIS provides information on counts of reported injuries in California, to get a sense of the frequency of injuries for firefighters compared to other occupations we need estimates of the population of workers at risk in California in each year. We use data on the number of workers by occupation and year collected by the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES). The OES provides estimates of total employment, hours and wages for over 800 occupations at the national and state level. The OES data come from a semiannual survey of approximately 200,000 nonfarm establishments, for a total of about 1.2 million establishments over a three-year survey frame, which BLS uses to provide annual estimates. Because of the nature of the survey, the data exclude farms and self-employed workers, but otherwise should closely match employment for firms reporting to the WCIS.

In addition to the OES, we also use data from the Occupational Information Network (O*Net), a comprehensive collection of job characteristics, conditions and requirements for different occupations that replaced the Dictionary of Occupational Titles (DOT). The O*Net is made up of a content model that describes the characteristics of more than 1,100 occupations across 6 broad domains. The domains include worker characteristics, worker requirements, experience requirements, occupational requirements, workforce characteristics and occupation-specific information. The O*Net is the most comprehensive, publicly available resource for understanding the characteristics and requirements of different occupations across the US economy.

Data are collected for O*Net from a national survey of establishments. The survey identifies workers in different occupations from within randomly selected establishments, and surveys them on different aspects of the job. As of December 31, 2017, the O*Net Data Collection Program had conducted 154 survey waves that sampled 333,566 workers in 308,642 different establishments.¹³ The O*Net survey data is considered complete for an occupation once survey have been completed from at least 15 workers. For occupations that are difficult to obtain information for through survey—say, because they are relatively uncommon and difficult to capture with a random survey—data is collected by nonrandom means through direct contact with occupational experts designated by third parties (e.g., a professional society).

We use data from the work context module, which is designed to capture workplace hazards and other factors that are job specific and would potentially related to health risks. The work context module has questions covering 55 aspects of work grouped into three broad categories: interpersonal relationships (14 questions), physical work conditions (33) and structural job characteristics (11). The physical work conditions category has a section on job hazards, which we would obviously expect to be associated with injury risk. However, the other two categories also address factors that could be associated with work-related injuries and illnesses. For

¹³ For a more complete description of the O*Net Data Collection methods, see the US Department of Labor, “O*Net Data Collection Program, Office of Management and Budget Clearance Package Supporting Statement, Part B: Statistical Methods” June 2018 available at: https://www.onetcenter.org/dl_files/omb2018/Supporting_StatementB.pdf (accessed April 20, 2019).

example, the interpersonal relationship category includes factors such as frequency of conflict situations while the structural characteristics category includes factors that could relate to job stress, such as the pace of work or importance of the position. In each question, respondents are asked to evaluate the relevance of a particular factor on a scale of 1 to 5, with 5 indicating the factor is more relevant. As we discuss below, we will use these data on job demands to select private-sector occupations similar to firefighting for inclusion in a comparison group.

Methods

We had to choose how to define musculoskeletal disorder claims in our data, how to identify active firefighters, and how to select appropriate comparison groups. This section details our approach to these three tasks.

Identifying Musculoskeletal Disorders

One of the important advantages of the WCIS compared to the DEU data used in the prior study is that the FROI data provide a much greater ability to identify MSDs. While, as noted above, there is no single definition of MSD, we use the data on body part and type of injury to identify conditions that are likely to encompass the majority of MSDs. Specifically, using the FROI, we identify MSDs for injuries to the neck, trunk, lower extremities, or upper extremities based on the reported part of body (excluding amputations, injuries to internal organs or other conditions that are unlikely to be musculoskeletal in nature). We further restrict the sample to injuries caused by dislocation, hernia, inflammation, rupture, sprain or strain or repetitive motion (including carpal tunnel syndrome), as reflected in the WCIS nature of injury codes. By comparison, the DEU injury codes are almost exclusively based on part of body, so the prior study had to focus on body parts in which a majority – though certainly not all – injuries would be considered musculoskeletal in nature, most notably back injuries.

Identifying Firefighters

One of the limitations inherent to workers' compensation administrative data is the way in which occupation is recorded. While the WCIS does include information on the occupations of injured workers, the data are not reported using the Standard Occupational Classification (SOC) coding system used by federal agencies such as the BLS and US Census. Rather, the WCIS has two data fields that reflect a workers' occupation. The first is a text field in which the name of the workers' occupation is listed as reported on the FROI. As with all text fields, this can be challenging to use to group workers into occupations because it is sensitive to misspellings or to minor differences in reporting (e.g., some agencies might use "FIREFIGHTER" while others might use "FIRE FIGHTER"). The second data field is the classification code, a four-digit code that used by insurers to classify workers in different occupations and industries as described in the California Uniform Statistical Reporting Plan (USRP). Although classification codes are not equivalent to occupation codes, they capture detailed information about the type of work done at an establishment and have the advantage of being a standardized classification system, unlike the occupation description. Submission of class codes to the WCIS is optional for self-insured employers, however, so class codes are not present in all of the FROI records, with differentially low rates of reporting among public employers.

For this study, we use a multi-step process to identify firefighters. First, we identify the job titles listed by workers identified as firefighters in the O*Net survey (based on the SOC codes for firefighters).¹⁴ We then match these to the entries in the WCIS occupation code, using a “fuzzy” matching algorithm to allow for small discrepancies or typographical errors. We also manually reviewed different values listed in the WCIS occupation code in claims that also had the reported class code 7706 (Firefighting Operations—not volunteers). In these steps, we include only occupations that represent active firefighters and front-line supervisors, including for example: “Firefighter,” “Fire Engineer,” “Fire Equipment Operator,” “Fire Lieutenant,” and “Battalion Chief.” Conversely, we exclude volunteers, inmates, and jobs in fire departments that are not active firefighters (e.g., dispatchers or arson investigators). To verify the validity of the occupation choices, we also had a current fire chief in California identified from the California Fire Chiefs Association website review our list of occupation titles and identify titles unlikely to reflect active firefighting. We followed this fire chief’s recommendations and removed six job titles that had been initially identified as active firefighters.

It is worth noting differences between our approach and that taken in the 2010 RAND Firefighter study, where the only source of information on occupation was the DEU occupation description field. To identify firefighters in that study, a search and cleaning algorithm was adopted to sort through the text string and identify claims that were likely to involve firefighters. While the exact implications of this difference are unclear, our review of the prior approach indicates that it appears more likely to have included related but non-firefighting occupations such as fire inspectors in the firefighter group, while firefighters with job titles that do not include the text string “fire” (such as “battalion chief” or “apparatus operator”) were omitted from the 2010 study. Differences in the two approaches may contribute to differences in findings from the earlier study, but only a minority of cases are likely to be classified differently under the two approaches given that “firefighter” and close variants of “firefighter” are by far the most common occupation titles for active firefighters identified by our current approach.

Comparing Job Demands for Firefighters and Workers in Other Occupations

As with the 2010 RAND Firefighter study, our analysis compares injury frequency and outcomes for firefighters to a selection of workers in other occupations. There are many reasons why injury frequency, severity and outcomes could differ for firefighters compared to other workers. Some differences come from the nature of firefighting; it is risky work with high physical demands, meaning that injuries could be both more frequent and more debilitating when they occur. On the other hand, firefighters are public employees, meaning they are more likely to be unionized, receive higher earnings and more job security than private-sector workers with comparable education and demographics (Gregory and Borland 1999), all factors which we would expect to lessen the economic consequences of injuries. These are consistent with the findings from the 2010 study, that injuries were common among firefighters but the long-term earnings losses from permanently disabling injuries were smaller on average.

¹⁴ Specifically, we used the O*Net’s *Sample of Reported Titles*, which contains frequently used verbatim responses from O*Net respondents and thus provides a characterization of what workers in each occupation call themselves. Available at https://www.onetcenter.org/dictionary/20.1/excel/sample_of_reported_titles.html as of May 20, 2019.

Our approach to selecting comparison occupations in this study differs significantly from the 2010 study, which compared firefighters to an *ad hoc* group of two public occupations in protective service (police officers and corrections workers), two private occupations (construction workers and laborers) and one that could be either but that tends to be highly unionized and has special injury provisions (teachers).

In this study, we use data from O*Net to identify non-firefighter occupations in private industry that are most like firefighters in terms of job demands. Then, we compare firefighters to police officers, other public workers, the O*Net-based private sector comparison group or to the entire WCIS.

To identify police officers, we use an approach similar to that used to identify firefighters, starting with a fuzzy match between the WCIS occupation description field and occupation titles reported to the O*Net, and then followed by refinements based on class code. After inspecting the results and comparing them to the cases identified in the 2010 study, we added cases with occupations counted as police using the algorithm applied in the 2010 study (which examined only the occupation description field).

Using O*Net, we identified municipal firefighters using the SOC 33-2011.01 and took the mean value of each of the 55 different work context factors. Table 3.1 reports the average value of each factor for firefighters compared to the overall mean across occupations. To highlight characteristics where firefighting differs most from other occupations, the factors are sorted in descending order of the difference between firefighters and the mean value for all occupations. This difference can be interpreted as a measure of how much more or less relevant each factor is for a firefighter compared to someone in a randomly selected occupation, according to whether the difference is positive or negative, respectively. Even though the precise ordering should be taken as suggestive since the results depend on an arbitrary assignment of ordered qualitative responses to a set of numerical values, Table 3.1 describes the range of job characteristics that we considered in selecting comparison occupations and illustrates the differences between firefighters and other occupations.

Table 3.1. Comparison of O*Net Work Context Factors for Firefighters and Other Occupations

	Mean Value for Municipal Firefighters	Mean Value for all Occupations	Difference
<u>Interpersonal Relationships</u>			
Deal with Physically Aggressive People	2.89	1.54	1.35
Responsible for Others' Health and Safety	4.37	3.2	1.17
Deal with External Customers	4.47	3.4	1.07
Deal with Unpleasant or Angry People	3.61	2.92	0.69
Responsibility for Outcomes and Results	3.89	3.28	0.61
Public Speaking	2.78	2.25	0.53
Frequency of Conflict Situations	3.43	2.94	0.49
Coordinate or Lead Others	4.02	3.54	0.48

Work with Work Group or Team	4.59	4.16	0.43
Contact with Others	4.68	4.34	0.34
Face-to-Face Discussions	4.82	4.57	0.25
Electronic Mail	3.95	3.81	0.14
Telephone	4.14	4.15	-0.01
Letters and Memos	3.04	3.17	-0.13
<u>Physical Work Conditions</u>			
Exposed to Disease or Infections	4.07	1.82	2.25
Wear Specialized Protective or Safety Equipment such as Breathing Apparatus	3.79	1.69	2.1
Outdoors, Exposed to Weather	4.35	2.31	2.04
Exposed to Hazardous Equipment	4.14	2.19	1.95
In an Enclosed Vehicle or Equipment	4.17	2.24	1.93
Extremely Bright or Inadequate Lighting	3.97	2.08	1.89
Exposed to High Places	3.5	1.63	1.87
Exposed to Hazardous Conditions	3.74	2.04	1.7
Wear Common Protective or Safety Equipment such as Safety Shoes, Glasses, Gloves	4.59	2.95	1.64
Cramped Work Space, Awkward Positions	3.53	2.02	1.51
Exposed to Contaminants	4.28	2.77	1.51
Outdoors, Under Cover	3.15	1.78	1.37
In an Open Vehicle or Equipment	2.89	1.56	1.33
Indoors, Not Environmentally Controlled	3.55	2.31	1.24
Very Hot or Cold Temperatures	3.51	2.29	1.22
Sounds, Noise Levels Are Distracting or Uncomfortable	4.26	3.11	1.15
Physical Proximity	4.54	3.41	1.13
Exposed to Whole Body Vibration	2.44	1.36	1.08
Spend Time Climbing Ladders, Scaffolds, or Poles	2.4	1.42	0.98
Exposed to Minor Burns, Cuts, Bites, or Stings	3.06	2.16	0.9
Spend Time Kneeling, Crouching, Stooping, or Crawling	2.63	1.83	0.8
Spend Time Bending or Twisting the Body	3.03	2.29	0.74
Spend Time Keeping or Regaining Balance	2.31	1.58	0.73
Exposed to Radiation	1.72	1.27	0.45
Spend Time Walking and Running	2.86	2.5	0.36
Spend Time Standing	3.42	3.07	0.35
Spend Time Using Your Hands to Handle, Control, or Feel Objects or Tools	3.65	3.34	0.31
Spend Time Making Repetitive Motions	2.71	3.04	-0.33
Indoors, Environmentally Controlled	3.43	3.94	-0.51
Spend Time Sitting	2.57	3.11	-0.54

<u>Structural Job Characteristics</u>			
Consequence of Error	4.11	3.04	1.07
Level of Competition	3.56	3.1	0.46
Impact of Decisions on Co-workers or Company	4.18	3.84	0.34
Importance of Repeating Same Tasks	3.54	3.24	0.3
Frequency of Decision Making	4.09	3.84	0.25
Importance of Being Exact or Accurate	4.26	4.19	0.07
Pace Determined by Speed of Equipment	1.81	1.93	-0.12
Freedom to Make Decisions	3.96	4.12	-0.16
Structured versus Unstructured Work	3.87	4.03	-0.16
Time Pressure	3.65	3.85	-0.2
Degree of Automation	1.72	2.16	-0.44

*Notes: Table reports the average value of O*Net work context factors for municipal firefighters and for all occupations. Work context factors are ranked on a scale of 1 to 5 with higher values indicating the factor is more relevant for the job. A positive difference is interpreted as a factor being relatively more relevant for firefighting than other jobs, while a negative value suggests is is less relevant.*

The areas where firefighting appears to be particularly demanding compared to other occupations involve environmental exposures or use of equipment. For example, the five factors where the difference between firefighting and the overall average is most positive are *Exposed to Disease or Infections, Wear Specialized Protective or Safety Equipment, Outdoors, Exposed to Weather, Exposed to Hazardous Equipment* and *In an Enclosed Vehicle or Equipment*. Conversely, the five factors for which the difference is most negative – indicating the factor is less relevant for firefighters on average – are *Time Pressure, Spend Time Making Repetitive Motions, Degree of Automation, Indoors, Environmentally Controlled* and *Spend Time Sitting*. It is worth noting that the difference between firefighters and the overall average is negative for just 10 of the 55 factors, and the difference is small compared to the positive differences in the other factors.

To identify jobs that are similar to firefighting using these factors, we perform the following steps. First, we take the difference between firefighting and each occupation at the SOC level. We then compute the sum of squared differences – a standard measure of statistical difference between two variables – across all 55 factors and select the 25 occupations for which the sum of squared differences is smallest, listed in Table 3.2. Notably, the first three occupations that match most closely to municipal firefighters, and 4 of the first 5, are other firefighting occupations. Four more of the top 25 are jobs involving policework. Excluding these 8 jobs, we are left with 17 occupations that we consider to be closely matched to firefighters based on job characteristics.

Table 3.2. Firefighters Compared to Similar Occupations

Occupation Title	Statistical Distance
<i>Municipal Firefighters</i>	0.0
<i>Municipal Fire Fighting and Prevention Supervisors</i>	5.3
<i>Fire Investigators</i>	7.9
<i>Forest Firefighters</i>	9.5
<i>Emergency Medical Technicians and Paramedics</i>	10.6
<i>Forest Fire Fighting and Prevention Supervisors</i>	15.8
<i>Control and Valve Installers and Repairers, Except Mechanical Door</i>	18.8
<i>Telecommunications Line Installers and Repairers</i>	19.1
<i>Transit and Railroad Police</i>	19.8
<i>Hydroelectric Plant Technicians</i>	20.3
<i>Electrical and Electronics Repairers, Powerhouse, Substation, and Relay</i>	20.7
<i>Pilots, Ship</i>	21.6
<i>Sheriffs and Deputy Sheriffs</i>	23.0
<i>Weatherization Installers and Technicians</i>	23.0
<i>Police Identification and Records Officers</i>	23.1
<i>Commercial Divers</i>	23.6
<i>First-Line Supervisors of Police and Detectives</i>	23.6
<i>Industrial Safety and Health Engineers</i>	24.2
<i>Elevator Installers and Repairers</i>	24.3
<i>Mates- Ship, Boat, and Barge</i>	24.5
<i>Ambulance Drivers and Attendants, Except Emergency Medical Technicians</i>	24.7
<i>Refrigeration Mechanics and Installers</i>	24.8
<i>Septic Tank Servicers and Sewer Pipe Cleaners</i>	25.0
<i>Millwrights</i>	25.1
<i>Commercial Pilots</i>	25.2
<i>Occupational Health and Safety Technicians</i>	25.3

Notes: Table reports the 25 closest occupations to firefighters based on the work context factors reported in Table 2, which make up the private sector comparison group we use in the analysis. "Statistical difference" is the sum of squared differences between the value of each factor for firefighting and other occupations. Shaded occupations are excluded because they represent firefighting or police occupations.

While our main analysis uses all 55 work context factors to identify this ranking, as an alternative approach we redo the analysis using only the 30 physical working factors. In general, the ranking based only on physical work conditions is correlated with the ranking based on structural job conditions (correlation coefficient 0.54) but less so with the ranking based on

interpersonal characteristics (correlation coefficient 0.21). Using only the physical work conditions factors results in a similar occupation mix as using all factors, with 11 of the 17 occupations the same.¹⁵ We think that using the full set of work context factors is appropriate and is unlikely to yield sharply different results from a comparison group defined using only physical work conditions. In addition, given our interest in psychiatric comorbidities in addition to physical injuries, we think there is value to including

The Frequency of Firefighter Injuries and Musculoskeletal Disorders in California

Table 3.3 reports the raw counts of FROI in the WCIS by occupation and injury year. We examine injury rates and case mix from 2005-2018, with the start date of 2005 chosen to reflect implementation of the major reforms enacted as in 2004 under Senate Bill (SB) 899. We note that 2018 only reflects partial year reporting due to lags in data reporting and the time of the extract, resulting in a significantly smaller number of reported injuries. In the data, we have 108,724 firefighter injuries across all years, compared to 236,018 for police and 951,326 for all public workers, reflecting differences in the size of the underlying labor force for each occupation.

Overall, the number of firefighter injuries per year is fairly stable, ranging from 7,414 to 9,178 in all years. Notwithstanding firefighters' greater job security, we note a brief dip in claim volumes from 2009-2011 in the number of injuries that coincides with the rise in state unemployment during and after the Great Recession. This dip may reflect reduced employment, as well as the deterrence of minor, non-traumatic injury claims where the worker has discretion over whether to file a claim (Boone et al., 2010). Both these mechanisms (employment changes and deterrence via the implicit threat of layoff) are likely to be much less pronounced for public sector workers than for workers in the private sector: differences in the cyclicity of injury counts reported in Table 3.3 appear to be consistent with this difference. The number of injuries grows steadily for police and other public workers, while the number of injuries in the peak recession years of 2008-2010 falls nearly 50% for workers in the private sector comparison group and by about 25% for the rest of the WCIS compared to 2005. This likely reflects the greater job security in public sector occupations, which help to insulate workers from changing economic conditions.

¹⁵ The occupations that appear in the 25 closest matches based on physical work conditions, but are excluded from our comparison group, include Glaziers; Hazardous Materials Removal Workers; Maintenance and Repair Workers, General; Plumbers; Riggers; Signal and Track Switch Repairers; Telecommunications Equipment Installers and Repairers, Except Line Installers; and Wind Turbine Service Technicians. Occupations that are included in our comparison group, but that do not appear in the 25 closest matches based on physical work conditions, include Ambulance Drivers and Attendants, Except Emergency Medical Technicians; Commercial Pilots; First-Line Supervisors of Police and Detectives; Industrial Safety and Health Engineers; Mates- Ship, Boat, and Barge; Millwrights; Occupational Health and Safety Technicians; and Police Identification and Records Officers. We did not identify the excluded occupations in the WCIS data, so we are unable to compare case counts between the included and excluded groups.

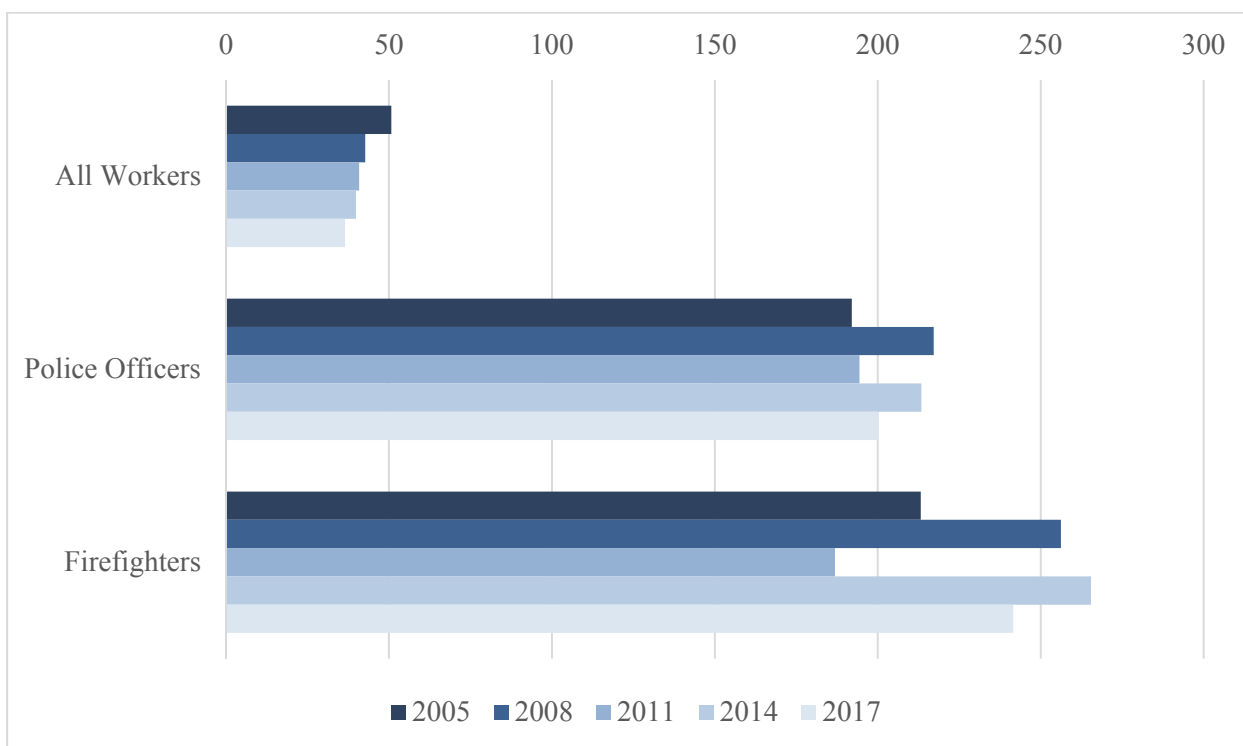
Table 3.3. WCIS Injury Counts by Occupation and Year

<i>Year of Injury</i>	Firefighters	Police Officers and Sherriff's Deputies	Other Public Sector Workers	Private Sector Comparison Workers	Other Workers
2005	7,929	17,046	66,346	8,468	646,832
2006	7,414	17,085	64,105	7,618	625,318
2007	8,204	18,229	66,835	6,863	591,623
2008	9,082	18,026	70,608	6,454	545,680
2009	7,945	18,037	70,267	4,993	479,815
2010	7,038	18,133	66,165	4,344	474,487
2011	6,763	17,491	65,184	4,764	479,659
2012	8,978	17,874	73,611	4,986	483,142
2013	8,673	17,764	76,275	4,928	481,606
2014	8,661	18,235	77,801	5,484	492,425
2015	9,178	18,185	75,559	7,658	499,379
2016	8,486	16,882	77,020	8,258	490,341
2017	8,099	17,258	75,266	7,187	502,296
2018	2,274	5,773	26,283	1,654	174,690
<i>All years</i>	108,724	236,018	951,326	83,658	6,967,294

Source: Authors' calculations from the Workers Compensation Information System. Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS..

As noted, these trends are driven at least in part by changes in aggregate employment. To normalize injury rates for the size of the labor force, we report the total number of injuries per 1,000 workers in California in Figure 3.1. We report values for 2005, 2008, 2011, 2014 and 2017, excluding additional years to make the figure more readable. However, the general patterns are the same even with additional years.

Figure 3.1. Number of Reported Injuries per 1,000 Workers in California



Notes: Authors' calculations from the Workers' Compensation Information System. Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS..

Note that these values aren't directly comparable to injury rates published by the BLS, which use additional data on hours worked to normalize by injuries to full-time equivalent workers (FTEs). Nonetheless, the general pattern is the same, in that the number of injuries per 1,000 workers ranges from about 30-50 overall but is significantly higher for police officers and firefighters. For all workers there is a general decline from 2005 through 2017, with a particularly noticeable drop in 2008 as the recession started. However, the patterns among police officers and firefighters are less pronounced, with the number of injuries rising and falling across years. Part of this could reflect the smaller samples of workers, which generates more sampling variation. But it could also reflect the likely fact that staffing levels – and thus injury rates – for public safety personnel are not as sensitive to economic conditions.

To understand the relative importance of MSDs for firefighters compared to other occupations, we used the WCIS injury type information as described above to compute the percent of WCIS reported injuries by occupation and year. We report this information in Table 3.4. Overall, the table makes it clear that MSDs are an important injury group for all workers but particularly for firefighters. For firefighters, MSDs account for 47.3% of all injuries, compared to 38% for police officers, 42.5% for other public sector workers, 37.2% for workers in the private sector comparison group and 41.8% in the rest of the WCIS. The trends appear to be common across occupations, with an increasing share of MSDs from 2005 through about 2010, but then it declines to about the same level by 2017.

Table 3.4. Percent of Injuries involving MSDs by Occupation and Year

Year of Injury	Firefighters	Police Officers and Sherriff's Deputies	Other Public Sector Workers	Private Sector Comparison Workers	Other Workers
2005	47.0%	35.4%	42.1%	36.8%	41.6%
2006	45.3%	35.4%	41.9%	36.9%	41.1%
2007	47.3%	34.4%	42.6%	36.9%	40.7%
2008	43.7%	34.4%	42.5%	36.4%	40.9%
2009	46.3%	38.3%	43.5%	39.8%	42.6%
2010	50.3%	39.4%	44.9%	40.2%	43.1%
2011	49.3%	39.9%	45.0%	39.8%	42.8%
2012	48.9%	39.8%	44.1%	37.5%	42.7%
2013	49.7%	39.5%	43.6%	37.7%	43.0%
2014	49.5%	41.1%	42.8%	36.8%	42.8%
2015	47.4%	40.3%	42.4%	36.2%	42.1%
2016	44.4%	39.1%	40.2%	35.6%	41.5%
2017	45.8%	37.0%	38.9%	35.5%	39.8%
2018	47.7%	38.3%	38.9%	38.6%	39.8%
2005-2018	47.3%	38.0%	42.5%	37.2%	41.8%

Notes: Authors' calculations from the Workers' Compensation Information System (WCIS). Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS.. Each cell reports the percent of WCIS injuries that are musculoskeletal disorders (MSDs), as defined in the text.

Table 3.5 describes the demographics of injured workers with musculoskeletal disorder claims by occupation. In addition to the three comparison occupations, we include demographics for other claims in the WCIS to suggest how our sample differs from the average injured worker statewide. Firefighters are older at injury than police and comparable private-sector workers, but are also younger than the sample of other public-sector workers with musculoskeletal disorders, largely due to a much higher proportion of other public-sector workers who are injured above age 50 and, especially, above age 60. Retirement pensions for public safety workers commonly become available at age 50 for workers with sufficient years of service, and so the low proportion of injuries among workers aged 60-64 is likely to reflect differences in the population at risk.

The other important demographic pattern that emerges from Table 3.5 is that firefighters with musculoskeletal disorder are overwhelmingly male: just one in twenty firefighters (5.8 percent) with a musculoskeletal disorder claim is female. While the injured worker populations in similar private-sector occupations (13.9 percent female) and police (19.9 percent female) are also much

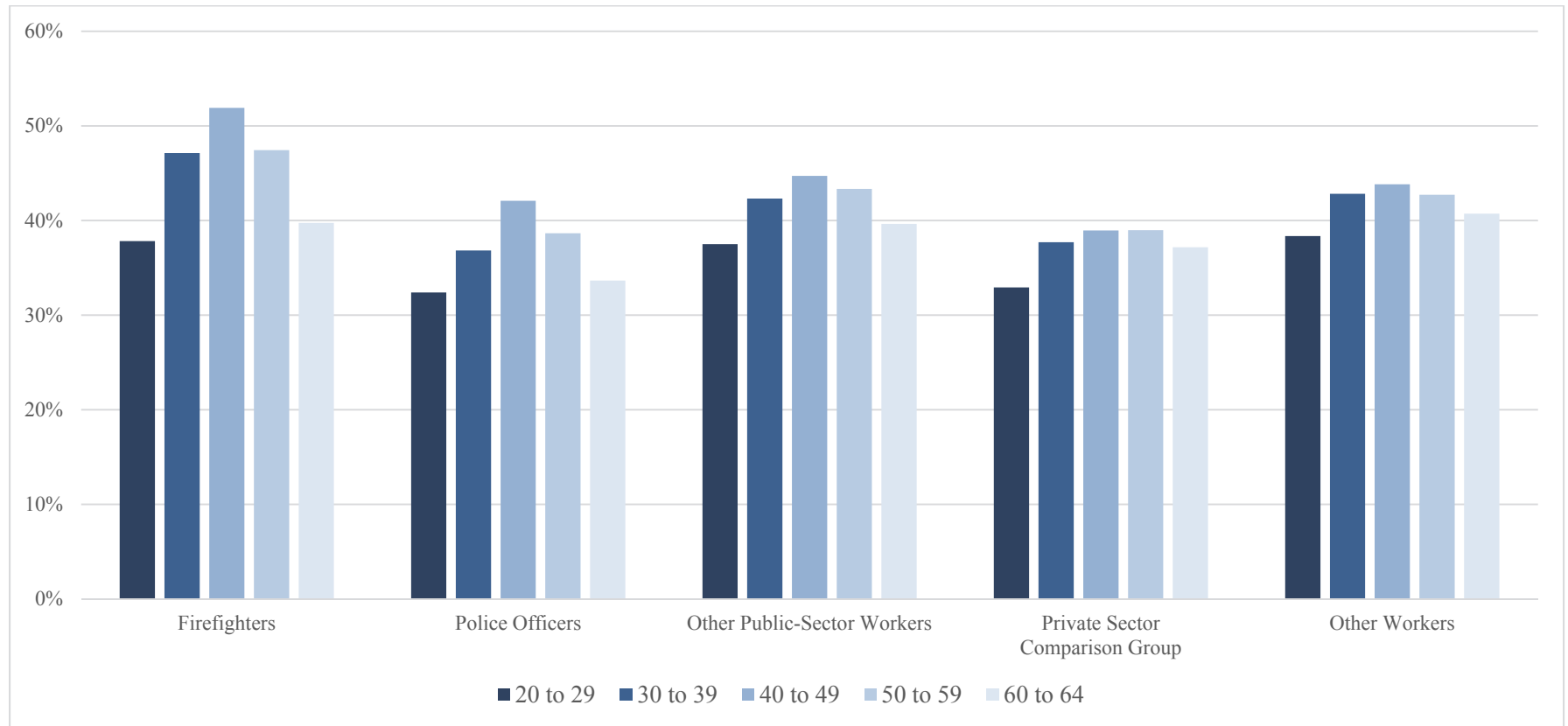
more heavily male than is typical throughout the rest of the workers' compensation system (43.4 percent female), firefighters stand out even when compared to these occupations. Other public-sector workers, in contrast, are more likely (54.6 percent) than the statewide average to be female.

Table 3.5: Demographics of Injured Workers with Musculoskeletal Disorder Claims, by Occupation

	Active Firefighters	Active Police	Rest of Public Sector	Rest of Private Sector	All Other Injured Workers
Average Age at Injury	42.0	40.0	45.1	40.4	40.1
% Female	5.8%	19.9%	54.6%	13.9%	43.4%
Age at Injury (% of Workers)					
20-29	12.6%	14.2%	10.5%	20.8%	23.9%
30-39	27.8%	33.9%	19.8%	28.1%	24.9%
40-49	33.8%	35.7%	30.1%	26.4%	25.7%
50-59	23.9%	15.0%	32.0%	20.6%	20.8%
60-64	1.9%	1.2%	7.6%	4.2%	4.8%

In Figure 3.2, we examine how the differences across occupations in terms of the share of injuries that are MSDs compares across different age groups. Specifically, we compute the share of injuries in the WCIS for each occupation for age ranges 20 to 29, 30 to 39, 40 to 49, 50 to 59 and 60 to 64, with age defined as the age at the date of injury. In general, for all occupations the share of MSDs follows an inverted U-shaped pattern, with the share initially increasing and then decreasing at older ages. What is noteworthy in the figure is how much more pronounced the pattern is for firefighters than workers in other occupations. The share of injuries that are MSDs at the youngest or oldest age categories are fairly comparable to workers in other occupations, but there is a much sharper increase in the share of MSDs for firefighters between ages 30 and 59. For example, the share of MSDs for firefighters jumps from 38% for workers age 20 to 29 to 52% for workers age 40 to 49 and then down to just under 40% for workers age 60 to 64, while by comparison the share of MSDs for workers in the private sector comparison group increases from 33% at age 20 to 29 to 39% at age 40 to 49 and then declines to 37% at age 60 to 64.

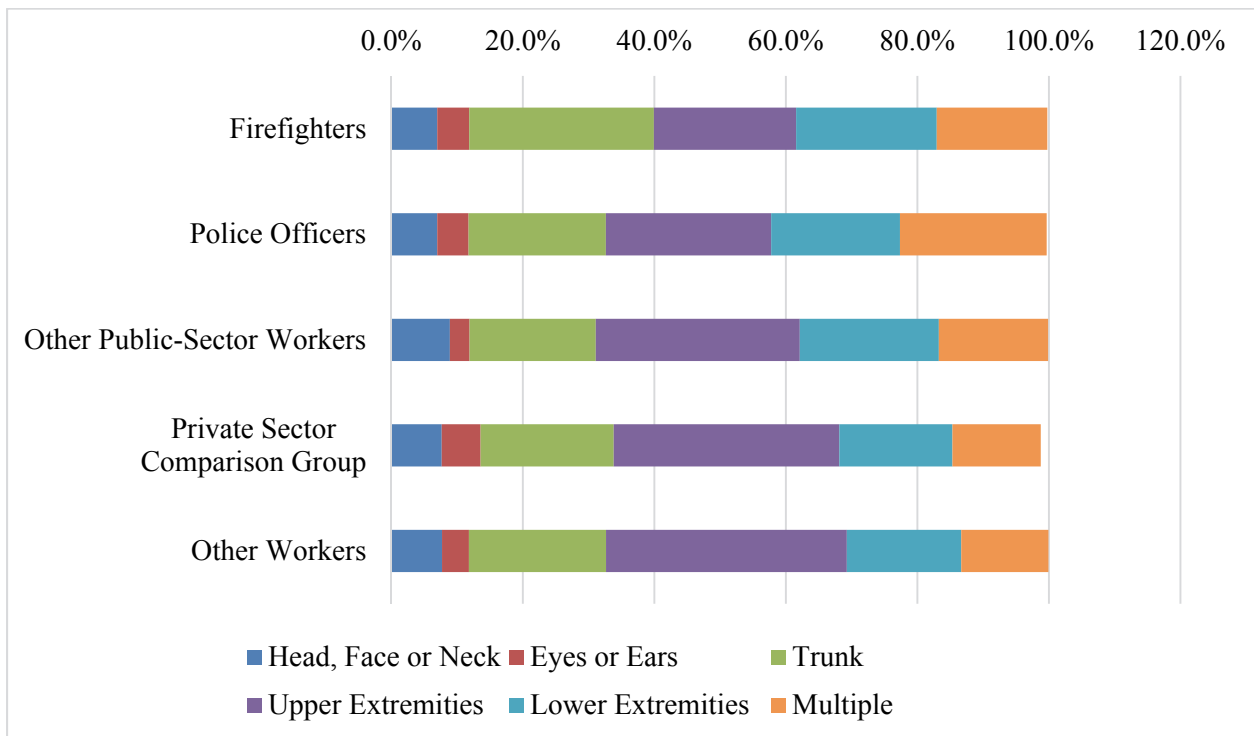
Figure 3.2. Share of Injuries that are MSDs by Occupation and Age (%)



Notes: Authors' calculations from the Workers' Compensation Information System (WCIS). Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS.. Each bar reports the percent of WCIS injuries that are musculoskeletal disorders (MSDs) for a given age category, with the definition of MSD provided in the text and age defined as age at the date of injury.

To provide more information on injury differences by occupation, we also computed the share of all injuries by part of body. These are reported in Figure 3.3, which displays the percent of all injury claims in the WCIS by occupation that involve injuries to the head, face or neck, injuries to the eyes or ears (including blindness or deafness), injuries to the trunk, upper extremity injuries, lower extremity injuries or injuries that occur to multiple body parts.

Figure 3.3: Injuries by Occupation and Body Part



Notes: Authors' calculations from the Workers' Compensation Information System. Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS..

For most workers, upper extremity injuries are most common (about 37% for the other workers category), followed by injuries to the trunk (21%) and lower extremities (17%). The injury distribution for workers in the private sector comparison group is similar. For police officers, injuries involving multiple body parts represent the second most common type of injury (22%), the highest share of any occupation. By comparison, firefighters have the highest share of injuries to the trunk (28%) and the highest share of injuries to the lower extremities (21%), and the lowest share of injuries to the upper extremities (22%).

If we restrict the analysis to just MSDs, the differences across occupations are similar. About 22% of firefighter MSDs involve the upper extremities, compared to 28% for police officers, 35% for other public sector workers, 30% for workers in the private sector comparison group and 35% for other workers. On the other hand, 35% of firefighter MSDs involve the lower extremities, compared to 35% for police officers, 30% for other public sector workers, 25% for private sector comparison workers and 22% for other workers.

Table 3.5. Cause of Injury Breakdown by Occupation and Injury Type

Cause of Injury	Firefighters	Police Officers and Sherriff's Deputies	Other Public Sector Workers	Private Sector Comparison Workers	Other Workers
<u>All Injuries</u>					
<i>Burn/Scald</i>	6.4%	3.7%	2.7%	3.8%	2.8%
<i>Caught</i>	1.2%	1.1%	2.2%	3.3%	3.1%
<i>Crash</i>	1.1%	5.0%	1.9%	3.0%	2.3%
<i>Cut</i>	3.5%	2.5%	5.0%	10.9%	10.0%
<i>Fall</i>	7.0%	6.9%	17.0%	13.1%	13.8%
<i>Rubbed By</i>	0.7%	1.3%	0.5%	0.6%	0.5%
<i>Strain</i>	31.8%	20.0%	26.6%	28.7%	34.0%
<i>Striking</i>	2.6%	2.6%	3.2%	3.9%	4.3%
<i>Struck By</i>	7.0%	14.9%	15.8%	12.4%	12.7%
<i>Miscellaneous</i>	37.0%	39.8%	23.1%	17.9%	15.3%
<u>Musculoskeletal Disorders Only</u>					
<i>Burn/Scald</i>	0.6%	0.6%	0.3%	0.8%	0.3%
<i>Caught</i>	0.5%	0.5%	0.7%	0.9%	0.8%
<i>Crash</i>	1.2%	4.7%	2.1%	3.5%	2.1%
<i>Cut</i>	1.0%	0.3%	0.6%	0.6%	0.7%
<i>Fall</i>	9.1%	8.0%	16.5%	14.8%	13.9%
<i>Rubbed By</i>	0.6%	1.6%	0.7%	0.5%	0.6%
<i>Strain</i>	57.5%	39.6%	50.9%	61.2%	64.8%
<i>Striking</i>	2.1%	2.1%	1.8%	2.1%	1.9%
<i>Struck By</i>	3.0%	8.4%	8.1%	4.7%	4.8%
<i>Miscellaneous</i>	22.9%	31.8%	16.4%	9.7%	8.8%

Notes: Notes: Authors' calculations from the Workers' Compensation Information System (WCIS). Estimates use sampling weights to produce estimates representative for the full population of workers' compensation claims reported to WCIS. Columns do not necessarily add to 100% because of missing data on injury cause.

The WCIS also includes some information on the cause of injury, which we compare for MSDs versus other injuries across occupations in Table 3.6. Specifically, we report the share of all injuries reported to the WCIS that fall into the following categories: Burn/Scald, Caught, Crash, Cut, Fall, Rubbed By, Strain, Striking, Struck By or a general catch-all category of Miscellaneous. As we would expect, firefighter injuries are much more likely to involve burns,

though burns still represent a small share of injuries overall (6%). Strains are more common among firefighters than other public sector workers, but not than among the other private sector workers in the WCIS. This is true both overall and for MSDs, for which strains represent more than 50% of injuries in all occupations except police officers.

Table 3.6: Proportion of MSD Injuries Classified as Cumulative Trauma, by Occupation

	Active Firefighters	Active Police	Rest of Public Sector	Rest of Private Sector	All Other Injured Workers
Cumulative Trauma	5.6%	7.0%	10.7%	7.0%	7.7%

Finally, in Table 3.6, we examine nature of injury codes to identify MSDs reported as cumulative trauma in order to compare the incidence of cumulative trauma injuries between firefighters and other occupations. Firefighters are less likely to have their injuries classified as cumulative trauma on the first report of injury.

Discussion

From this analysis, there are several general lessons about firefighter injury risk that stand out. First, as has been shown in past work including the prior RAND study, firefighting is an extremely dangerous occupation that exposes workers to injury risk at higher rates than other occupations. Also, MSDs are much more prevalent among firefighters than among workers in other public and private occupations. Finally, the nature and causes of injury differ, with injuries to the trunk and lower extremities represent a disproportionately high share of injuries compared to workers in all other occupations.

It is noteworthy that the injury distribution is so different for firefighters than for workers in the private sector comparison group or for police officers, even though the private sector comparison workers were specifically selected because the job demands are similar to those of firefighters. Also, as Table 3.2 shows, the demands for police officers and firefighters are similar. Thus, the differences in types of injury do not appear to be explained entirely by differences in job demands or physical factors.

It is possible that job characteristics differ among firefighters and these other occupations in ways that influence injury risk and are not captured by O*Net. However, it is also possible that the nature of firefighting influences injury claiming behavior in ways that change the injury mix. We are not specifically referring to job security or injury compensation, as we expect that job security and injury compensation are similar between firefighters, police officers and other public employees. While definitively studying the factors that drive injury composition is ultimately beyond the scope of this report, further work that studies the underlying claiming behavior of firefighters compared to other workers, perhaps with a review of accident narratives, is warranted.

4. Economic Consequences of Musculoskeletal Injury for Firefighters and Other Workers

We evaluate the earnings loss and relative employment of firefighters compared to other occupations. This includes comparisons of workers across occupations with MSDs and other types of injuries, overall and stratified by age. We also examine earnings losses and relative employment for workers with indemnity injuries in comparison to medical-only cases, and we examine outcomes separately for indemnity injuries with and without paid permanent disability benefits. Finally, we will also examine how outcomes evolved over time to examine how labor market conditions affected the earnings losses for firefighters with MSDs compared to other employees.

Methods

Our analysis of earnings losses uses methods from previous and ongoing RAND studies to estimate earnings losses. The discussion presented below draws heavily on Chapter 2 of Dworsky, Rennane, and Broten (2018), as the data used here were originally extracted for that study; readers interested in a more complete introduction to our methods should reference that study.

Uninjured Control Workers

We define earnings loss due to a workplace injury as the difference between what a worker earns following an injury and what he would have earned had he or she not been injured. We refer to the counterfactual amount that a worker would have earned absent the injury as potential earnings. A control group is necessary for estimating the impact of injury on earnings and employment because it is impossible to observe what an injured worker's labor market outcomes would have been if he or she had not been injured. To illustrate this problem, imagine that we had data only on an injured worker's earnings before and after an injury. For instance, we might see that a worker earned \$40,000 in the year before the injury, but only \$35,000 in the year after the injury. It might be tempting to say that the earnings loss caused by the injury was \$5,000. In the absence of a control group, however, we cannot draw this conclusion without making a very specific assumption that the worker's earnings would have remained constant over time.

While the assumption of constant earnings over time has the virtue of simplicity, it is clearly unrealistic. On the one hand, workers who remain steadily employed can generally anticipate some degree of wage growth as they gain experience or find better jobs, in which case earnings losses would be greater than the observed drop in earnings from before an injury to after an injury. On the other hand, non-injured workers might experience declines in earnings over time for a wide range of reasons, including both involuntary changes (reductions in hours, layoff, firing) and voluntary changes (e.g., quitting, retirement, school attendance). The fundamental challenge of estimating earnings loss without a control group is that there is little theoretical basis to guide the choice between alternative assumptions. In fact, there is little reason to believe that any one set of assumptions about the evolution of future earnings is broadly applicable to the

diverse population of injured workers, or even to observably similar workers facing different economic conditions.

Instead of extrapolating from an injured workers' pre-injury earnings to his potential earnings after the accident, we followed previous RAND studies in constructing a control group consisting of similar workers who did not file a workers' compensation claim during the period under study. The addition of the matched control workers to the analysis makes it possible to rely on much weaker assumptions than would be necessary if we had data only on injured workers' earnings. In this case, our key assumption is that, in the absence of the injury, the earnings of injured workers would have continued to resemble the earnings of control workers who had the same employer, same job tenure, and very similar trends in prior earnings. In effect, this method uses data to tell us how each injured worker's earnings would have evolved over time. A major advantage of our method is that the data on the matched controls can capture subtle differences between workers in the dynamics of potential earnings, including differences that might reflect the compensation policies or turnover rates of specific employers, the risk of layoffs, or fluctuations in economic conditions. Other studies have taken alternative approaches to estimating the extent of earnings loss; see Dworsky, Rennane, and Broten (2018) for a comprehensive discussion of these studies.

One might reasonably ask why control workers who have lost their jobs or stopped working for other reasons should be used to calculate the benchmark level of earnings against which earnings losses are measured. In particular, an alternative benchmark consisting only of workers who remained continuously employed might seem more appropriate since a portion of an injured worker's losses derives from the loss of the possibility of wage growth while staying on the job. Under the assumption that workers would remain continuously employed into the indefinite future in the absence of an injury, a measure based on continuously employed workers could be justified. In some industries or work settings with extremely high job security, such as state and local government or unionized manufacturing, such an assumption could well be a reasonable approximation in the absence of better data.

However, this is not a justifiable assumption for the typical worker. The American labor market is characterized by high rates of job turnover and, for many workers, periodic episodes of job loss or unemployment. Data on employment transitions from the U.S. Census Bureau indicate that, between 2000 and 2017, over 10 percent of workers at any given point in time will separate from their job within the next three months. Around half of these separations reflect job-to-job mobility, which may be associated with either increases or decreases in earnings. The rest represent transitions to non-employment, which generally represent sharp decreases in earnings.

In light of the high levels of dynamism that characterize the American labor market, using continuously employed workers as the control group for estimating earnings losses would lead to biased estimates of earnings losses by, in effect, cherry-picking the workers who have been lucky enough not to experience a job separation or an earnings decline for reasons unrelated to workplace injury. This might seem reasonable in some employment settings with high job security, but we can easily think of cases (such as temporary agency workers at the end of a short-term job placement, seasonal farm workers after harvest, ski instructors in April) where workers are extremely likely to transition to non-employment with or without a workplace injury. The assumption of continued employment in the absence of an injury is less tenable in these cases. Even for firefighters and other public-sector workers who have exceptionally high job security compared to the typical American worker, some amount of turnover and transition to

non-employment should be expected due to retirement or other voluntary job separations. When data on employment dynamics due to factors other than injury are available, those data should be used to define the counterfactual to which injured workers' outcomes will be compared.

In order to produce scientifically valid earnings loss estimates that are credible to all sides of the workers' compensation policy debate, it is critically important to select a control group only on the basis of information available before an injury takes place. By using a control group of workers who match the injured worker's work history leading up to the injury, we are able to substitute data for assumptions, effectively letting the data tell us what level of earnings growth or employment risk should be expected given the experience of other workers at the same employer. A valid control group such as the one used in this study allows us to isolate the incremental reduction in earnings attributable to the workplace injury.

Medical-Only Control Group

A key departure from previous RAND research on earnings losses is the use of medical-only injuries as an alternative control group. A limitation of our typical methodology is that the individual characteristics available for uninjured control workers are limited to variables included in the EDD Base Wage File, which does not contain demographic information on workers. This limitation was a concern for three specific worker characteristics: occupation, gender, and, above all, age at injury. Earnings dynamics in the absence of injury are systematically related to age, most notably at retirement age (typically 50 or above for firefighters), and so it is important to estimate earnings losses relative to a control group with the same age composition when making comparisons across age groups.¹⁶ Because data on injured workers in our previous study on firefighter musculoskeletal disorders was limited to cases that received disability ratings, we were not able to access data on a group of workers who could be used to control for labor market dynamics related to age.

The availability of the WCIS in the present study enables us to overcome this limitation by using medical-only injuries as an alternative control group. We classify injured workers who have no paid or settled indemnity benefits as medical-only claims. Because we observe worker demographics (including age) on the FROI for each of these workers in addition to earnings data, the medical-only sample enables us to compare earnings after indemnity injuries to earnings for workers with the same age at injury. We use differences-in-differences regression models (described in Appendix A) to estimate the earnings losses associated with indemnity claims relative to medical-only controls. In general, however, regression-adjustment has little impact on cross-industry differences, and we obtain similar wage loss estimates whether we use medical-only injuries or uninjured co-workers as the control group.

In principle, the underreporting of SROI in the WCIS could lead us to mistakenly classify indemnity claims as medical-only. However, our WCIS analysis sample was limited to claims administrators who appear to be reliable SROI reporters (as noted in Chapter 3) and so it is

¹⁶ Previous RAND studies that have adjusted earnings losses for age have acknowledged this limitation. It is possible to include age as a control variable when other variables are of primary interest, but the bar is considerably higher when we wish to interpret age-specific estimates as capturing the effect of age on injury.

reasonable to assume that cases with no paid indemnity benefits are medical-only within the set of claims in our analytic sample.¹⁷

Data

The analysis reported in this chapter combines data from workers' compensation claims for injuries in 2005-2015 with data on earnings and employment through 2017, providing us with at least two years of post-injury follow-up for all injury years. Our data source for measuring the impact of injuries on earnings and employment is the Base Wage File, a database of quarterly earnings records maintained by the state Employment Development Department (EDD). Among other functions, EDD administers California's Unemployment Insurance (UI) program. Employers covered by the UI program must report the wage and salary earnings of every employee to EDD on a quarterly basis. EDD stores these data in the Base Wage File. Both workers' compensation and UI are nearly universal in California, and so the wage and salary earnings of nearly all workers filing workers' compensation claims should be captured in the Base Wage File. The Base Wage File represents the most accurate and comprehensive source of data on quarterly wage and salary earnings in California.

Under an interagency agreement between DIR and EDD, we were able to link injured workers appearing in the WCIS to earnings data using the claimant's Social Security Number (SSN). We also used the earnings data to construct an uninjured control group for each injured worker by identifying workers at the same firm with a similar earnings history who did not have a workers' compensation claim. Additional details on the linkage process and control group selection are available in Dworsky et al. (2018).

We use the occupation definitions introduced in Chapter 3 to define samples of firefighters and other comparison groups in the linked WCIS-EDD data. Because not all WCIS cases were successfully linked to wage data or matched control workers, we constructed an additional set of sampling weights so that estimates from the sample with complete earnings data would match the average characteristics of the full sample of claims (FROI) reported to the WCIS.¹⁸

Results

Table 4.1 reports the sample size of injured workers with indemnity benefits available for wage loss estimation. We are able to examine approximately 8,000 injured firefighters with indemnity musculoskeletal injuries, including about 2,400 injured in 2013-2015.¹⁹ In comparison

¹⁷ To examine sensitivity to this assumption, we conducted a sensitivity analysis in which we excluded medical-only claims with a reported disability start date on the FROI. The excluded claims likely represent workers who had a work absence of less than California's three-day waiting period. As we discuss below, this exclusion had no meaningful impact on our estimates.

¹⁸ Match rates were very similar across occupational categories: summing across all injuries and injury years available, between 57.5 and 61.5 percent of the sample used in Chapter 3 was successfully matched to EDD wage data with matched controls.

¹⁹ This sample of firefighters with indemnity MSD claims is substantially smaller than the sample used in Chapter 3 for several reasons. Besides restricting to MSD claims (under half of firefighter injuries), the range of injury years considered is two years shorter (2005-2015 vs. 2005-2017), the sample is limited to indemnity injuries

to other occupations, firefighters with indemnity injuries have dramatically higher annual earnings in the year leading up to injury, with *average* annual earnings of nearly \$119,000. This indicates that firefighters with indemnity injuries had annual earnings roughly twice as high as observed among the other occupations in this study.

Table 4.1: Sample Size for Earnings Loss Analysis, by Occupation and Injury Year

	Active Firefighters	Active Police	Other Public-Sector	Private- Sector Comparison
Pre-Injury Earnings	7 \$118,92	\$60,655	\$56,861	\$64,429
% with Paid or Settled Permanent Disability Benefits	51.9%	53.3%	53.6%	54.0%
Number of Observations (Unweighted)				
2005-2007	2467	5904	18672	1691
2008-2009	1221	3668	14003	924
2010-2012	1946	6117	26277	1330
2013-2015	2391	6379	27936	1382
All Years	8025	22068	86888	5327

Source: Authors' calculations, 2005-2015 WCIS-EDD. Sample limited to indemnity musculoskeletal disorder claims with 2005-2015 injury dates.

The high earnings for firefighters in comparison to other public-sector and private-sector workers are not surprising, but the difference from police earnings are somewhat surprising since data from the BLS OES program indicate that statewide police officer wages are, on average, higher than firefighter wages.²⁰ However, we also note that the BLS OES wage data specifically exclude overtime, which may account for a large proportion of firefighters' annual earnings in comparison to the other occupations studied here.²¹ Another possible explanation is that higher-wage firefighters, such as those with greater seniority, are more likely to experience indemnity

(typically around 30% of claims), and injured workers without a match to both their own earnings history and a valid control worker were dropped (reducing the sample size about one third further). Additional details on sample construction are presented in Appendix A.

²⁰The BLS OES program reports an average hourly wage of \$35.51 for firefighters and an annual mean wage of \$48.12 for police. See <https://www.bls.gov/oes/2017/may/oes333051.htm> for police and [https://www.bls.gov/oes/2017/may/oes332011.htm#\(2\)](https://www.bls.gov/oes/2017/may/oes332011.htm#(2)) for firefighters.

²¹A recent investigative report by the *Los Angeles Times* estimated that overtime accounted for 32 percent of total pay in the Los Angeles County Fire Department in 2017, compared with 6 percent in other county departments. Source: <https://www.latimes.com/local/lanow/la-me-ln-county-fire-overtime-20181021-story.html>. However, it is unclear whether a similarly high incidence of overtime is common in other state fire departments or in earlier years. While a statewide analysis of the relationship between work hours, earnings, and injury risk could be valuable for prevention, such an analysis would require additional data collection and is far beyond the scope of the present study.

injuries. If, as seems plausible, long shifts and major emergency response contribute to elevated MSD injury risk, then we might also expect to see higher earnings among injured firefighters relative to averages for the entire workforce.

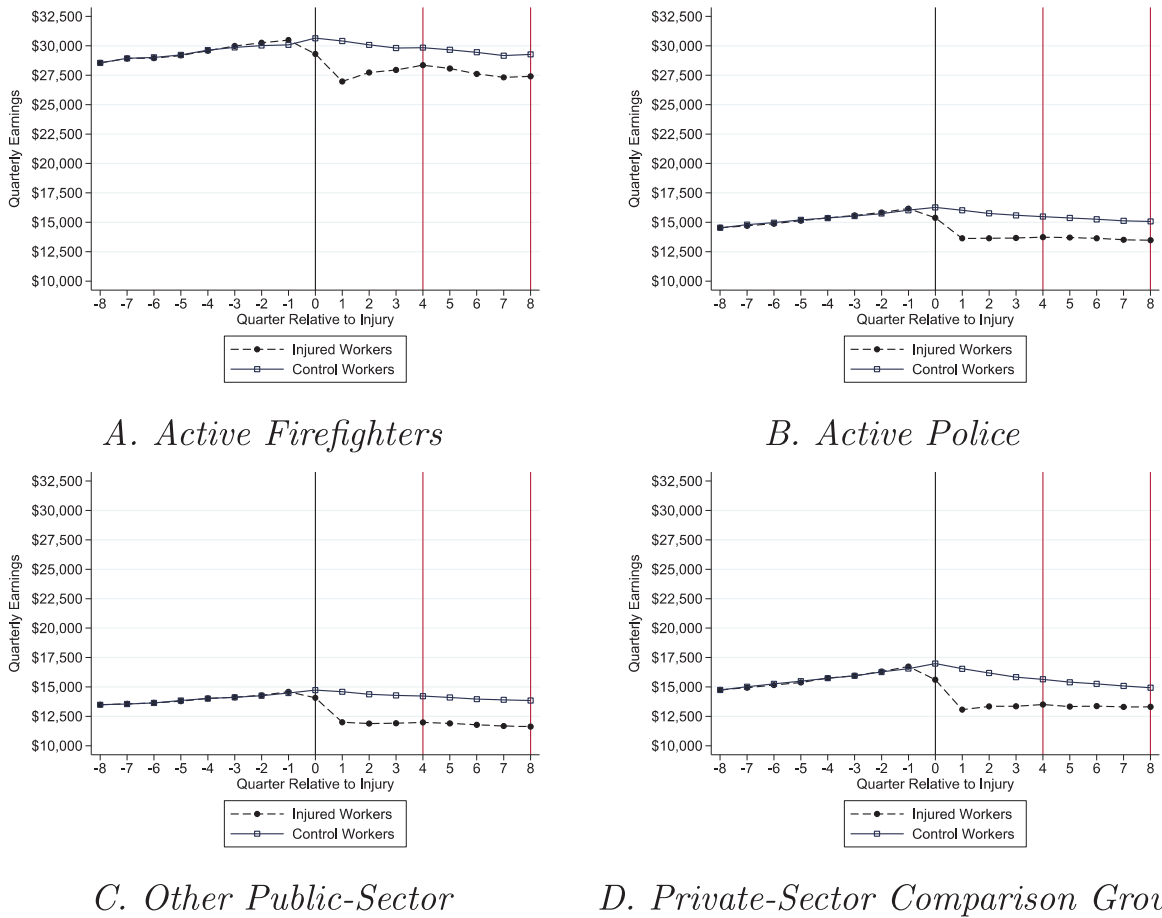
Table 4.1 also reports the proportion of workers with indemnity injuries who also received paid or settled permanent disability benefits. Across all occupations in our analysis, 51.9 to 54.0 percent of indemnity injuries resulted in permanent disability, a rate consistent with system-wide estimates and rules of thumb used by workers' compensation actuaries.²²

Our analysis accommodates the large differences in pre-injury earnings between firefighters and their comparison groups in two ways. First, as noted above, we follow previous RAND studies in reporting post-injury earnings as percentages of workers' potential earnings in order to allow comparisons of losses across different income levels. Second, we report findings on employment rates and retention or return-to-work rates (defined by employment at the at-injury employer).

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See (M. S. Dworsky et al. 2018) for further discussion.

Figure 4.1: Injured and Control Worker Earnings by Occupation, Indemnity Musculoskeletal Disorder Claims



Source: Authors' calculations, 2005-2015 WCIS-EDD

Figure 4.1 compares the trajectories of quarterly earnings for injured workers with indemnity benefits in the four occupation groups examined here and their matched controls. In all occupations, earnings for injured and control workers track closely before the quarter of injury, with slightly higher earnings for injured workers. Earnings for both injured and control workers peak in the quarter of injury. The declines before and after the date of injury are driven by the fact that we are sampling workers at a point when 100 percent of both injured and control workers are employed: the lower employment rate (and as a result, earnings) before and after the point of observation simply reflects regular churn in the labor market due to reasons unrelated to workplace injuries. However, the trajectory is interrupted in the quarter of injury for injured workers, as some injured workers begin to experience work absence and reduced earnings.

Apart from having higher pre-injury earnings, earnings trajectories for firefighters are comparable to those observed for other occupations. However, firefighters appear to have a slightly stronger recovery after the quarter immediately following injury. It is also instructive to compare control worker earnings across the four groups examined here: even in the absence of an injury, private-sector workers experience a larger drop in quarterly earnings over the two

years after injury (approximately \$2,000) than is the case for firefighters, police, or other public-sector workers. These differences in earnings track closely with differences in control worker employment rates across occupations. Two years after the injury date, the employment rate for control workers matched to firefighters with indemnity musculoskeletal disorder claims is 92 percent, as against 82 percent for police 87 percent for other public-sector workers, and 79 percent for similar private-sector workers.²³ The differences in control worker earnings dynamics illustrated by Figure 4.1 are thus in line with our expectations given the greater levels of job security associated with public-sector employment, serving to illustrate why control groups are needed to estimate the impacts of injury on labor market outcomes.

To calculate earnings losses based on the data presented in the above figures, note that the earnings loss in each quarter is the vertical distance between injured and control worker earnings. Our primary measure for earnings is relative earnings over the first two years after injury, which corresponds to the area between the injured and control workers' earnings trajectories from 1 to 8 quarters post-injury. When examining employment, we focus on relative employment, defined as the employment rate for injured workers divided by the employment rate for control workers.

Table 4.2 reports post-injury earnings, relative earnings, relative employment, and relative at-injury employment by occupation, averaged over all workers injured between 2005-2015. As suggested by Figure 4.1, all occupations experience significant reductions in earnings following an injury. The dollar value of the drop in earnings is substantial for firefighters, who earn about \$8,000 less on average two years after an injury than they did in the year before the injury. Similar drops in earnings are observed among police and other public-sector workers, albeit from a baseline level of earnings roughly half that observed for firefighters. The drop in earnings for private-sector workers is considerably larger (about \$12,000), but we saw above in Figure 4.1 that some of this additional drop is due to differences in earnings dynamics between public-sector and private-sector jobs: .

Table 4.2: Earnings, Employment, and At-Injury Employment After Indemnity Musculoskeletal Disorder Claims, by Occupation

	Active Firefighters	Active Police	Other Public-Sector	Private- Sector Comparison
Earnings (\$)				
1 Year Pre-Injury	\$116,185	\$59,201	\$56,116	\$66,220
1 Year Post-Injury	\$101,409	\$47,256	\$43,230	\$51,393
2 Years Post-Injury	\$94,956	\$42,861	\$38,010	\$47,673
Relative Earnings				
1 Year Post-Injury	92%	85%	83%	81%
2 Years Post-Injury	95%	88%	85%	87%
Relative Employment				

²³ Authors' calculations, 2005-2015 WCIS-EDD.

1 Year Post-Injury	98%	89%	91%	88%
2 Years Post-Injury	96%	90%	90%	91%
Relative At-Injury Employment				
1 Year Post-Injury	97%	86%	90%	80%
2 Years Post-Injury	95%	82%	87%	75%

Source: Authors' calculations, 2005-2015 WCIS-EDD

When we calculate earnings relative to control worker outcomes, we find that firefighters' earnings relative to their control group is 92 percent in the first year after injury and 96 percent in the second year after injury, reflecting in part the recovery in earnings noted above. Similar recoveries in relative earnings are apparent for other occupations as well, but relative earnings in the second year after injury are sharply lower for all other occupations studied here: 88 percent for police, 85 percent for other public-sector workers, and 87 percent for private-sector workers. As in our 2010 study, firefighters with musculoskeletal disorders appear to have less severe economic consequences from their injuries than do workers in similar occupations.

The next set of estimates, which focus on relative employment rates at any job (relative employment) and at the employer as of the time of injury (at-injury employment), help to shed some light on possible explanations for the better outcomes observed among firefighters. Earnings losses due to disability typically reflect non-employment or labor force exit more than reduced hours or slower wage growth, and so it is not surprising to see the differences in relative earnings across occupations closely mirrored by differences in relative employment, with a gap of about 6 percentage points between firefighters and the other occupations studied here.

What is more striking is the difference in relative at-injury employment, which reflects job retention after the injury compared to what would be expected for uninjured workers. In most occupations, relative employment at the at-injury employer is well below the overall relative employment rate, indicating that injury can lead to increased job separations or career changes even for workers who remain employed. Among private-sector occupations examined here, for instance, the relative employment rate two years after injury is 91 percent while the relative at-injury employment rate is just 75 percent. At-injury employment for police and other public-sector workers is higher than in the private-sector, but still somewhat lower than the overall employment rate.

For firefighters, in contrast, at-injury employment two years after injury is 95 percent of the level that would have been expected in the absence of injury. This is a very unusual pattern of post-injury outcomes, both because at-injury employment is nearly as high as overall employment and because it is much higher than observed in comparison occupations. These results indicate that fire departments are much better even than other public-sector employers at retaining injured workers, a pattern that seems likely to explain the much more modest earnings losses experienced by firefighters.

Although musculoskeletal disorders are the focus of the present study, we calculated similar measures for the remainder of workers' compensation claims that were unrelated to musculoskeletal disorders; a table reporting these estimates is in the Appendix. We find very similar patterns of relative earnings across occupations, although the gaps in earnings and relative employment between firefighters and other occupations are far less pronounced in non-musculoskeletal cases. However, relative at-injury employment remains sharply higher for

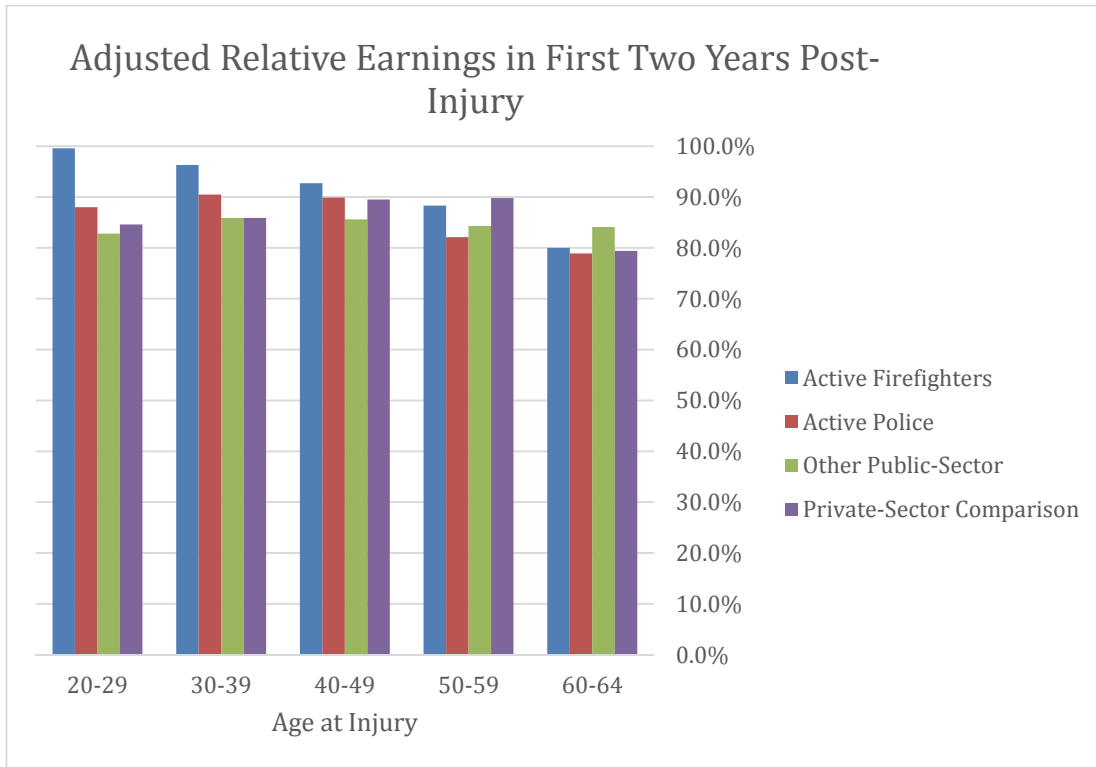
firefighters (90 percent) than for other comparable occupations (83 percent for police, 85 percent for other public-sector workers, and 76 percent for private-sector workers). We interpret the similarity of outcomes between musculoskeletal and non-musculoskeletal injuries as suggestive evidence that fire departments are more successful even than other public-sector employers at supporting successful return to work after injury.

Losses by age

RAND's 2010 study found that post-injury earnings for firefighters increased sharply with age. While it is not unusual for earnings losses to increase with age at injury, the worsening of post-injury labor market outcomes with age was more pronounced for firefighters than for other occupations. The data sources available in this study allow us to revisit this question with a more rigorous methodology that uses a control group of workers the same age. The only injured workers with earnings data available for the 2010 study were permanently disabled workers rated at the DEU, making it impossible to define a control group of workers who matched the age of the injured workers. Using a medical-only control group might be important since retirement behavior and other job separations or labor force exits unrelated to injury vary over the life cycle.

Table 4.3 presents earnings loss estimates over the first two years after injury adjusted for age at injury and occupation. The levels of relative earnings implied by these estimates are plotted in Figure 4.2. As in the previous RAND study, we find that post-injury earnings decline sharply for firefighters with age at injury. While firefighters with musculoskeletal disorder claims at age 20-29 have no statistically significant earnings losses over the two years after injury, losses increase by about 3.5 percent with each decade of age at injury and jump to 20 percent for workers injured at ages 60-64. The relationship between age at injury and earnings loss is much steeper for firefighters than for other occupations, but this appears to reflect worse outcomes for younger workers in the comparison occupations.

Figure 4.2: Relative Earnings by Age at Injury and Occupation, 2005-2015 Musculoskeletal Indemnity Injuries



Note: Authors' calculations, 2005-2015 WCIS-EDD

As noted in Chapter 3, injured firefighters are overwhelmingly male and several years older at injury than the other occupations examined here. The estimates presented in Figure 4.2 clearly show that earnings losses vary with age at injury. We estimated a regression model to adjust our relative earnings estimates for demographic differences across occupations. We focus on relative earnings over the first two post-injury years as our outcome measure. Estimates of relative earnings adjusted for age and gender are presented in Table 4.3. To assess the impact of adjusting for these demographics, and to provide a comparison to results obtained using uninjured control workers, we also present unadjusted relative earnings based on medical-only controls as well as estimates based on uninjured control workers. Table 4.3 focuses on earnings over the full two-year period following injury, and so the estimates using uninjured control workers should be thought of as averaging together the relative earnings in Year 1 and Year 2 post-injury reported in Table 4.2 above.

The first row of Table 4.2 reports relative earnings by occupation over the first two post-injury years. We first compare our relative earnings estimates using uninjured controls to estimates using medical-only controls. The unadjusted earnings losses estimated for firefighters and other public-sector workers are nearly identical to estimates based on uninjured controls. Earnings losses for police and private-sector comparison groups are somewhat higher when medical-only controls are used, but comparisons with firefighters are qualitatively very similar. Adjusting for age and gender has little impact on the relative earnings across occupations.

Table 4.3: Relative Earnings Adjusted for Age and Gender, by Occupation

	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison Group
Uninjured Controls, Unadjusted	93.3%	88.6%	83.5%	87.1%
Medical-Only Controls, Unadjusted	92.8%	83.8%	83.4%	81.9%
Medical-Only Controls, Adjusted for Age and Gender	93.3%	85.0%	84.0%	82.8%

Trends

A central question of this study is how firefighters and other workers with musculoskeletal disorders have fared since implementation of SB 863 began in 2013. Table 4.4 reports relative earnings for workers with indemnity musculoskeletal disorders by injury date. Comparing the full 2005-2012 period to 2013-2015 injuries, we can see a striking drop in relative earnings for firefighters, from 95.5 percent to 92.2 percent. While both of these figures indicate much better labor market outcomes than those experienced by workers in similar occupations, the decline is troubling.

Table 4.4: Relative Earnings by Injury Year and Occupation, Indemnity Musculoskeletal Injuries

Injury Year	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
2005-2007	98.4%	89.6%	86.4%	89.9%
2008-2009	94.1%	86.6%	83.8%	84.5%
2010-2012	91.9%	86.8%	81.6%	83.6%
2013-2015	92.2%	87.4%	84.6%	83.9%
Pre-SB863 (2005-2012)	95.5%	87.9%	83.8%	86.6%
Post-SB863 (2013-2015)	92.2%	87.4%	84.6%	83.9%
All Years (2005-2015)	94.7%	88%	84%	86%
N (unweighted)	8,025	22,131	86,714	5,316

However, when we separate pre-SB 863 injuries into distinct time periods reflecting the business cycle, we find that most of this decline occurred between 2005-2007 and 2010-2012, and that a similar deterioration in outcomes was evident in the other occupations as well. Comparing workers injured just before SB 863 took effect (2010-2012 injury years) to those injured just after SB 863 took effect (2013-2015 injury years), we find that labor market

outcomes were stable for firefighters and other occupations, with the exception of an uptick in post-injury earnings for other public-sector occupations.

Losses for Workers with Permanent Disability

The estimates reported above are averages for all workers who received paid indemnity benefits, including many workers who might have had relatively short spells of temporary disability. Workers with permanent impairment account for the most severe earnings losses, and so it is also valuable to look more closely at workers who received permanent disability benefits.

We selected workers in the WCIS with paid or settled benefits for Permanent Partial or Permanent Total Disability. Table 4.5 presents average post-injury earnings by injury date and occupation for these workers.²⁴

As with overall post-injury earnings, firefighters with permanent disability have smaller losses as of the second post-injury year than other occupations. However, the decline in labor market outcomes observed over time for all injured workers is reflected in the estimates for workers with permanent disability. While the drop from pre- to post-SB 863 injuries is quite dramatic, earnings for permanently disabled firefighters trended downward over the eight years preceding SB 863, falling 11.6 percentage points between 2005-2007 injuries and 2010-2012 injuries. More muted downward trends are apparent for police (4.2 percentage point decline) and other public-sector workers (5.1 percentage point decline), but earnings for similar private-sector occupations fell by even more (12.7 percentage point decline).

Table 4.5: Relative Earnings by Injury Year and Occupation, Musculoskeletal Injuries with Permanent Disability

Injury Year	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
2005-2007	95.7%	82.5%	78.6%	84.2%
2008-2009	89.4%	77.2%	75.9%	76.1%
2010-2012	84.1%	78.3%	73.5%	71.5%
2013-2015	77.2%	72.7%	69.7%	66.6%
Pre-SB863 (2005-2012)	91.8%	79.7%	75.9%	78.5%

²⁴ We note that, because permanent disability may take some time to emerge after injury, estimates from earlier years may not be directly comparable to estimates from more recent years.

Post-SB863 (2013-2015)	77.2%	72.7%	69.7%	66.6%
All Years (2005-2015)	90.1%	78.2%	74.6%	76.3%
N (unweighted)	3,822	10,353	40,204	2,497

One concern that was raised by a member of CHSWC was that longer-term outcomes for firefighters with permanent disability might decline sharply after the second post-injury year. We examined this possibility by estimating earnings trajectories up to three years post-injury for injured and control workers in each occupation; figures plotting these trajectories are shown in the appendix. We do not find evidence of a sharp decline in the third post-injury year for firefighters when compared to outcomes for other permanently disabled workers.

Sensitivity Analyses

We were concerned that reporting of 4850 benefits might not be uniform across jurisdictions. Two forms of measurement error were identified as potential concerns: underreporting of 4850 benefits to the WCIS would lead us to underestimate benefit payments to firefighters, while reporting of 4850 benefits as wage and salary income might lead us to underestimate earnings losses. To evaluate the robustness of our analysis to this form of misreporting, we produced earnings loss estimates focusing solely on the second year after injury, after the expiration of 4850 time. Additional details, figures and estimates are presented in Appendix B.

We find that earnings loss estimates focusing on the second year after injury are very similar to those focusing on the first two years after injury: proportional earnings losses for firefighters with indemnity benefits (6.08 percent reduction in earnings) are about 7 percentage points less than losses for police (13.7 percent reduction in earnings) , while losses for other public-sector workers and private-sector workers are larger still (14.5 and 14.9 percent reduction in earnings, respectively).

During a briefing of preliminary findings to the Commission on Health and Safety and Workers' Compensation, stakeholder concerns were also voiced that earnings losses might not materialize in the first two years after injury. The specific concern was that firefighters might be retained up to the time limit for temporary disability benefits (two years of benefits) and then let go in year three. We accordingly examined earnings trajectories for injured and control workers up to three years post-injury to see whether there was a differential drop in earnings for firefighters after the second post-injury year. We found no evidence of such a pattern, suggesting that earnings loss patterns over the first two post-injury years are indicative of outcomes through the end of the third post-injury year.

Discussion

Labor market outcomes for firefighters declined following the Great Recession of 2008-2009. In some ways, it is surprising to see this decline in outcomes among firefighters because the high post-injury job retention among firefighters and their status as critical public safety personnel should have protected firefighters from some of the slack labor market conditions facing private-sector workers. One possible explanation, which we examine in Chapter 6 below, is that average injury severity rose during the Great Recession because workers with less severe injuries were reluctant to file claims, as suggested by Boone et al. (2010). We would expect this mechanism to be less relevant for firefighters given the high levels of job security (including high post-injury job retention); we cannot rule out that the severe pressure and sharp cuts in state and local government spending triggered by the Great Recession may deterred claim-filing for minor injuries even among public safety workers. However, earnings losses for injured workers remained lower than they were before the Great Recession for all occupation groups examined here, suggesting that temporary shifts in claiming behavior are not the only factor driving trends in labor market outcomes.

5. Incidence of PTSD and Other Psychiatric Co-Morbidities for Firefighters with Musculoskeletal Disorders

In this chapter, we turn to the incidence of post-traumatic stress disorder (PTSD) and other psychiatric conditions that might accompany musculoskeletal disorders in firefighters. After discussing prior evidence on psychiatric comorbidities, we present incidence estimates for California firefighters and their comparison groups.

Background

There has been a growing awareness in the US about the importance of mental health and the adverse consequences of mental and behavioral health disorders. Part of this is due to an increasing prevalence of depression and psychiatric conditions, particularly among youths. Meanwhile, a dramatic rise in morbidity and mortality in midlife among white non-Hispanics has also drawn greater awareness to mental health concerns, particularly among older blue-collar workers (Case and Deaton, 2015). The consequences have been dramatic, with the increasing prevalence of mental health disorders coinciding with an increase in suicide rates of 24% from 1999-2014, according to data from the Centers for Disease Control and Prevention (CDC) (Curtin, et al. 2016).

Mental health disorders have always been challenging from the standpoint of workers' compensation systems. There has long been a suspected relationship between workplace factors, in particular work-related stress, and common psychological conditions such as depression, anxiety or substance abuse (Karasek 1979). However, establishing a causal relationship between work conditions and mental health outcomes has been difficult due to a lack of data and difficulty with study design.²⁵ This lack of an evidence base makes it difficult for workers to objectively establish whether their mental health conditions are work-related or not, which can make it difficult to obtain workers' compensation benefits even if these conditions are covered by their states.

Post-traumatic stress disorder (PTSD) is somewhat different in that it is caused by exposure to traumatic "stressor" event, including "death, threatened death, actual or threatened serious injury, or actual or threatened sexual violence."²⁶ Past work has shown a high incidence of PTSD among the victims of occupational injury (c.f.,(Asmundson et al. 1998)). It is not necessary to suffer a violent injury in order to experience PTSD. However, because of the difficulty in establishing objective diagnostic criteria to establish the existence of a mental health

²⁵ For a recent meta-analysis that discusses this literature, see(Harvey et al. 2017). They reviewed 37 studies and found that there were associations between work factors and common mental health conditions, but concluded "...methodological limitations continue to preclude more definitive statements on causation between work and mental disorders."

²⁶ See the American Psychiatric Association's *Diagnostic and statistical manual of mental disorders (5th ed.)* for more details (APA, 2013).

disorder, obtaining benefits for PTSD in a workers' compensation claim can be as difficult as with any other psychiatric condition.

Because of the intense nature of the work and the frequent exposure to risk and traumatic events, it is reasonable to suppose that firefighters face a high risk of PTSD. (Skogstad et al. 2013) evaluated different occupations for the risk of PTSD, and found that, along with police officers, firefighters and ambulance personnel were among the workers most likely to be exposed to the kinds of traumatic events that lead to PTSD. One German study found a prevalence rate of about 18% among firefighters (Wagner et al., 1998). Other studies have documented comparable rates of PTSD among firefighters after extreme disasters. (Berninger, Webber, Niles, et al. 2010; Berninger, Webber, Cohen, et al. 2010) report an elevated prevalence of PTSD among firefighters in New York exposed to the World Trade Center disaster even several years after the event. (North et al. 2002) found that about 13% of firefighters who responded to the Oklahoma City bombing experienced PTSD, though they noted that this was less than the prevalence among surviving victims of the attack (23%).

In this Chapter, we explore the rates at which firefighters claim PTSD or other psychiatric impairments in the California workers' compensation system. We focus on those with musculoskeletal disorders, but we also examine psychiatric condition incidence rates among firefighters with non-MSD injuries. Based on the above discussion, we would expect the PTSD rates to be higher among this population than among workers in the private sector (though not necessarily higher than police officers). However, this assumes that workers actually file a claim when they experience PTSD. There is concern that stigma could deter workers from seeking help, as has been shown to be a problem among military veterans.²⁷ While we lack the ability to study stigma with data based solely on claims, it is an important consideration when interpreting our findings.

Data and Methods

PTSD and other forms of psychiatric distress following a musculoskeletal disorder claim are unlikely to be captured in the First Report of Injury (FROI), which is the component of the WCIS that we have used to ascertain MSD injuries. In order to identify injured workers experiencing psychiatric comorbidities alongside their injuries, we examined medical claims billed to workers' compensation up to two years after the earliest date of service observed for each injured worker. Medical claims data were available for this study on service dates between 2007 and 2016, when the format of WCIS medical claims data was updated.

We linked medical claims to FROI and SROI records using the JCN. Medical claims submitted to the WCIS often lacked a JCN in earlier years, making it impossible to include these claims in our analysis. Slightly under half (47 percent) of the complete-records FROI cases for injury dates between 2007-2016 linked to one or more medical claims. As in Chapters 3 and 4,

²⁷ (Hoge et al. 2004) survey veterans returning from Iraq and Afghanistan and found that less than half of those experiencing PTSD symptoms sought treatment, with the fear of stigma serving as a significant barrier to seeking care.

we constructed sampling weights to correct for match failure and obtain estimates that are representative for the population of all claims reported to the WCIS.²⁸

We also estimated how earnings losses due to musculoskeletal disorders differed between workers with and without comorbid psychiatric disorders. To conduct this analysis, we used a subset of workers with FROI/SROI records, medical claims, and earnings data. Weights were also constructed for this sample to produce estimates that are representative for the population of all claims reported to the WCIS.²⁹

Methods

We used two criteria to identify workers suffering from psychiatric conditions. First, we examined primary and secondary diagnosis codes on all services billed to workers' compensation.³⁰ While we initially focused on the diagnosis code for PTSD, we found this specific diagnosis code was very rarely used for workers with musculoskeletal disorders and so we broadened our criteria to include all non-psychotic mental disorders.³¹ Attempts to identify workers with diagnosis codes indicating physical signs of PTSD also failed to capture many additional cases so we did not use this approach in our analysis.³² In addition to diagnosis codes, we examined pharmacy bills and coded workers as having psychiatric disorders if they received any prescriptions for antidepressants or antipsychotics. Workers were classified as having a psychiatric disorder if they had either a mental disorder diagnosis or one or more prescriptions filled for antipsychotics or antidepressants.

We calculated the incidence rate of comorbid psychiatric disorders among workers with musculoskeletal disorder claims by occupation. Because diagnosis and treatment patterns may vary by gender, we also calculated incidence rates stratified by gender to provide a more informative comparison between the overwhelmingly male firefighter population and other occupational groups.

Finally, to estimate how earnings losses were affected by psychiatric comorbidities, we estimated regression models similar to those described in Chapter 4 that used medical-only musculoskeletal disorder claims as a control group for indemnity musculoskeletal disorder claims. We interacted the differences-in-differences variables with an indicator for the presence of comorbid psychiatric disorders. We used this model to estimate how the presence of psychiatric conditions on a medical-only musculoskeletal disorder claim affected earnings losses

²⁸ See Appendix for additional details on sample definition and weighting. The analysis sample for estimating psychiatric condition incidence is referred to as sample 3 in the Appendix.

²⁹ See Appendix for additional details on sample definition and weighting. The analysis sample for estimating the economic consequences of comorbid psychiatric conditions is referred to as sample 4 in the Appendix.

³⁰ We conducted this analysis only on claims with dates of service

³¹ The ICD-9 code for PTSD is 309.81. Our measure of psychiatric disorders includes all ICD-9 codes from 300 to 316.

³² These signs (ICD-9 codes) are: depressed mood (311.x), difficulty concentrating (799.51), fatigue (780.7), headache (339.2, 339.1, 307.81, 784.0), joint pain (307.8, 338.x), memory loss (780.93), and sleep disturbance (780.5).

and whether indemnity musculoskeletal disorder claims with a comorbid psychiatric condition experienced additional earnings losses that were greater than the sum of the separate earnings penalties associated separately with psychiatric conditions and with indemnity musculoskeletal injuries relative to medical-only musculoskeletal injuries with no comorbid psychiatric conditions.

Results

Table 5.1 reports our main results on the incidence of psychiatric conditions by occupation for musculoskeletal and non-musculoskeletal disorder claims. Across all occupations, musculoskeletal disorder claims are less likely to have psychiatric conditions diagnosed or to have antidepressants or antipsychotics prescribed than other types of injuries. Among firefighters, 3.1 percent of musculoskeletal disorder claims have evidence of psychiatric conditions treated in the workers' compensation system, versus 5.2 percent of non-musculoskeletal disorder claims. Police and public-sector workers are also more than twice as likely to have psychiatric conditions treated in workers' compensation on non-musculoskeletal claims. The gap in psychiatric condition incidence rates is smaller for private-sector workers but psychiatric conditions remain more common on non-musculoskeletal disorder claims.

Table 5.1: Proportion of Claims with Psychiatric Disorders, by Type of Injury and Occupation

	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
MSD	3.1%	2.5%	5.4%	6.4%
Non-MSD	5.2%	4.7%	11.7%	5.4%

Source: 2007-2015 WCIS-EDD

Looking across occupations, psychiatric conditions appear to be much less common among firefighters and police with musculoskeletal disorder claims in comparison to other public-sector workers and similar private-sector workers. On non-musculoskeletal disorder claims, psychiatric disorder rates for firefighters and police are closer to those observed among comparable private-sector workers, but far below the rates observed for other public-sector workers.

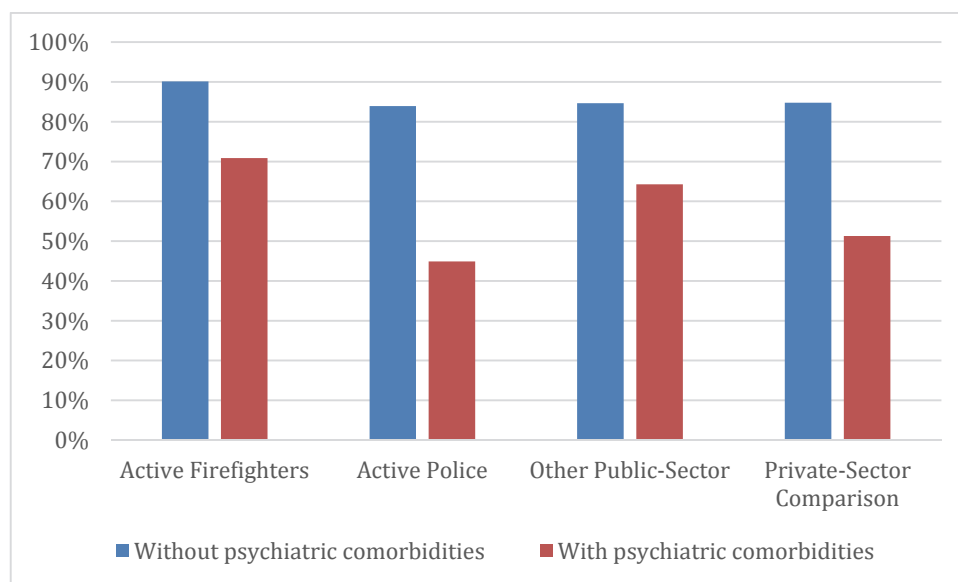
One possible explanation for these differences in incidence rates is that differences in the gender composition of different occupations may contribute to these patterns, so we calculated the incidence rates in Table 5.1 separately for male and female workers. Results are presented in Table 5.2. Table 5.2 suggests strongly that the findings in Table 5.1 are not driven by gender differences. Incidence rates of comorbid psychiatric conditions for firefighters and police with musculoskeletal disorders are lower than those observed in comparison occupations for both male and female workers. We also observe lower incidence rates on non-musculoskeletal conditions for male firefighters and police. Among female workers, comorbid psychiatric conditions are less common for public safety workers than for other public-sector workers, although we estimate that female firefighters with non-musculoskeletal disorder claims have higher rates of psychiatric disorders (10.9 percent) than do female workers in similar private-sector occupations (7.7 percent).

Table 5.2: Proportion of Claims with Psychiatric Disorders, by Type of Injury, Occupation, and Gender

Male				
	Active Firefighters	Active Police	Rest of Public Sector	Rest of Private Sector
MSD	3.1%	2.2%	4.8%	5.4%
Non-MSD	4.9%	4.3%	10.2%	6.3%
Total	4.0%	3.4%	7.6%	5.9%
Female				
	Active Firefighters	Active Police	Rest of Public Sector	Rest of Private Sector
MSD	3.1%	3.6%	5.8%	4.9%
Non-MSD	10.9%	6.0%	12.7%	7.7%
Total	6.8%	5.0%	9.5%	6.4%

While the evidence above suggests that firefighters and police are both less likely to have comorbid psychiatric conditions than other comparable workers, it is also important to understand the economic consequences of these comorbidities for injured workers. Previous wage loss estimates for permanently disabled workers have shown very severe earnings losses for workers whose highest-rated permanent impairment is a psychiatric condition (Dworsky et al., 2016). We are not aware of evidence on the impact of comorbid psychiatric conditions for workers who entered the workers' compensation system because of a musculoskeletal disorder or other physical injury, however.

Figure 5.1: Relative Earnings After Indemnity Musculoskeletal Disorder Claim, by Occupation and Presence of Comorbid Psychiatric Disorders



Note: Authors' calculations, 2007-2015 WCIS-EDD. Relative earnings without psychiatric comorbidities represent earnings over first two years post-injury for workers with indemnity musculoskeletal disorder claims and no comorbid psychiatric conditions as a proportion of earnings for medical-only musculoskeletal disorder claims with no psychiatric comorbidities. Relative earnings with psychiatric comorbidities represent the combined effect of psychiatric comorbidities for medical-only claims and the interaction effect of psychiatric comorbidities on indemnity claims.

Figure 5.1 presents our estimates of relative earnings for workers with indemnity musculoskeletal disorder claims with and without psychiatric comorbidities. Across all occupations, musculoskeletal disorders with psychiatric comorbidities are associated with sharply lower post-injury earnings compared to workers who have musculoskeletal disorders without psychiatric comorbidities. Firefighters who received indemnity benefits for musculoskeletal disorders without psychiatric comorbidities had relative earnings of 90 percent over the two years after injury, versus relative earnings of 71 percent for firefighters who also had psychiatric comorbidities. Consistent with the estimates in Chapter 4, relative earnings for workers in other occupations with indemnity musculoskeletal injuries were lower (84 to 85 percent) than observed for firefighters, while psychiatric comorbidities were associated with even larger incremental reductions in relative earnings, especially for police and other public-sector workers.

Table 5.3: Differences in Relative Post-Injury Earnings Associated with Indemnity Musculoskeletal Disorder Claims and Incremental Effects of Comorbid Psychiatric Disorders

	Active Firefighters	Active Police	Other Public-Sector	Private- Sector Comparison
Post * Indemnity	-0.099*** (0.018)	-0.161*** (0.016)	-0.154*** (0.007)	-0.152*** (0.031)
Post * Psych	-0.087 (0.100)	-0.167* (0.097)	-0.100*** (0.030)	-0.208 (0.178)
Post * Psych * Indemnity	-0.204 (0.136)	-0.383*** (0.112)	-0.258*** (0.038)	-0.279 (0.230)

Table 5.3 reports the regression coefficients underlying Figure 5.1. These estimates separate the effects shown in Figure 5.1 into additional earnings losses for medical-only cases with comorbid psychiatric disorders and assess statistical significance. While medical-only cases with psychiatric comorbidities are associated with worse outcomes in all occupation groups, these coefficients are imprecisely estimated. The incremental earnings loss associated with psychiatric comorbidities on indemnity claims is substantial, but the estimates are too imprecise to conclude that these losses are significantly different across occupations.

Discussion

We find that firefighters and police with musculoskeletal disorder claims have similar rates of comorbid psychiatric conditions, but that rates for public safety workers are substantially lower than rates observed among other public-sector workers or comparable private-sector workers.

We do find evidence that psychiatric comorbidities are associated with worse labor market outcomes compared to musculoskeletal disorders without such comorbidities. This finding was anticipated given previous evidence on earnings losses for workers with permanent disability due to psychiatric impairments. We do not, however, find strong evidence that the incremental losses associated with psychiatric comorbidities vary across occupations.

Taken together, these findings do not provide evidence that PTSD or other psychiatric comorbidities are a more serious concern for firefighters than for workers in other similar occupations. Two important limitations of this work need to be added, however.

The first limitation is that we observe only medical care provided through the workers' compensation system. Because public-sector workers are likely to have access to high-quality health insurance outside of workers' compensation, we cannot rule out the possibility that workers are seeking treatment for psychiatric conditions outside the workers' compensation system, either through group health or without any reimbursement from insurance at all. This argument would seem likely to apply to other public-sector workers, who have markedly higher rates of comorbid psychiatric conditions than do the public-sector workers. However, it might also be the case that the substantially higher pre-injury earnings observed among firefighters in our sample gives them a greater ability to seek care from providers outside workers' compensation. We unfortunately cannot test these hypotheses with the data at hand.

A second, and more troubling, caveat is that mental health stigma could also lead to the patterns observed in these data. Stigma is widely recognized as a barrier to diagnosis and treatment of PTSD and mental disorders more generally among public-safety workers. Because this study views the world through the lens of care provided through the workers' compensation system, we are not in a good position to evaluate the magnitude of stigma or to identify workers with might fail to seek and receive necessary mental health care.

6. Disability Ratings and Benefits for Firefighters with Musculoskeletal Disorders

In this chapter, we examine disability ratings and benefits for firefighters with permanent disability using administrative data on disability evaluations performed by the state Disability Evaluation Unit (DEU). We compare ratings for firefighters to those received by workers in other occupations and examine how ratings have changed since implementation of SB 863 began in 2013. We also examine which types of impairments are most frequently rated for firefighters and other workers and document how often psychiatric impairments are rated for workers whose primary impairment is a musculoskeletal disorder.

Background on the SB863 reforms to benefits and the rating system

In this section, we provide a brief overview of permanent disability benefits in California and the changes implemented under SB 863. This discussion draws heavily on Chapter 5 of Dworsky et al. (2016). Readers seeking further details may wish to consult that report.

The level of Permanent Disability (PD) benefits provided to an injured worker in California is determined by the worker's permanent disability rating. The permanent disability rating is a number between 0 percent and 100 percent that indicates the severity of permanent disability, with higher numbers indicating greater severity and leading to larger amounts of indemnity payments for permanent partial disability.

When a worker's impairment has reached maximum medical improvement, meaning that "his or her condition is well stabilized and unlikely to change substantially in the next year with or without medical treatment," a physician can evaluate the severity of the impairment and produce an impairment rating for each distinct impairment that may lead to a loss of earnings capacity lasting beyond the date of maximum medical improvement (Division of Workers' Compensation, 2005). For injuries occurring in 2005 or later years, impairment ratings are assigned using procedures specified in the *AMA Guides to the Evaluation of Permanent Impairment, 5th Edition (AMA Guides)*.

After impairment ratings have been assigned, disability ratings are calculated according to procedures outlined in the Permanent Disability Rating Schedule (PDRS) issued by DWC, which specifies rules for combining multiple impairments and calculating final ratings (which are used to determine benefits) from the standard ratings assigned to a worker's specific impairments. Each impairment evaluated by the evaluating physician is identified by an impairment number, which is listed in the PDRS and corresponds to the chapter and section in the *AMA Guides*. A rating in units of Whole Person Impairment (WPI) is assigned by the DEU rater based on the impairment number and the description supplied by the doctor.

Each impairment number has an associated Future Earnings Capacity (FEC) factor. The product of the WPI and the FEC gives the standard rating after adjustment for FEC. Under S.B. 899, the FEC ranged from 1.1 to 1.4, depending on the impairment. Under S.B. 863, the FEC takes a single value, 1.4, for all impairments. Next, the rater assigns the worker to an occupational group based on a description of the worker's primary job at injury. As an example,

an FEC-adjusted standard rating of 10 percent with a C occupational adjustment (the lowest factor) would be reduced to 7 percent while the same rating with a J adjustment (the highest factor) would be increased to 16 percent. The DEU rater then adjusts the rating for age. Ratings are reduced for workers younger than 37 and increased for workers older than 42. The younger or older the worker, the larger the magnitude of the adjustment. Again assuming a 10-percent rating after occupational adjustment, a 21-year-old worker would have the rating reduce to 8 percent and a 62-year-old worker would be increased to 13 percent. The age-adjusted rating is the final rating before apportionment, if any.³³ For the range of injury years examined in this study (2005 and later), the doctor's report is required to indicate whether any of the final disability rating should be apportioned to non-industrial cause, reducing the rating.

A single doctor's report can also be rated more than once. This occurs when one or both parties request a rating under the AMA Guides and a rating based on the case law standard established by the *Almaraz* en banc decision by the Workers' Compensation Appeals Board (WCAB). The 2009 *Almaraz* decision interpreted Labor Code Section 4660(c) as allowing physicians to use alternative rating methods based on the *AMA Guides* within certain constraints. SB 863 codified the approach allowed under *Almaraz*, affirming that such alternative ratings can be used to rebut ratings conducted by following standard *AMA Guides* procedures. When there was both an AMA Guides and Almaraz rating, we used the higher of the AMA Guides rating and the Almaraz rating. However, we conduct some analyses (such as comparison of standard ratings before and after SB 863) using only AMA Guides ratings.

A worker's final disability rating determines the level of weekly permanent disability benefits the worker is entitled to and the number of weeks for which benefits are to be paid. Both the level of payment and the number of weeks for which benefits are available increase with the final disability rating. Finally, workers with a rating of 70 or more are eligible for a small weekly life pension.

The maximum weekly PD benefit is two-thirds of wages subject to a weekly cap. In contrast to temporary disability benefits, for which the weekly benefit is calculated on a wage base that is capped at the statewide average weekly wage, the maximum wage used to calculate PD benefits is substantially lower than the average wage in California. Also in contrast to TD benefits, the maximum PD benefit is not indexed to wage inflation, but rather is fixed at a nominal level specified in the labor code.

PD Rating Changes Under SB 863 and Potential Impacts on Firefighters with Musculoskeletal Disorders

In order to address concerns about the adequacy of PD benefits, SB 863 used two policy levers to make PD benefits more generous. First, SB 863 increased the minimum and maximum limits on the amount of a worker's pre-injury earnings used to calculate permanent partial disability. Second, SB 863 made several modifications to the Permanent Disability Rating

³³ Firefighters and police officers are both in occupation group 490, which has the highest or second-highest occupational variants (I or J) for most conditions, but a neutral occupational adjustment (F) for some conditions.

Schedule. We briefly discuss these changes here, with an emphasis on the potential impacts on firefighters with musculoskeletal disorders.³⁴

One major benefit increase in SB 863 came from increasing, for the first time since 2006, the maximum weekly PD benefit payment. For workers injured between 2005 and 2012, the cap increased with the disability rating and was at levels set under Assembly Bill 749 (A.B. 749) in 2002. For example, workers injured on or after January 1, 2006, after A.B. 749 was fully implemented, would have been eligible for up to \$230 per week if their disability ratings were under 70 percent, and up to \$270 per week if their disability ratings were 70 percent to 99 percent. SB 863 increased the maximum weekly benefit for all workers to \$290, with the increases partially implemented in 2013 and fully implemented for all workers injured on January 1, 2014 or later. The minimum weekly PD benefit was also increased.

Table 6.1: Proportion of Injured Workers with Weekly Wages Above Maximum Used to Calculate Permanent Disability Benefits, by Occupation and Policy Regime

	Percentage of Workers with Weekly Wage Above Maximum Under...	
	SB 899	SB 863
Active Firefighters	86.4 %	86.13%
Active Police	86.1 %	85.78%
Other Public Sector	76.9 %	73.69%
Private-Sector Comparison Group	73.2 %	68.24%
Rest of WCIS	61.5 %	51.08%

Source: Authors' Calculations, 2005-2018 WCIS. Sample contains all injury claims.

³⁴ Another important change to compensation for workers with PD was the creation of the Return to Work Fund, which is a supplementary cash benefit to be paid to permanently disabled workers with disproportionately high earnings losses. The Return to Work Supplement, as this benefit was later named, is likely to have a limited effect on firefighters for two reasons. First, eligibility is limited to workers who fail to receive a qualifying return to work offer from their employer, and we saw in Chapter 4 that firefighters have much better job retention outcomes after injury than do comparable injured workers. Although public-safety workers were not directly examined, a recent evaluation of the Return to Work Fund found that receipt of the Supplemental Job Displacement Benefit (SJDB), which is a rough proxy for Return to Work Supplement eligibility, was lower for workers in public administration and education than for any other industries examined, consistent with higher job retention after injury in the public sector. Second, the value of the Return to Work Supplement is fixed at \$5,000 regardless of workers' wages, and so the benefit's value to relatively high-wage firefighters is likely relatively modest. While data on the Return to Work Supplement were not available for this study, it may be worthwhile to examine the role that this benefit and the Supplemental Job Displacement Benefit play for public-safety workers who are unable to return to work.

The increase in the maximum weekly PD benefit unambiguously increased benefits for the vast majority of permanently disabled workers. At any given level of disability ratings, workers with wages above the weekly maximum wage specified under SB 863--\$435 per week--gain the most from SB 863 in dollar terms (\$60), representing a 26 percent increase in the weekly payment rate. Because the maximum weekly wage used to calculate PD benefits remains far below the statewide average weekly wage, the majority of all injured workers were receiving the maximum weekly PD benefit before SB 863. The workers examined in this report--particularly firefighters and police officers--have particularly high wages in comparison to the average injured worker: Table 6.1 shows that five in six injured firefighters and police officers have weekly wages above the maximum benefit under both SB 899 and SB 863. Low-wage workers who were earning below the SB 899 maximum wage are slightly more common among the other public-sector and private-sector comparison groups, but three out of four of these workers experienced an increase in weekly benefit payments due to SB 863. In this chapter, we calculate statutory benefits for all workers under the assumption that PD benefits are paid at the maximum weekly rate--an assumption that will tend to underestimate benefit increases for firefighters and police in comparison to the other comparison groups examined here. Sensitivity analysis using the weekly wage reported in the WCIS when available does not have a noticeable impact on our findings.

In addition to raising the weekly benefit rate for most injured workers, S.B. 863 made a number of changes to the calculation of ratings. First, the legislation eliminated compensation for certain secondary impairments that were “added on” to the primary impairment. These included sleep, sexual dysfunction, and psychiatric impairments secondary to a primary condition. Sleep and sexual dysfunction had very small effects on overall average ratings, but psychiatric impairments were expected to have a more important effect. Dworsky et al. (2016), which examined patterns of ratings performed under SB 899, estimated that 2.2 percent of DEU ratings for injuries in 2005 to 2012 were rated for psychiatric add-on impairments. That study did not specifically examine psychiatric impairment ratings on cases with primary musculoskeletal disorders, nor did it examine patterns of psychiatric impairment ratings across occupations.

Second, S.B. 863 eliminated the 15-percent bump up/bump down in the weekly PPD benefit rate that depended on whether the at-injury employer could offer a worker post-injury employment with a wage near pre-injury levels. If the employer offered such work, weekly benefits were reduced by 15 percent. If no complying offer was made, benefits were increased by 15 percent. Like the add-on elimination, the bump-up/bump-down elimination was expected to have limited effect because the implementing language in S.B. 899 was interpreted by the courts to mean a substantial fraction of PPD benefits are paid out before the bump up/bump down could be applied.

Finally, and most notably, S.B. 863 raised final ratings for most injured workers by increasing all FEC adjustment factors to 1.4. Under S.B. 899, FEC factors ranged from 1.1 to 1.4 and averaged 1.22. This was expected to lead to a substantial increase in PPD indemnity, but also to vary substantially by the type of impairment. For example, impairments of the hand/fingers would have their FEC increased from 1.1 to 1.4. Psychiatric impairments would have the same FEC (1.4) under S.B. 899 and S.B. 863.

It is less clear whether we would expect a differential impact on firefighters with musculoskeletal injuries from SB 863's codification of alternative rating procedures (i.e., *Almaraz* ratings). It seems plausible that *Almaraz* ratings would be more common on

musculoskeletal disorder cases than other types of injuries insofar as disability resulting from a given impairment might vary widely across cases that appear similar in terms of the anatomically based rating methods emphasized in the *AMA Guides*. While analysis of the factors associated with the use of alternative rating procedures is beyond the scope of this study, it is suggestive that the impairments at issue in the original *Almaraz* and *Guzman* decisions (which were consolidated in the WCAB's en banc rulings) would both appear to meet our definition of musculoskeletal disorders.³⁵ Whether alternative ratings would be more or less commonly used for firefighters, in comparison to other occupations, is not apparent to us. Even if impacts of SB 863 are theoretically unclear, it may, at least, be informative to have a description of long-run differences in alternative rating frequency across occupations.

In light of the evidence presented in Chapter 3 on case mix differences between firefighter musculoskeletal disorders and the injuries experienced by other comparable workers, the changes to FEC ratings under SB 863 may have favored some firefighters. Chapter 3 indicated that injuries to the lower extremities were far more common among firefighters with musculoskeletal disorders, while back injuries and other injuries to the trunk were also somewhat more common. Impairments of the knee and ankle had the second-lowest possible FEC adjustment factor (1.14), and thus received the second-largest possible increase in ratings under SB 863. However, "general lower extremity" impairments and spine impairments had a higher FEC adjustment factor (1.27) under SB 899, and thus received a more modest increase in ratings under SB 863. To sum up, increases in disability ratings and PD benefits under S.B. 863 were primarily focused on workers whose impairments fell into lower FEC ranks under SB 899.

Data

We rely on disability ratings performed by the state Disability Evaluation Unit (DEU). The DEU performs three types of ratings, known as *Consult*, *Summary*, and *Formal* ratings. The characteristics of cases differ in important ways across the three types of ratings performed at the DEU, and so it is important to analyze these types of ratings separately to make valid comparisons across groups of workers. Workers evaluated by Consult ratings have legal representation, whereas workers with Summary ratings are unrepresented. Formal ratings, which are far less common, are performed at the request of a workers' compensation administrative law judge to help resolve issues in a disputed claim before the WCAB and may or may not be represented. In general, injuries that receive consult ratings are more complex (as indicated by the presence of legal representation) and receive substantially higher ratings than cases evaluated in summary ratings. Formal ratings have even higher ratings and complexity and are not performed frequently enough to examine in depth in the present study.

From the DEU, we received transaction-level data for claims rated between 2005 and October 2018. Excluding ratings for injuries occurring before 2005 (which were rated using a different disability rating schedule), the DEU performed between 30,000 and 55,000 ratings per year during this period, with volumes typically between 35,000 and 42,000 ratings

³⁵ The injury in the *Almaraz* case was a back injury. The injury in the *Guzman* case was carpal tunnel syndrome.

Among other variables, the DEU ratings include precise data on:

- type of physician evaluating the worker (treating physician, qualified medical evaluator, or agreed medical evaluator)
- whether the case is represented
- rated impairment(s)
- Whole Person Impairment (WPI) standard rating for each impairment
- effect of occupational adjustment
- effect of age adjustment
- effect of apportionment, if any
- final rating after apportionment
- rating method (*AMA Guides* or *Almaraz*)

DIR programmers matched DEU data to WCIS claims using direct identifiers that were not transferred to RAND. RAND processed the data further to disambiguate DEU cases that matched to multiple WCIS claims. Ultimately, 90 percent of DEU cases were matched to a WCIS claim.³⁶

Although the DEU is the most detailed and complete data source available on PD ratings performed in the California workers' compensation system, it has several important limitations. In addition to potential errors introduced by our reliance on indirect identifiers to link some DEU and WCIS records, the population of workers who receive a DEU rating is not a random sample of all workers with PD and it is therefore unclear whether the DEU can be treated as representative of the full population of workers with PD. As discussed above, cases with different types of ratings (Summary, Consult, or Formal) reach the DEU through distinct pathways that may result in somewhat different selection mechanisms. Unfortunately, because it is also challenging to identify the full population of workers with PD (as we discuss in the Appendix), it is also difficult to evaluate how representative the DEU is of all workers or even to define the population of workers with PD as a benchmark that could be used to define sampling weights for the DEU data.

Summary Statistics

Table 6.2 show the size of our analytic sample by occupational group and injury date range. Across the four occupation groups that we focus on in this study, 19 percent of usable DEU ratings that linked to the WCIS were excluded due to unavailability of any data on ratings, rated impairments, or basic demographics. An additional 24 percentage points of all DEU cases (30 percent of the complete records cases) were excluded because the rating was not performed within 33 months of the injury date, making analysis of changes in ratings over time potentially misleading. As a result, only 57 percent of DEU ratings with a link to the WCIS were included in our analytic sample. The percentage of cases excluded at each step is very similar across occupation groups and injury years, however, suggesting that missing data patterns may not lead

³⁶ Multiple potential WCIS matches were identified for about 10 percent of DEU cases. See appendix A for further details. Since DIR estimates that WCIS FROI data are 91 to 92 percent complete, we view a 90 percent match rate from DEU to WCIS as very close to the best feasible match rate.

to inaccurate comparisons of ratings across occupations or analysis of trends. Sample sizes by occupation and time period (pre- vs. post- SB 863) are presented below.

Table 6.2: Sample Size by Occupation, Injury Date, and Data Completeness

A. All usable cases with WCIS match

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	4,034	9,561	36,867	1,977
2013-2015	1,482	3,180	10,813	569
Total	5,516	12,741	47,680	2,546

B. Complete-Records cases with WCIS match

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	3,411	7,893	28,806	1,627
2013-2015	1,306	2,829	9,185	503
Total	4,717	10,722	37,991	2,130

C. Analysis Sample (Constant-Maturity, Complete Records Cases with WCIS Match)

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	2,414	5,342	19,051	1,132
2013-2015	1,080	2,323	7,138	404
Total	3,494	7,665	26,189	1,536

Usable DEU claims are those containing at least one report with a final rating after apportionment and at least one rated impairment with a non-missing final rating. Complete records claims are usable claims that also contain (in the WCIS) employee gender and age and (in the DEU) a valid body system for at least one impairment. Constant-maturity claims are those rated within 33 months (1005 days) of injury date, allowing valid comparisons of rating trends for injuries through December 31, 2015 rated on October 1, 2018 or earlier.

Table 6.3 shows summary statistics on DEU ratings for workers in one of the occupations of interest in this study with musculoskeletal disorders. Panel A reports summary statistics for all injuries between 2005-2015 regardless of maturity, a sample of 30,845 injured workers. Overall, 54 percent of these cases were summary ratings, 45 percent were consult ratings, and just under 1 percent were formal ratings. As discussed above, consult ratings tend to be performed on more severe and complex injuries, with an average rating of 25.3 for consult ratings compared to 12.3

for summary ratings. Differences in complexity are also reflected in the number of impairments rated: 82 percent of summary ratings have just a single impairment, versus 51 percent of consult ratings. Injuries with consult ratings also take much longer to reach the DEU, with a median of 904 days between the injury and the first DEU rating, versus 588 days for summary ratings.

Table 6.3: Summary Statistics on Disability Ratings for Musculoskeletal Disorder Cases by Rating Type, Complete-Records and Constant-Maturity Samples

A. 2005-2015 Musculoskeletal Disorder Cases, Any Maturity

	Consult	Summary	Formal	Total
Final Rating	25.3	12.3	31.4	18.2
N	13,784	16,811	250	30,845

Number of Impairments

0	6.4	3.3	1.2	4.7
1	51.3	81.6	46.4	67.4
2	21.7	12.0	18.4	16.2
3	10.7	2.1	13.2	5.9
4+	9.9	1.1	20.8	5.0

Duration to Rating from Injury Date

Mean	1081	695	1373	862
Median	904	588	1142	724

B. 2005-2015 Musculoskeletal Disorder Cases, Constant-Maturity

	Consult	Summary	Formal	Total
Final Rating	21.6	11.5	27.4	15.2
N	7,773	13,805	97	21,675

Number of Impairments

0	5.4	3.1	2.1	3.9
1	58.5	83.6	57.7	74.5
2	20.6	10.8	16.5	14.3
3	7.7	1.7	11.3	3.9
4+	7.9	0.9	12.4	3.4

Duration to Rating from Injury Date

Mean	642	536	695	575
Median	648	518	730	566

These high durations between injury and rating underscore the need to use a constant-maturity sample for comparisons over time. Panel B restricts attention to injuries that were rated

within 33 months of the injury date, and thus provides summary statistics for the sample that we use for most of our analysis in this chapter. Excluding cases that take longer to reach the DEU reduces the sample size by about one third, from 30,845 to 21,675 injuries. The sample size is reduced more for consult ratings than for summary ratings, as suggested by the timing differences in Panel A, and the average ratings are somewhat lower (21.6 for consult ratings and 11.5 for summary ratings). While limiting attention to a constant-maturity sample hinders our ability to study the most severe injuries, this restriction is necessary in order to make valid comparisons between workers injured after SB 863 implementation began in 2013 and those injured in earlier years.

Results

Impairments and Disability Ratings for Firefighters and Other Workers

Before comparing ratings and benefits across occupations, we examine the distribution specific impairments rated in musculoskeletal disorder for firefighters and other occupations. We grouped impairments by the first four digits of the impairment number, which identify a body system and, in most cases, a specific body part of impairment. Ratings with multiple impairments are classified according to the impairment with the highest standard rating.

Table 6.4 describes the distribution specific impairments rated in musculoskeletal disorder for firefighters and other occupations.³⁷ For firefighters, impairments of the knee account for three in ten cases rated at the DEU. The most common specific impairment of the knee is meniscectomy (i.e., surgery to remove a torn or damaged meniscus), but other knee impairments are also quite common for firefighters, including arthritis, muscle atrophy and impairments to the cruciate or collateral ligaments.³⁸ Police officers have a similarly high rate of knee impairments (27.8 percent of rated cases), but knee impairments are less common for other public-sector workers (21.9 percent) and private-sector workers (24.1 percent). After knee impairments, lumbar spine impairments are the next most commonly rated impairments for firefighters (27.4 percent of cases), a rate that is similar to that observed for private-sector workers (28.4 percent) but higher than police (24.6 percent) or other public-sector workers (22.6 percent). Shoulder impairments, the third-most common type of impairment for firefighters (18.5 percent of cases), are equally common for police (18.2 percent) but are more common for other public-sector workers (19.4 percent) and private-sector workers (22.2 percent). Other commonly rated impairments for firefighters with musculoskeletal disorders include impairments of the cervical spine (7 percent of cases), ankle (2.1 percent), hip (1.7 percent), elbow (1.2 percent), and peripheral arm neuropathies--principally carpal tunnel syndrome and other entrapment neuropathies. There are also 0.7 percent of firefighters with musculoskeletal disorders (as coded on the first report of injury) whose highest-rated impairment was hypertensive cardiovascular

³⁷ The impairment groups tabulated in Table 6.4 cover 90 percent of firefighters with musculoskeletal disorders rated at the DEU.

³⁸ We list the ten most common specific impairments for firefighters in the appendix and provide estimates of the frequency of these impairments for other occupations. However, because the frequency of specific impairments is sensitive to the number of distinct rating methods available in the AMA Guides, we focus on the more aggregated classifications reported in Table 6.4.

disease. As Table 6.4 illustrates, many of these conditions are widespread among other occupations. Those that are differentially common among firefighters are impairments of the knee, lumbar spine, cervical spine, and hip.

Table 6.4: Body Part of Highest-Rated Permanent Impairment by Occupation, Constant-Maturity Musculoskeletal Disorder Cases

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
Knee	30.7%	27.8%	21.9%	24.1%
Lumbar Spine	27.4%	24.6%	22.6%	28.4%
Shoulder	18.5%	18.2%	19.4%	22.2%
Cervical Spine	7.0%	5.9%	8.5%	5.4%
Ankle	2.1%	3.0%	2.7%	2.3%
Hip	1.7%	1.0%	0.7%	0.4%
Elbow	1.2%	0.9%	1.3%	1.3%
Arm Neuropathy	1.2%	3.5%	6.9%	3.3%
Hypertensive Cardiovascular Disease	0.7%	2.0%	0.4%	0.1%
Other	9.5%	13.0%	15.7%	12.6%

We begin by examining standard ratings. Standard ratings are calculated using the *AMA Guides* throughout the entire period examined in this study and, because they do not reflect apportionment or the impact of adjustments for earnings capacity, age, or occupation, standard ratings provide an indication of the underlying severity of permanent impairments. Standard ratings thus provide the most direct measure available of whether the severity of permanent impairment was changing over time—an important question for understanding trends in earnings losses presented in earlier chapters. However, because final ratings determine compensation (and, unlike standard ratings, were directly affected by SB 863), we also analyze final ratings below.

Table 6.5 compares the average standard by rating type (Consult or Summary) within each occupation group. Consult ratings for firefighters with musculoskeletal disorders were one rating point higher for workers injured in 2013-2015 than for workers injured in 2005-2012. Other occupations also saw higher standard ratings on consult ratings after 2012, although the increase was more muted for other public-sector workers and for private-sector workers. A similar pattern was apparent among summary ratings, with increases over time for all occupations, but slightly larger increases for firefighters. Comparing the average rating for all injury years across occupations, we see that firefighters receive standard ratings that are similar to those observed for the comparison groups--average ratings for all occupations range between 12.5 and 13.9 on consult ratings and between 6.2 and 7.1 on summary ratings.

Table 6.5: Combined Standard Ratings by Occupation and Policy Regime, Constant-Maturity Musculoskeletal Disorder Cases

A. Summary Ratings

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	6.4	6.1	7.1	6.8
(SB 899)	(0.28)	(0.23)	(0.11)	(0.54)
2013-2015	7.2	6.5	7.4	7.3
(SB 863)	(0.50)	(0.40)	(0.21)	(1.15)
All Years	6.7	6.2	7.1	6.9
	(0.25)	(0.20)	(0.10)	(0.49)

B. Consult Ratings

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	13.1	12.2	12.8	13.9
(SB 899)	(1.05)	(0.54)	(0.26)	(1.08)
2013-2015	14.1	13.0	13.0	14.1
(SB 863)	(1.62)	(0.74)	(0.40)	(1.81)
All Years	13.4	12.5	12.9	13.9
	(0.89)	(0.44)	(0.22)	(0.93)

Source: Authors' calculations, WCIS-DEU 2005-2015.

Table 6.6 presents final ratings by occupation, both for the full 2005-2015 sample and by injury date, with injury dates grouped into cases rated under the pre-SB 863 disability rating schedule (2005-2012 injury dates) or the post-SB 863 disability rating schedule (2013-2015 injury dates).

Table 6.6: Final Ratings After Apportionment by Occupation and Policy Regime, Constant-Maturity Musculoskeletal Disorder Cases

A. Summary Ratings

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	11.9 (0.28)	11.0 (0.23)	10.7 (0.11)	12.0 (0.54)
2013-2015	15.1 (0.50)	13.1 (0.40)	12.6 (0.21)	14.9 (1.15)
All Years	12.9 (0.25) 126%	11.6 (0.20) 119%	11.2 (0.10) 118%	12.6 (0.49) 124%

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	23.5 (1.05)	21.3 (0.54)	20.1 (0.26)	23.1 (1.08)
2013-2015	26.5 (1.62)	25.2 (0.74)	22.2 (0.40)	24.6 (1.81)
All Years	24.4 (0.89)	22.7 (0.44)	20.8 (0.22)	23.5 (0.93)

Source: Authors' calculations, WCIS-DEU 2005-2015. Standard errors in parentheses.

Differences in final ratings across occupations generally track differences in standard ratings noted above, although estimates of average consult ratings for firefighters are not very precise due to the limited sample size of consult ratings. Within a given type of rating, firefighters with MSDs receive slightly higher final ratings than do other workers with MSDs.

On Consult ratings, the average final rating for a firefighter with an MSD is 24.4 percent, while average ratings in other occupations range from 20.8 to 23.5. On Summary ratings, the average final rating for a firefighter with an MSD is 12.9 percent, while average ratings in other occupations range from 11.2 to 12.6. Within both rating types, workers in the private-sector comparison group have the next-highest disability ratings (after firefighters), while final ratings for police and other public-sector workers are slightly lower.

Table 6.6 also reports the average final rating after apportionment by occupation for Summary (Panel A) and Consult (Panel B) ratings performed before and after implementation of SB 863. Summary ratings for firefighters increased by 3.2 rating points after SB 863 took effect, a 26 percent increase over the average for injuries between 2005-2012. While all occupation groups had substantially higher ratings after 2012, firefighters had the largest absolute increase and the largest percentage increase in final ratings among occupation groups examined here. On Consult ratings, final ratings increased by slightly more for police (3.9 rating point increase) than for firefighters (3.0 rating point increase). Both firefighters and police saw much larger increases in ratings than other public-sector or private-sector comparison workers.

The pre-SB 863 results presented in Table 6.6 reflect average outcomes over the entire period when the disability rating schedule established under SB 899 was in effect, from 2005-2012. Since outcomes may have changed during this period, a narrower-term comparison between pre- and post-SB 863 outcomes may be more informative about the effects of SB 863 in isolation from other factors. In the Appendix, we note that standard ratings on consult ratings were much higher in all occupations after 2007, suggesting that pooling 2005-2007 injuries with those occurring in 2008-2012 might lower the average pre-SB 863 average rating in a way that obscures the effects of SB 863--though the limited sample size of consult ratings for firefighters leads to much less precise estimates when we look at shorter time periods. Changes in summary ratings were more muted, but an upward trend in standard ratings is evident for firefighters: those injured in 2010-2012 who received summary ratings had an average standard rating of 6.7, versus 6.0 in 2005-2007. A similar increase is apparent among private-sector workers, while ratings for police and other public-sector workers changed little between 2005-2007 and 2010-2012.

Table 6.7 disaggregates the final ratings examined in Table 6.6 into four time periods, enabling a comparison of ratings for injuries occurring within three years of SB 863 implementation. When we compare 2013-2015 injuries with consult ratings to those occurring in 2010-2012, we see that final ratings increased sharply for police, but did not change meaningfully for firefighters or other comparison groups.³⁹ However, estimates the change in consult ratings for firefighters are very imprecise due to the limited sample size, and the change

³⁹ We assessed the statistical significance of within-occupation changes in ratings and tested for differences between firefighters and other occupations using linear regression. See Appendix for regression tables. For summary ratings, in contrast, we see increases in final ratings for all occupations, with firefighters and private sector workers each experiencing increases of 2.7 to 2.8 rating points and smaller increases for other occupations. Despite the larger sample size available, differences across occupations in the change in ratings were not statistically significant.

in ratings following SB 863 does not differ by a statistically significant amount between firefighters and other occupations.

Table 6.7: Final Ratings After Apportionment by Occupation and Injury Date, Constant-Maturity Musculoskeletal Disorder Cases

A. Summary Ratings

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2007	11.4 (0.49)	11.0 (0.38)	10.8 (0.18)	10.6 (0.71)
2008-2009	11.8 (0.54)	10.8 (0.46)	10.3 (0.21)	14.2 (1.29)
2010-2012	12.4 (0.44)	11.2 (0.37)	10.9 (0.17)	12.1 (0.89)
2013-2015	15.1 (0.50)	13.1 (0.40)	12.6 (0.21)	14.9 (1.15)
All Years	12.9 (0.25)	11.6 (0.20)	11.2 (0.10)	12.6 (0.49)

B. Consult Ratings

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2007	20.5 (1.46)	20.0 (0.93)	17.8 (0.41)	20.0 (1.35)
2008-2009	26.9 (2.35)	22.8 (1.27)	20.0 (0.57)	28.0 (2.98)
2010-2012	26.0 (1.95)	21.8 (0.78)	22.2 (0.42)	25.1 (1.95)
2013-	26.5	25.2	22.2	24.6

2015	(1.62)	(0.74)	(0.40)	(1.81)
All Years	24.4 (0.89)	22.7 (0.44)	20.8 (0.22)	23.5 (0.93)

Source: Authors' calculations, WCIS-DEU 2005-2015. Standard errors in parentheses.

For summary ratings, in contrast, we see increases in final ratings for all occupations, with firefighters and private sector workers each experiencing increases of 2.7 to 2.8 rating points and smaller increases for other occupations. Despite the larger sample size available, differences across occupations in the change in ratings were not statistically significant.

Other Medicolegal Issues

We also examined patterns of *Almaraz* ratings across occupations to understand if SB 863's affirmation of alternative rating procedures had a noteworthy effect on firefighters. Among consult ratings, the proportion of constant-maturity musculoskeletal disorder claims that received *Almaraz* ratings has been slightly lower since SB 863 took effect, at 14 percent for 2013-2015 injuries versus 18 percent for 2010-2012 injuries. Firefighters with consult ratings were slightly less likely to receive *Almaraz* ratings (12 percent of cases in 2010-2012 and 10 percent of cases in 2013-2015) than other occupations. *Almaraz* ratings were less common on summary ratings, averaging 7 percent of all cases with 2010-2012 injury dates and 7.5 percent of cases with 2013-2015 injury dates. Like the overall sample, firefighters saw a slight increase in *Almaraz* ratings, from 6.4 percent for 2010-2012 injuries to 7 percent for 2013-2015 injuries.

We also compared the frequency of apportionment between 2005-2012 injuries and 2013-2015 injuries; since physicians were required to evaluate the need for apportionment on all injuries in our sample, we include earlier years in this comparison. We find that apportionment has become more widespread on consult ratings in recent years, with the overall proportion of cases with apportionment recommended rising from 10 percent on 2005-2012 injuries to 15 percent on 2013-2015 injuries. The frequency of apportionment on consult ratings doubled for firefighters, police, and the private-sector comparison group while growing by about 40 percent for other public-sector occupations. On summary ratings, meanwhile the proportion of cases with apportionment recommended largely held steady between 12 and 12.5 percent. Apportionment declined slightly for firefighters and private-sector workers, while rising slightly for police and other public-sector workers. In short, while apportionment became more widespread on consult ratings and remained steady on summary ratings, this appeared to reflect system-wide rating practices rather than anything particular to firefighters.

These findings suggest that increased apportionment among Consult ratings may have offset some of the rating increases anticipated under SB 863. However, a broader analysis of occupations not included in this study (and less comparable to firefighters) would be needed to produce informative estimates about the frequency of apportionment. Important limitations of the apportionment data in the DEU should also be noted. DEU ratings data for consult ratings do not contain reliable information about how apportionment affects ratings (such as the percent apportioned by impairment or the rating before apportionment), and so we cannot attribute the differences in SB 863 impacts between consult and summary ratings to apportionment without

further investigation. In short, our findings regarding apportionment on consult ratings should, at this point, be taken as suggestive due to limitations in the apportionment information available on DEU consult ratings. More systematic validation of apportionment information in DEU ratings data—which was well beyond the scope of this report—is needed to confirm these suggestive findings.

Compensation for Psychiatric Impairments

A major goal of this report was to study the occurrence of comorbid psychiatric conditions among workers with a musculoskeletal injury. In Chapter 5 above, we addressed this question by examining information on diagnoses and prescriptions in the medical claims billed to workers' compensation. Another way to approach this question is to examine the rate at which permanently disabled workers had rated psychiatric impairments. Examination of psychiatric impairment rating is also important for assessing SB 863 since SB 863 restricted compensation for add-on or secondary psychiatric impairments.

Table 6.8 reports the proportion of cases that received an impairment rating for any psychiatric impairment by occupation, comparing musculoskeletal disorder cases to all other cases rated at the DEU. Due to very low incidence rates, we pool together consult and summary ratings in this analysis. Overall, psychiatric impairments are infrequently rated on musculoskeletal disorder claims, and they are particularly rare among firefighters and police. Just 0.6 percent of firefighter musculoskeletal disorder cases had a psychiatric impairment rated, while the rate for police was 0.5 percent. Private-sector workers (0.9 percent) and other public-sector workers with musculoskeletal disorders were far more likely to have psychiatric impairments rated. For reference, Table 6.8 also reports the frequency of psychiatric impairments for non-musculoskeletal injuries, including cases where a psychiatric impairment is the primary reason for the workers' compensation claim. Psychiatric impairments are much more widespread on these other claims, yet the frequency for firefighters and police remains less than half that observed for other public-sector workers.

Table 6.8: Proportion of Claims with Rated Psychiatric Impairments by Occupation, Gender, and Type of Injury

A. All Injured Workers

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
Musculoskeletal Disorders	0.6%	0.5%	1.6%	0.9%
Other Injuries	4.0%	3.7%	10.6%	5.0%
Number of Cases				

B. Male Workers

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
MSD Injuries	0.6%	0.4%	1.3%	0.9%
Non-MSD Injuries	0.0%	1.0%	1.8%	0.0%
Number of Cases				

C. Female Workers

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
MSD Injuries	0.0%	1.1%	1.8%	0.0%
Non-MSD Injuries	7.7%	6.0%	11.5%	12.6%

Given these extremely low rates of psychiatric impairments for firefighters and police, it is not surprising to find that the elimination of add-on psychiatric impairments under SB 863 had a smaller impact (in terms of the proportion of cases affected) on these groups of workers than on other public-sector or private-sector occupations. Table 6.9 tabulates the proportion of musculoskeletal disorder cases with any rated psychiatric impairment by occupation and injury year. Consistent with the changes in SB 863, the proportion of cases with rated psychiatric

impairments fell by about half after 2012. However, even before SB 863 was implemented, less than 1 percent of musculoskeletal disorder claims had any rated psychiatric impairments.⁴⁰

Table 6.9: Proportion of Cases with Any Rated Psychiatric Impairments by Injury Date and Occupation, Constant-Maturity Musculoskeletal Disorder Cases

A. Secondary Psychiatric Impairments

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005	0.21%	0.28%	0.71%	0.51%
2013	0.15%	0.09%	0.54%	0.00%
All Years	0.19%	0.22%	0.67%	0.38%

B. Any Psychiatric Impairments

	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005	0.69%	0.59%	1.74%	1.02%
2013	0.30%	0.09%	1.10%	0.00%
All Years	0.57%	0.43%	1.56%	0.77%

Changes in Statutory Benefits After SB 863

Table 6.10: Average Statutory Benefit by Injury Date and Occupation, Constant-Maturity Musculoskeletal Disorder Cases

A. Summary Ratings

⁴⁰ In an effort to isolate add-on impairments, we also repeated this analysis excluding claims where a non-psychiatric impairment was the highest-rated on the claim. Only 0.21 percent of firefighter musculoskeletal injuries in 2005-2012 had an add-on psychiatric impairment under this definition, compared with 0.28 percent of police, 0.51 percent of private-sector occupations, and 0.71 percent of other public-sector occupations.

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	\$10,139	\$9,227	\$9,114	\$10,405
2013-2015	\$15,881	6	\$13,47 6	\$15,628

B. Consult Ratings

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	\$27,558	4	\$23,63 9	\$21,33 \$25,114
2013-2015	\$37,855	1	\$33,72 3	\$29,11 \$31,402

Source: Authors' Calculations, 2005-2015 WCIS-DEU

The analyses above indicate that ratings for firefighters increased on summary ratings after SB 863 was implemented; changes in consult ratings were more difficult to assess due to limited sample sizes, but ratings have trended upward over time. To more directly characterize SB 863's impact on benefits, we calculated statutory benefits for workers rated at the DEU and compared the average statutory benefit across occupations and over time. Table 6.10 shows that there were substantial increases in statutory benefits after SB 863 took effect for both summary and consult ratings. As above, we compare 2010-2012 injury dates to 2013-2015 injury dates in order to better isolate the impact of SB 863 from the longer-term upward trend in ratings.

Between 2010-2012 and 2013-2015, statutory benefits for firefighters with consult ratings increased by about \$5,800, from \$32,019 to \$37,855. As expected given the patterns of final ratings observed above, police with consult ratings experienced a \$9,700 increase in statutory benefits, while other public-sector employees and private-sector occupations had more modest increases.

Firefighters with summary ratings, who experienced larger increases in final ratings, saw statutory benefits increase by an average of about \$5,300 after SB 863 took effect. Not surprisingly, increases across other occupations also tracked changes in ratings documented above.

Discussion

Based on their standard ratings, firefighters with permanently disabling musculoskeletal disorders who were rated at the DEU appeared to have similar impairment severity to police and other comparison occupations who had the same type of rating. Firefighters had slightly higher final ratings than comparable occupations prior to SB 863, however. As noted above, firefighters have relatively high occupational adjustments, and their slightly older age at injury may also

results in more favorable adjustments under the current disability rating schedule. Other aspects of the rating process, such as the frequency with which apportionment is recommended and the use of alternative rating procedures, were not dramatically different between firefighters and other occupations.

Implementation of SB 863 was followed by higher final ratings for firefighters with musculoskeletal disorders who received summary ratings. It is somewhat surprising that the average final rating did not increase on consult ratings, however. The only provision of SB 863 that would tend to reduce ratings was the elimination of psychiatric add-on impairments, and we saw that psychiatric impairments were rated in fewer than 1 in 100 musculoskeletal disorder cases for firefighters prior to SB 863. Our results hint at an alternative mechanism that may have operated independently of SB 863, which was an increase in the frequency of apportionment to non-occupational cause. While we did not have a sufficient sample size of firefighters with consult ratings to examine differences across occupation, across all occupations the increased frequency of apportionment was concentrated among consult ratings, suggesting that increased apportionment among consult ratings may have offset some of the rating increases anticipated under SB 863.⁴¹ However, a broader analysis of occupations not included in this study (and less comparable to firefighters) would be needed to produce informative estimates about the frequency of apportionment. Furthermore, DEU ratings data for consult ratings do not contain reliable information about how apportionment affects ratings (such as the percent apportioned by impairment or the rating before apportionment), and so we cannot attribute the differences in SB 863 impacts between consult and summary ratings to apportionment without further investigation. Notwithstanding the somewhat muted benefit increases that we observed on consult ratings, statutory benefits were substantially higher across all occupations and rating types examined thanks to the higher weekly maximum.

⁴¹ On summary ratings, the proportion of all musculoskeletal disorder cases with any apportionment recommended was 12.9 percent for 2010-2012 injuries and 12.4 percent for 2013-2015 injuries. On consult ratings, in contrast, the proportion of cases with apportionment rose from 12.5 percent to 15.0 percent.

7. Treatment Caps and Claim Denials

The workers' compensation system is designed to provide injured workers with necessary medical care. There is concern among stakeholders that some policies used to control costs have interfered with workers' ability to access needed care, however. Claim denials can also be an indicator of barriers to accessing care if claims are rejected altogether or if partial denials lead to delays in receiving care.

In this chapter, we examine patterns of claim denials across occupations and types of injuries to ask whether claim denials differentially affect firefighters with musculoskeletal injuries. We also provide evidence on the effects of treatment caps enacted in 2003 that limit the use of chiropractic, OT, and PT care to 24 visits each over the life of a claim without written authorization from the employer.

Background

Senate Bill 228, enacted in 2003, sought to control medical spending growth through a number of policy levers, including the establishment of treatment caps on chiropractic and physical medicine. Labor Code section 4604.5 provides that "notwithstanding the medical treatment utilization schedule, for injuries occurring on and after January 1, 2004, an employee shall be entitled to no more than 24 chiropractic, 24 occupational therapy, and 24 physical therapy visits per industrial injury." We note that a 24-visit cap applies separately to each of the three targeted modes of treatment: chiropractic, occupational therapy (OT), and physical therapy (PT). Although LC section 4604.5 specified that the cap could be waived with written authorization by the employer, the treatment caps clearly established a new and substantial barrier to receipt of care beyond the 24-visit cap.

The forceful approach to controlling utilization adopted in SB 228 reflects the severity of the challenges that confronted workers' compensation policymakers in the early 2000s, when instability in the workers' compensation market and dramatic cost growth demanded urgent action. In the years leading up to enactment of SB 228, chiropractor and physical therapist visits had accounted for over a third of outpatient medical spending in the workers' compensation system, leading to concerns about overutilization.

Our 2010 study found that average chiropractic and PT utilization volumes were below the cap for most patient populations. As noted in that study, treatment guidelines developed by the American College of Occupational and Environmental Medicine (ACOEM) recommended relatively limited use of chiropractic and physical therapy for low back injuries. These guidelines and the studies reviewed in our previous report would seem to suggest that the 24-visit cap should not interfere with the provision of necessary care in most cases. That said, chiropractic and PT utilization rates tend to be higher for chronic low back pain patients and those being treated through workers' compensation. A 2005 study of SB 228's early impacts by the California Workers' Compensation Institute (CWCI) found immediate and dramatic reductions in average chiropractic and PT utilization among claims receiving these modes of treatment. The average number of chiropractic visits over the first nine months of the claim fell from 28.5 for workers injured in 2002 to 12.6 for workers injured in 2004, a reduction in utilization of 56 percent. The

average number of PT visits, meanwhile, fell from 20.4 for workers injured in 2002 to 11.2 for workers injured in 2004, a reduction in utilization of 45 percent. Spending on these treatment modalities was similar, in percentage terms, to the reductions in utilization (Swedlow, 2005).

In short, utilization of the capped services was very high relative to treatment guidelines prior to implementation of SB 228, and the evidence reported by Swedlow (2005) clearly indicates that the treatment caps changed utilization patterns. What is less clear is whether the reductions in utilization due to the treatment caps were, on average, driven by avoidance of unnecessary care or by reductions in necessary care.

A recent study by Powell and Seabury (2019) provided some evidence on this question by studying the relationship between medical spending changes and post-injury earnings outcomes for low-back injuries in California. They found that, taken together, the medical reforms enacted in SB 228 and SB 899 differentially reduced spending on low back injuries and that this reduction in spending led to worse labor market outcomes for injured workers. Powell and Seabury, however, did not have access to data on medical claims and were not able to isolate the impact of the treatment caps or determine which of the many medical reforms implemented between 2004 and 2005 were most important in changing utilization patterns.

We are not aware of more recent evidence on impacts of the SB 228 treatment caps on patterns of care or worker outcomes. This topic is of concern to workers and other stakeholders throughout the WC system and not just firefighters, and a comprehensive evaluation of the treatment caps was far beyond the scope of the current study. Furthermore, WCIS medical data is not available from the time period preceding SB 228, making it challenging to evaluate the impact of the caps.

Instead, we take a more descriptive approach and ask what proportion of workers with and without musculoskeletal disorders have sufficiently high utilization of the capped services to potentially be affected by the caps. We limit the scope of our analysis in this study to firefighters and the comparison occupations examined in other chapters, although in this chapter we also report some descriptive evidence on average treatment patterns for all injured workers with musculoskeletal disorder claims.

We also consider whether claim denial patterns differ systematically between firefighters and other injured workers, or between musculoskeletal disorder claims and other types of injuries.

Methods

Our primary data source for analysis of treatment caps is the sample of claims in the WCIS with linked FROI, SROI, and Medical claims data. As described in Chapter 5, analysis of medical data is limited to cases with complete FROI/SROI data (as defined in Chapter 3) and one or more medical bills successfully linked to the FROI/SROI data. Claims with medical data available were reweighted to match the distribution of FROI injuries so that the target population for weighted estimates is comparable to that examined in Chapters 3, 4, and 5.

Claim denials are identified using a variable constructed by DIR that indicates whether a claim was ever fully or partially denied. We were not able to distinguish between full and partial denials with the data available for this study, nor did we have access to information about the timing of denial in the course of the claim. A large share of claims with a denial indicated also received paid benefits, and we cannot say whether these claims reflect initial denials that were reversed, partial denials of specific benefit types, or full denials that were made after benefit

payment had begun. Despite the limited amount of detail on claim denials in our data, these data provide us with a unique view of claim denial patterns across occupations and types of claims, and even partial denials or denials that are subsequently reversed are a reasonable indication of delays and hassles encountered by injured workers.

To study the treatment caps, we focused on visit counts within the three varieties of capped services: chiropractic, OT, and PT. We focus our analysis of utilization on indemnity claims since utilization of capped services was very low on non-indemnity claims. A complication in data construction was that Labor Code section 4604.5 does not explicitly define any of the treatment categories subject to the cap. Inquiries with DIR staff and other experts in California workers' compensation indicated that there is no official definition of capped services, while we were not able to identify any WCAB rulings that clarified this definition. It is possible that application of the cap may depend to some extent on the discretion of claim administrators and may not yet have been adjudicated in a published WCAB ruling.

We accordingly developed two alternative approaches to identifying capped services. The approach we focus on in this chapter, which is the more inclusive approach, relies on the specialty of the provider. We also developed a list of procedure codes for therapy and conducted a sensitivity analysis requiring that both the provider specialty and the procedure code indicate that the visit was for one of the three treatment modalities subject to the cap.⁴²

Our ability to study the impact of the cap is constrained by the fact that all of our claims data come from injuries for which the cap was in effect, so we have no way to measure what treatment patterns would look like in the absence of the cap. Instead, we focus on two descriptive measures that can indicate the frequency with which workers may be affected by the cap: the proportion of workers with exactly 24 visits (indicating that a course of treatment stopped at the cap), and the proportion of workers with more than 24 visits. A large volume of workers with exactly 24 visits would be an indication that the cap is affecting treatment patterns. Workers with more than 24 visits, in contrast, must have obtained written authorization to exceed the cap. The share of workers with 24 or more visits also indicates the share of workers who are directly exposed to the treatment cap.

We also provide graphical evidence, in the form of histograms of visit counts, describing the full distribution of visit counts. An advantage of the WCIS data available for this study is that we have a longer follow-up period after injury than was available in Swedlow (2005), which provided a short-term assessment just one year after the caps took effect. Indeed, much of the literature reviewed in our 2010 study focused on utilization patterns within a single year, which may understate the impact of the treatment caps because the 24-visit limit applies for the entire lifetime of a claim. We focus on visit counts up to three years after the first service date in the workers' compensation bills.

Results

Table 7.1 reports the proportion of indemnity claims receiving each of the capped services at any time in the first three years of medical care. Utilization rates are stratified by occupation (in

⁴² See appendix for details.

columns) and whether the injury is a musculoskeletal disorder claim or not (in rows). Utilization of chiropractic and physical therapy is markedly higher on musculoskeletal disorder cases than non-musculoskeletal disorder cases for all occupation groups. 8.5 percent of firefighters with musculoskeletal disorders received some chiropractic care, versus 4.1 percent of those with other injuries. Similarly, 50.5 percent of firefighters with musculoskeletal disorders received some physical therapy, versus 21.7 percent of non-musculoskeletal disorder injuries. Musculoskeletal disorder cases were associated with higher OT utilization for firefighters and police, but not for the other occupational groups examined here. While utilization of capped services is generally much higher in musculoskeletal disorder cases, the vast majority of workers with indemnity musculoskeletal disorder claims received no chiropractic treatment or OT in the workers' compensation system. Physical therapy utilization rates were far higher, with roughly half of workers with indemnity musculoskeletal disorder claims receiving PT across all occupations.

Table 7.1: Share of Injured Workers with Indemnity Benefits Receiving Any Capped Services, by Injury Type, Service Type, and Occupation

Occupation	Service Type	Active	Active	Other	Private-
		Firefighters	Police	Public-Sector	Sector Comparison
Chiropractic	MSD	8.5%	9.1%	11.9%	14.7%
	Non-MSD	4.1%	6.3%	8.5%	9.4%
Occupational Therapy	MSD	11.4%	4.4%	5.7%	4.2%
	Non-MSD	5.9%	3.6%	5.5%	8.8%
Physical Therapy	MSD	50.5%	51.1%	58.8%	57.9%
	Non-MSD	21.7%	29.7%	42.0%	40.1%
Number of Observations					
	Non-MSD	2977	9796	44758	4039
	MSD	4744	8451	59863	4824

Source: 2005-2015 WCIS. Table reports proportion of workers with 1 or more visits in first three years of medical care (dated from first date of service billed to workers' compensation).

Table 7.2 reports average visit counts at three years after the first service data among patients receiving each modality of care. Firefighters averaged 8.1 chiropractic visits, 5.6 OT visits, and 12.5 PT visits. Conditional on receiving any care in a given modality, utilization rates were very

similar across occupations and between musculoskeletal and non-musculoskeletal cases, with the exception of OT visits for the private-sector comparison group.

Table 7.2: Average Visits Injured Workers with Indemnity Benefits Receiving Any Capped Services, by Injury Type, Service Type, and Occupation

		Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
Chiropractic	Non-MSD	8.1	9.6	9.6	9.1
	MSD	9.2	9.1	9.3	8.3
Occupational Therapy					
	Non-MSD	5.6	8.1	9.0	10.1
	MSD	6.8	7.6	8.0	5.5
Physical Therapy					
	Non-MSD	12.5	12.1	12.6	13.5
	MSD	12.9	13.7	13.2	12.7

Source: 2005-2015 WCIS. Table reports average number of visits in first three years of medical care (dated from first date of service billed to workers' compensation) for workers with 1 or more visits.

Figures 7.1, 7.2, and 7.3 depict the distribution of chiropractic, OT, and PT visit counts for workers using each service type who had 36 or fewer visits in the first three years after the first service date. The fitted curve on each histogram is a fractional polynomial curve of best fit. A notable feature of the data is that there are large spikes in visit counts at multiples of six, particularly for PT. We accordingly excluded multiples of six when estimating the curve of best fit in order to highlight deviations from the broader shape of the distribution. In general, we do not see clear evidence that there is a large volume of workers who stop treatment at exactly 24 cases, nor do we see any drop-off in utilization above the treatment cap.⁴³

⁴³

Similar figures for firefighters, which are noisier due to a limited sample size, are presented in the appendix.

Figure 7.1: Number of Chiropractic Visits in Three Years of Medical Care, All WCIS Injuries with 1+ Chiropractic Visit

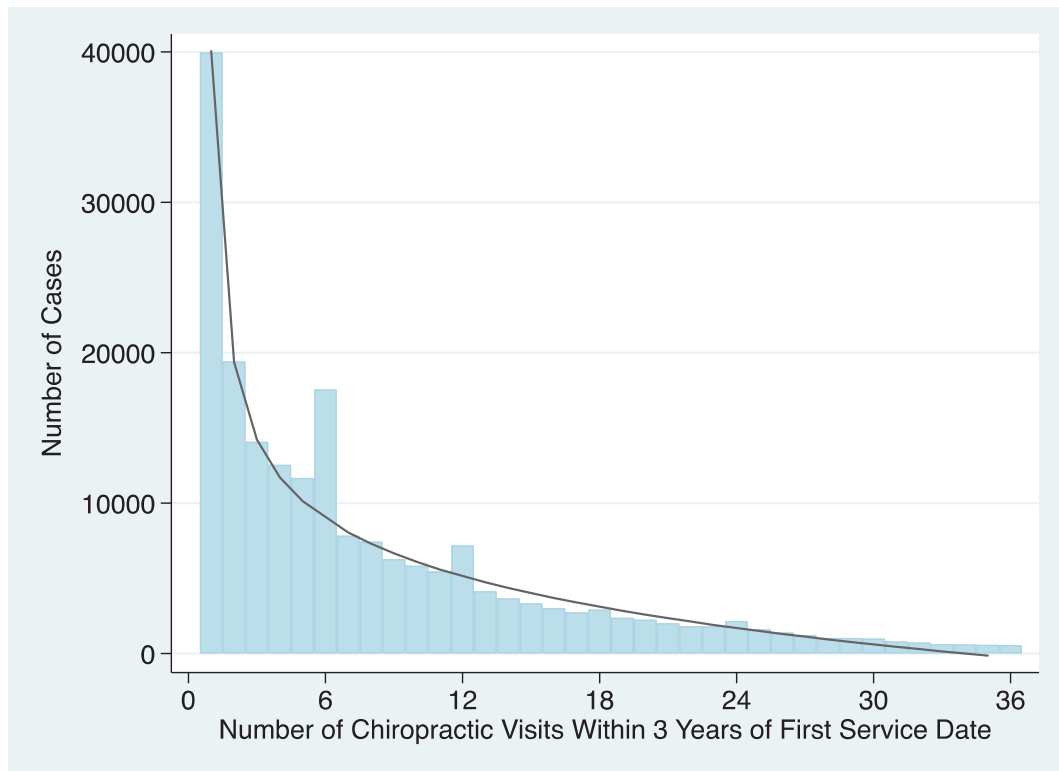


Figure 7.2: Number of Occupational Therapy Visits in Three Years of Medical Care, All WCIS Injuries with 1+ Occupational Therapy Visit

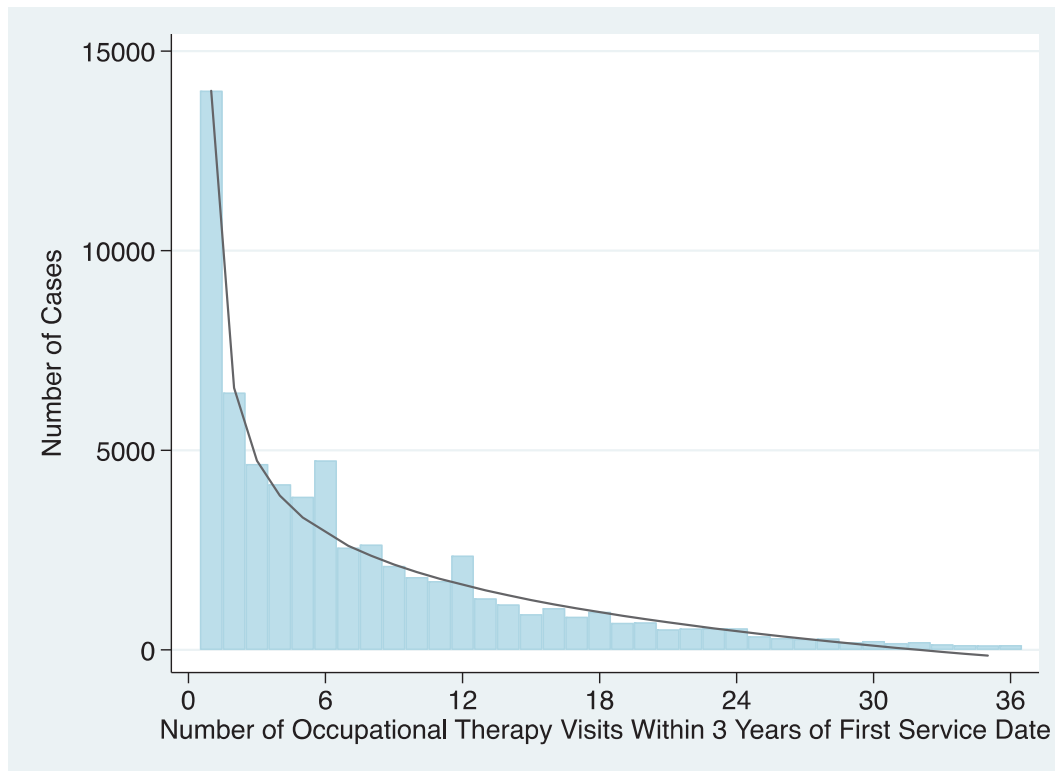


Figure 7.2: Number of Physical Therapy Visits in Three Years of Medical Care, All WCIS Injuries with 1+ Physical Therapy Visit

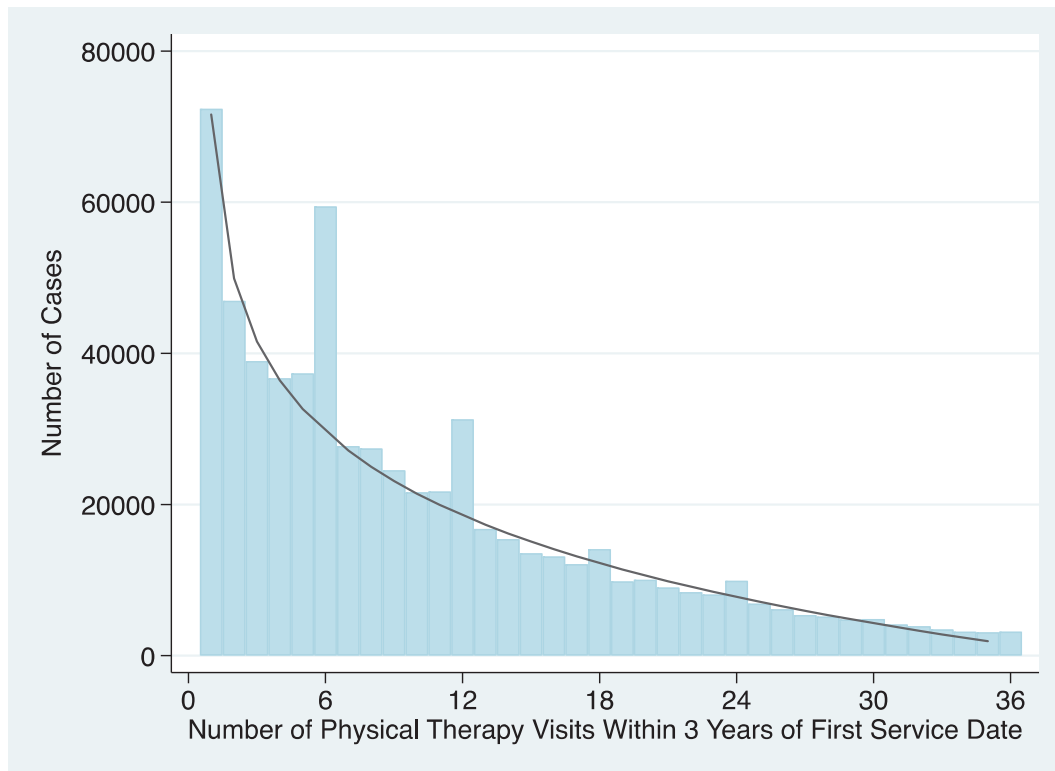


Table 7.3 groups workers into three categories: those below the cap (with fewer than 24 visits), those at the cap (with exactly 24 visits), and those above the cap (with more than 24 visits). As above, the sample is limited to indemnity musculoskeletal claims, and the sample in each panel is limited to workers who used each type of service. As suggested by the figures, very few workers appear to be constrained by the treatment caps. For firefighters, the proportion of workers at the cap is 0.45 percent for chiropractic, 0.56 percent for OT, and 1.63 percent for PT. Proportions of workers at the cap are similar or slightly higher in other occupations, but 2.34 percent or less in all cases. Workers are far more likely to receive capped services at levels above the treatment caps, with 5 to 14 times as many firefighters above the cap as exactly at the cap depending on the service; other occupations are 3 to 10 times more likely to be above the cap as at the cap, depending on the service.⁴⁴

⁴⁴ Results using a more restrictive definition of capped services that incorporates procedure codes are very similar. See appendix for details.

Table 7.3: Distribution of Capped Visits among Injured Workers with Indemnity Benefits with 1+ Visit, by Injury Type, Service Type, and Occupation

	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
Chiropractic				
Under 24 visits	93.30%	91.64%	91.93%	94.15%
Exactly 24 visits	0.45%	1.52%	1.22%	0.68%
Over 24 visits	6.25%	6.83%	6.85%	5.17%
Occupational Therapy				
Under 24 visits	96.46%	94.20%	93.85%	96.20%
Exactly 24 visits	0.56%	0.84%	0.78%	0.90%
Over 24 visits	2.98%	4.96%	5.36%	2.90%
Physical Therapy				
Under 24 visits	83.61%	82.06%	83.61%	83.87%
Exactly 24 visits	1.63%	2.34%	1.56%	1.69%
Over 24 visits	14.76%	15.60%	14.83%	14.44%

Source: 2005-2015 WCIS

Finally, Table 7.4 reports claim denial rates by occupation and type of claim (musculoskeletal or other) among all claims. Before turning to indemnity claims that are denied after initial payment or that receive a partial denial, we examine the overall population of all claims (including those with no paid benefits) and calculate the proportion with any denials reported to the WCIS. Musculoskeletal disorder claims are less likely to be denied than other claims within all public-sector occupations, while claim denial rates for private-sector workers are slightly higher for musculoskeletal disorder claims.

Table 7.4: Partial or Full Claim Denials by Type of Injury and Occupation, All Injuries

	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
Non-MSD	11.9%	10.1%	17.4%	7.3%
MSD	5.2%	7.5%	12.3%	8.8%

N	109,378	260,413	0	1,032,72	96,724
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Source: 2005-2015 WCIS

Table 7.5 narrows the focus of this analysis to claims with some paid indemnity benefits. As noted above, denials in these cases might represent partial denials, denials that are subsequently reversed, or full denials after an initial period of benefit payment. 3.7 percent of firefighters with indemnity musculoskeletal disorder claims have some form of denial on the claim record, a substantially lower rate than the other occupations examined here.

Table 7.5: Partial or Full Claim Denials by Type of Injury and Occupation, Indemnity Injuries

	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
Non-MSD	10.8%	7.8%	11.8%	6.4%
MSD	3.7%	6.2%	8.0%	7.1%
N	22,534	51,350	214,697	19,154

Source: 2005-2015 WCIS

Discussion

Taken together, Figures 7.1-7.3 and Table 7.3 suggest that the SB 228 treatment caps do not pose a particularly strong barrier to receipt of the types of care subject to the caps. While we are not aware of previous research on the proportion of workers reaching or exceeding the treatment caps (as opposed to average utilization and spending rates), the *average* chiropractic utilization rates reported by Swedlow (2005) for 2002 injuries were above the treatment caps. It is quite plausible that, besides reducing average utilization, the treatment caps and other concurrent reforms such as establishment of the MTUS and introduction of IMR and other utilization review tools may have changed the shape of the utilization distribution by reining in a minority of super-high utilizers and reducing the skewness of the distribution. In the absence of distributional statistics such as the median visit count or the share of patients with over 24 visits on pre-SB 228 injuries, it is difficult to know how many workers would have received more than 24 visits in the absence of the treatment caps. It is also plausible that the major reforms implemented in 2004-2005 (as well as the more recent medical treatment reforms enacted under SB 863) led to changes in the mix of physicians treating workers' compensation patients in the California system. If, as asserted anecdotally by some system observers, chiropractors, OTs and PTs have exited the state in response to medical reforms, then treatment patterns may have shifted away from these modalities. We also note that, without a comparison group not subject to the treatment caps, it is not possible to credibly evaluate impacts of the treatment caps on patient outcomes. However, the lack of evidence that workers are substantially constrained by the treatment caps suggests that other, more harmful consequences of the treatment caps may not be a significant concern.

We also did not see any clear evidence that firefighters with musculoskeletal disorders were more likely than comparable workers to experience claim denials: the opposite appears to be the case. Given that musculoskeletal disorder claims can be more challenging to diagnose than other injuries, we were surprised to find lower rates of claim denials for musculoskeletal disorder claims than for other claims; we expected to see the pattern observed for private-sector workers, with slightly higher rates of claim denial on musculoskeletal disorder claims. Given that this pattern is not limited to public safety workers, we think it is more likely that this pattern reflects claim administration practices at public entities. Even compared to other public-sector employees, however, firefighters with musculoskeletal disorder claims appear least likely to experience claim denials.

8. Conclusion

The purpose of this report was to provide new information to policymakers about the frequency, nature and consequences of firefighter injuries in California, with a particular focus on MSDs. We updated findings from a similar 2010 RAND report, taking advantage of new and better data to provide more detail on firefighter injury risk. We also conducted new analyses to in order to understand how injured firefighters fared during the Great Recession compared to other workers, and to understand how they were affected by changes introduced by SB 863.

Our project was organized around 10 specific research questions posed in the RFP. Questions 1 and 10 asked about the frequency of MSDs and cumulative injuries, respectively, among California firefighters compared to workers in other occupations. We used data from the WCIS to compare the injuries of active duty firefighters in California from 2005-2015 to injuries to police officers, other public sector workers, a set of private sector workers selected because they have similar observed job characteristics to firefighters, and all other workers. Similar to the 2010 report, we found that firefighters are significantly more likely to be injured than workers in other occupations, and a larger share of those injuries are MSDs. Specifically, we found that nearly half (47%) of firefighter injuries are MSDs, compared to 38% for police officers, 42% for other public sector workers, 37% in our private sector comparison group with similar job requirements to firefighters and 42% for other private sector workers.

We also found differences in the nature and cause of firefighter injuries. Compared to other occupations, injuries to firefighters are less likely to involve the upper extremities and significantly more likely to involve lower extremities or the trunk. Strains are the modal cause of injury for firefighters; burns are significantly more common among firefighters than other workers but still represent a small share of injuries (6%) in comparison to MSDs. However, a lower share of firefighter injuries were reported as being due to cumulative trauma than workers in other occupations.

Research questions 2 and 6 asked about the frequency of psychological injuries reported among firefighters, particularly PTSD. We examined diagnosis codes on medical services and prescriptions billed to workers' compensation to identify MSD injuries with comorbid psychiatric conditions. These data indicate that firefighters and police have similar rates of psychiatric comorbidities. However, perhaps surprisingly, incidence rates of psychological injuries—including PTSD—for public safety workers are substantially lower than rates observed among other public-sector workers or comparable private-sector workers. However, we think it is important to stress two important limitations of this work. First, our data only include medical claims to for psychiatric disorders being treated through the workers' compensation system. Because public-sector workers usually have access to high-quality health insurance outside of workers' compensation, we cannot rule out the possibility that workers are seeking treatment for psychiatric conditions there. Similarly, the fear of stigma over mental health concerns could be worse among public safety workers, which would also lead to the patterns observed in these data. Thus, while our study did not find evidence that firefighters are more likely to experience PTSD or other psychological disorders related to their injuries, we nonetheless believe that this topic is deserving of further study.

Questions 4 and 5 asked about the economic outcomes of firefighters with MSDs compared to workers in other occupations. As in our 2010 study, firefighters with musculoskeletal disorders appear to have less severe economic consequences from their injuries than do workers in similar occupations. In part, this appears to be due to the fact that firefighters are much less likely to separate from their at-injury employers than other types of workers. In most occupations, employment at the at-injury employer is well below the overall employment rate, indicating that injury can lead to increased job separations or career changes even for workers who remain employed. For firefighters, in contrast, at-injury employment two years after injury is 95 percent of the level that would have been expected in the absence of injury—very close to the overall level of employment (at any employer).

While the economic outcomes of firefighters are better than other workers, we did find that injured firefighters worsened during the Great Recession. Earnings losses for firefighters with permanent disabilities increased more than 10 percentage points between 2005-2007 injuries and 2010-2012 injuries, more than double than for police officers and other public workers but comparable to injuries to workers in private-sector occupations with similar job demands. It is somewhat surprising to see this decline in outcomes among firefighters because we would have expected the exceptionally high post-injury job retention among firefighters and their status as critical public safety personnel to have protected them from the slack labor market conditions facing private-sector workers.

The remaining questions focused on how different aspects of the system, including changes introduced by SB 863 and earlier reforms, impacted firefighters compared to other workers. We found that permanent disability ratings, and hence statutory benefits rose for firefighters after SB 863 implementation. We found only found higher final ratings for firefighters with musculoskeletal disorders who received Summary ratings and did not find a similar increase on Consult ratings. We hypothesize that this was because of an increase in apportionment due to causation in Consult ratings, but we lacked sufficient sample to confirm this. Despite this, statutory benefits for firefighters, and workers in other occupations, were substantially higher thanks to the increase in the weekly maximum implemented under SB 863, which led to a sharp increase in benefit adequacy.

Finally, we examined whether caps on chiropractic visits and other types of physical medicine negatively impacted firefighters. Senate Bill 228, enacted in 2003, sought to control medical spending growth through a number of policy levers, including the establishment of treatment caps on chiropractic and physical medicine. We examine the proportion of workers with and without MSDs with sufficiently high utilization of the capped services to be affected, and whether we see a larger-than-expected number of workers stopping treatment when they reach the cap. Overall, our evidence do not suggest that the SB 228 treatment caps impact a large number of workers. However, absent a comparison group not subject to the treatment caps, it is not possible to credibly evaluate their impact on patient outcomes.

There are a number of policy implications from the findings. Perhaps most importantly, California firefighters continue to face an elevated risk of injuries, particularly MSDs. While injury prevention strategies were beyond the scope of this report, our findings suggest a need for continued research and investment in strategies to reduce the number of firefighter injuries. Also, for firefighters, as for other groups of injured workers, the weak recovery of labor market outcomes from the Great Recession is worrisome. The findings of this report, as with other

analyses for broader groups of workers, highlights the need to understand how and why the Great Recession had such lasting effects on post-injury outcomes.

On a more positive note, our analysis of disability ratings indicated that the changes introduced by SB 863 have raised significantly raised benefits for both firefighters and for comparable groups of workers. The rating changes and the increase in the statutory maximum in SB 863 appear to have been particularly favorable for firefighters, likely due to the high proportion of firefighters who earn above the pre-SB 863 maximum weekly wage and and due to the prevalence of knee impairments, which received the second-largest possible increase in final ratings from changes to the formula used to calculate ratings.

We did, however, notice an uptick in the frequency with which apportionment was recommended on Consult ratings. While this trend was not notably different for firefighters than for other comparable occupations, it would be valuable to investigate changes in apportionment frequency more carefully and to collect additional data capable of illuminating the impacts of apportionment on ratings since SB 863 took effect. This may require substantial additional data collection beyond DEU, but clearer evidence on the role that apportionment plays in the disability rating system would likely be welcomed by policymakers and stakeholders.

Finally, while we are concerned about the impact of mental health stigma on our analysis of PTSD and psychiatric comorbidities, somewhat different methods and additional data collection are necessary to understand the implications of our findings that these public safety workers are far less likely to receive treatment for psychiatric conditions in the workers' compensation system. Data from the workers' compensation system also cannot speak to the incidence of PTSD or mental distress among workers who do not file claims for a workplace injury. The potential for stigma suggests a need to go beyond claims data and use complementary approaches to assess firefighters' and police officers' mental health, potentially including surveys or analysis of group health claims.

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Appendix A: Additional Details on Methods

This appendix contains additional details on methods underlying results in the text.

Sample Construction and Weighting

We construct four separate analytic samples for analysis. For each sample, we construct weights to correct for bias due to potentially non-random variation in data reporting across the population distribution. The four samples are listed in Table A.1 and described below.

1. FROI merged with SROI, complete cases on age (between 16 and 70), gender, occupation, self-insured status, and self-administered status, 2005-2018 injury dates.
2. Same as sample 1, merged with EDD earnings records, 2005-2015 injury dates.
3. Same as sample 1, merged with medical records, 2007-2016 injury dates.
4. Same as sample 1, merged with medical records and EDD records, 2007-2016 injury dates
5. Disability Evaluation Unit ratings linked to FROI, 2005-2015 injury dates

Table A.1: Sample Construction

	Target distribution	Analytic sample	Average Weight
Description	FROI with complete cases, 2005-2018	FROI who pass claim administrator screen with complete cases, 2005-2018	
Size of sample	8,730,704	7,381,928	1.18
Description	FROI with complete cases and link to wage data, 2005-2015	FROI who pass claim administrator screen with complete cases and link to matched wage data, 2005-2015	
Size of sample	5,915,526	4,288,361	1.38
Description	FROI with complete cases, 2007-2016	FROI who pass claim administrator screen with complete cases and link to medical data, 2007-2016	
Size of sample	6,314,492	2,955,657	2.14

Description	FROI with complete cases and link to wage records, 2007-2015	FROI who pass claim administrator screen with complete cases and link to medical and wage records, 2007-2015	
Size of sample	4,663,080	2,149,224	2.17
Description	Cases rated at DEU with 2005-2015 injury dates and usable ratings data	DEU cases with link to WCIS	
Size of Sample	372,828	334,421	Not Applicable (unweighted estimates used)

1. FROI merged with SROI, complete cases on age (between 16 and 70), gender, occupation, self-insured status, and self-administered status, 2005-2018 injury dates.

To identify post-injury receipt of benefits, we rely on consistent reporting of the SROI. If we were to include records of individuals who did receive lost-time or settlement payments, but whose claim administrator did not record these benefits, we would systematically bias any estimates that rely on comparing individuals who received benefits to those who did not. Our data include a unique identifier for each administrator managing claims in California. We use this identifier and the FROI and SROI to identify claims administrators who have filed at least 100 claims between 2005 and 2018 and who have reported a SROI for at least 15% of those claims. This process should screen out claim administrators who systematically under-report changes to claims.

As we are interested in outcomes related to the full population of injured workers in California, and not just those who pass this claim administrator screen, we construct weights to match the target distribution described above. To construct these weights, we first partition our data into mutually exclusive categories defined by occupation (Active Firefighters, Public Second, Active Police, Rest of WCIS), period of injury (2005-2009, 2010-2012, 2013+), gender, 15-year age bins, region (Southern California vs. rest-of-California), and self-administered status. We proxy self-administered status as observations where the claim administrator identifier matches the employer identifier. Weights are defined as the ratio of counts in these categories for all observations with complete cases to counts with complete cases who pass the claim administrator screen.

2. Same as sample 1, merged with EDD earnings records, 2005-2015 injury dates.

To examine relative earnings, we make use of a sample of injured workers who match to EDD earnings records and also match to uninjured comparison workers at the same place of employment. More detail about the construction of this comparison group is provided in Dworsky et al. (2018).

The target sample for defining weights in this case is the set of injured workers with complete cases who match to EDD data. The analytic sample is injured workers with complete cases who match to EDD data, pass the claim administrator screen, and match to control worker earnings. We add a categorical variable for the number of employees at the injured worker's place of employment and quartiles of pre-injury earnings to the variables used in step 1 to partition the data to construct weights. 2015 is the last year for which we have earnings data.

3. Same as sample 1, merged with medical records, 2007-2016 injury dates.

We have detailed medical records for a subset of claims whose injuries occurred between 2007 and 2016. Since less than half of our observations link to medical records, we construct weights to correct for bias caused by potential systematic differences in reporting of medical records. In this case, the target sample is the set of injuries with complete cases, and the analytic sample is the set of injuries with complete cases who pass the claim administrator screen and match to medical data. Weights are defined on the same variables as in step 1.

4. Same as sample 1, merged with medical records and EDD records, 2007-2016 injury dates.

To examine the earnings trajectory of injured workers who link to medical records, we construct an analytic sample of injured workers with complete cases, who pass the claim administrator screen, who link to matched earnings, and who link to medical records. Weights are defined on the same variables as in step 2.

A fifth research sample is used in Chapter 6 to analyze patterns of impairment rating and disability benefits:

5. Disability Evaluation Unit ratings linked to FROI, 2005-2015 injury dates

A limitation of our reliance on DEU data is that the population of workers who are rated at the DEU may not be representative of the full population of workers with permanent disability. Furthermore, because permanent disability may take many years to emerge after injury, even the WCIS claims data available at any point in time cannot be treated as a gold-standard measure of the full population of permanently disabled workers from a given injury year. In light of these issues, we do not attempt to reweight the DEU data, and instead report unweighted estimates that reflect the population of cases rated at the DEU that were also reported to the WCIS.

Musculoskeletal Disorder Case Definition (Chapter 3)

As noted in Chapters 2 and 3, there is no consensus definition of musculoskeletal disorders. We focused on the nature and body part of injury as reported on the First Report of Injury. An alternative approach we considered was to use primary and secondary diagnosis (ICD-9) codes reported on medical claims to identify workers with musculoskeletal disorders. Tables A.2 and A.3 list the codes we used to identify MSD claims based on the FROI and the medical claims, respectively.

Table A.2: Identifying Musculoskeletal Disorders Based on the First Report of Injury

Variables	Code Values Included
<i>Part of Body (DN36)</i>	
Neck	21, 22, 25
Upper Extremity	30-35, 38, 39
Trunk	40-47, 61-63
Lower Extremity (for selected analyses)	50-56
<i>Nature of Injury (DN35)</i>	
Dislocation	16
Hernia	34
Inflammation	37
Rupture	46
Sprain	49
Strain	52
Carpal Tunnel Syndrome	78
Other cumulative, NOC	80

Table A.3: Identifying Musculoskeletal Disorders Based on Diagnostic Codes from the Billing Data

Conditions	Diagnostic Categories	Diagnostic Codes
Arthritis and related conditions		274; 446; 710; 711;
	Gout; polyarteritis nodosa, temporal arteritis; disseminated lupus erythematosus, generalized scleroderma; pyogenic arthritis; arthroplasty associated with other disorders classified elsewhere; rheumatoid arthritis; Still's disease; osteoarthritis; traumatic arthritis; internal derangement of the knee; joint derangement, recurrent	713; 714; 715; 716; 717; 718; 719; 720;
	spondylitis; polymyalgia rheumatica; peripheral enthesopathies and allied syndromes; synovitis, tenosynovitis, bursitis, bunion, ganglion; Dupuytren's contracture; fibrositis, myositis, muscular rheumatism; other diseases of the musculoskeletal system and connective tissue	725; 726; 727; 728; 729; 739
Bone disorders		730; 731; 732; 733;
	Osteomyelitis; osteitis deformans, Paget's disease of bone; osteochondritis, Legg-Perthes disease; osteoporosis, spontaneous fracture, other diseases of the bone and cartilage; flat foot, pes planus; hallux vagus, hallux varus, hammer toe	734; 735
Back disorders		721; 722; 723; 724;
	Spondylosis and allied disorders; intervertebral disc disorders; spinal stenosis in cervical region; lumbar strain, lumbago, coccydynia, sciatica; scoliosis, kyphosis, lordosis	737
Repetitive motion disorders		

Carpal Tunnel Syndrome (CTS)	354
Disorders with ill-defined symptoms	
Symptoms such as: leg cramps, leg pain, muscle pain, joint pain	781

Source: Table is adopted with some modifications from Power et al. (2006).

Table A.4 reports a cross-tabulation of this definition against our main definition for the analysis sample used in Chapters 5 and 7 (consisting of complete-records FROI successfully linked to one of more medical claims), limited to the four occupation groups of interest in this study. While the two measures are positively correlated, there is a substantial number of off-diagonal observations. About 39 percent of claims identified as MSD based on the FROI do not have included ICD-9 codes on any medical claims. A similar proportion (38 percent) of claims identified as MSD based on diagnosis codes, meanwhile, are not identified as MSD based on the FROI.

Table A.4: Comparison of MSD Definitions Based on Nature/Body Part of Injury and Diagnosis Codes

Nature and Body Part of Injury	Diagnosis Codes	
	Non-MSD	MSD
Non-MSD	35.49%	9%
MSD	18.22%	%

Source: Authors' Calculations, 2007-2015 WCIS. Sample limited to firefighters and comparable occupations with complete-records FROI with linked medical claims. Table reports percentages of total in each cell. Sampling weights used to produce representative estimates for full population of claims reported to WCIS.

Table A.5 reports the concordance across definitions by occupation. We note that firefighters are much less likely than other occupations to have claims that are identified as MSD based on diagnosis, but not based on nature and body part of injury. Otherwise, the two definitions appear to line up similarly across occupations.

Table A.5: Comparison of MSD Definitions Based on Nature/Body Part of Injury and Diagnosis Codes, by Occupation

Nature/Body Part	Diagnosis	Active Firefighters	Active Police	Rest of Public Sector	Rest of Private Sector
Non-MSD	Non-MSD	34.7%	37.2%	34.9%	39.6%
Non-MSD	MSD	12.4%	20.0%	17.5%	15.8%
Non-MSD	Non-MSD	17.8%	16.2%	18.7%	18.7%
Non-MSD	MSD	35.1%	26.7%	28.9%	25.9%

Source: Authors' Calculations, 2007-2015 WCIS. Sample limited to firefighters and comparable occupations with complete-records FROI with linked medical claims. Table reports percentages of total in each cell. Sampling weights used to produce representative estimates for full population of claims reported to WCIS.

Table A.6 displays the average age and gender composition of the four groups. The diagnosis-based definition identifies a substantially older and somewhat more female group of workers than the definition based on nature and body part of injury.

**Table A.6: Comparison of Age and Gender by Nature/Body Part of Injury and Diagnosis Code
MSD Definitions**

Nature/Body Part	Diagnosis	Age	% Female
Non-MSD	Non-MSD	42.8	43.2%
Non-MSD	MSD	46.3	51.8%
MSD	Non-MSD	42.9	44.0%
MSD	MSD	45.3	45.2%

Table A.7 reports the prevalence of the specific types of diagnoses used in our diagnosis-based definition for the sample of claims that do vs. do not meet the FROI-based definition. The distribution of diagnoses is very similar across columns with one exception: workers who do not meet the FROI-based definition are 4 percentage points more likely to have arthritis reported on a medical claim. This suggests a potential limitation of the diagnosis-based approach, which is that highly prevalent musculoskeletal disorders such as arthritis could appear on the claim even if the workers' compensation claim was not triggered by arthritis. We think this is also consistent with the age differences identified in Table A.6.

Table A.7: Prevalence of Diagnoses by FROI-Based MSD Status for Claims Meeting Diagnosis-Based Definition

	Nature and Body Part of Injury	
	Non-MSD	MSD
Arthritis	80.4%	76.5%
Bone Disorders	5.9%	5.5%
Back Disorders	41.0%	41.7%
Carpal Tunnel Syndrome	10.3%	10.1%
Ill-Defined Symptoms	1.4%	0.8%
Any Diagnoses	100.0%	100.0%

Source: Authors' Calculations, 2007-2015 WCIS. Sample limited to firefighters and comparable occupations with complete-records FROI with linked medical claims who meet diagnosis-based definition of MSD. Columns indicate whether claims also meet FROI-based definition of MSD. Cells report percentage of claims with diagnosis present.

Despite the limitations of the FROI in identifying the full population of MSD cases, we felt that the drawbacks of relying on the medical claims for our primary case definition outweighed the advantages. The limited availability of medical claims data (in terms of years collected and in terms of the high proportion of FROI with no linked medical claims) is a concern. Similarly, we were concerned that the presence of a diagnosis on a medical bill may not necessarily imply that that diagnosis accurately reflected the nature of the injury or work-limiting health condition. We also note that the volume of claims with MSD diagnoses that were not identified as MSD claims under our FROI-based definition is very similar to the volume of claims that meet our FROI-based definition but do not have the corresponding diagnosis codes.

Ultimately, we chose to focus on the FROI-based definition in our study largely due to the much more consistent availability of FROI information in the WCIS data. As implied by the sample sizes reported in Table A.1 above, less than half the complete-records FROI claims with 2007-2016 injury years could be matched to any medical bills. Particularly in earlier years of operation, the WCIS suffered from reporting issues that prevented medical bills from being reliably assigned to the injured worker's FROI. While improvement in WCIS data collection has reduced the proportion of FROI without any medical bills. We judged that the FROI-based definition was likely to allow more consistent comparisons over time, which is an important advantage given our study's focus on trends in case mix and outcomes.

Additional Details on Methods for Earnings Loss Estimation (Chapter 4)

Our primary estimation sample for analysis of earnings losses includes injuries between 2005 and 2015 matched to wage records two years pre- and post-injury. Earnings are inflated to 2014 dollars using the California consumer price index. We remove outliers by estimating the 99.9th percentile of earnings in each quarter relative to injury (17 total quarters), and setting the outlier screen as the minimum of these values. The outlier threshold is \$77,422 in quarterly earnings, which corresponds to \$309,688 in annual earnings. Approximately 0.9% percent of observations are dropped due to this screen. For most of our analyses, we limit the sample to individuals between ages 20 and 64 at the time of injury.

Relative Earnings and Employment Measures Using Uninjured Controls

The estimates of average earnings losses reported in Chapter 4 rely on matching to estimate unadjusted measures of post-injury earnings and employment outcomes. To calculate relative earnings, we divide injured worker earnings in the second year following injury by the counterfactual earnings, which we define (as in Dworsky, Rennane and Broten, 2018) as the control worker's post-injury earnings adjusted by the pre-injury difference in earnings between injured and control workers. This measure can be expressed formally as:

$$\text{Relative Earnings} = \frac{\frac{1}{N} \sum_{i=1}^N \sum_{t=5}^8 y_{i,t}^I}{\frac{1}{N} \sum_{i=1}^N (\sum_{t=5}^8 y_{i,t}^C + \sum_{t=-4}^{-1} (y_{i,t}^I - y_{i,t}^C))}$$

where $y_{i,t}^I$ is the earnings of injured worker i in quarter t after injury, and $y_{i,t}^C$ is the average earnings of injured worker i 's matched controls in quarter t after injury. The summation over injured workers $i = 1$ to N in this expression also emphasizes that relative earnings is a statistic that must be calculated for groups of workers.

We also use the uninjured controls to examine post-injury employment outcomes, defining relative employment as the employment rate for injured workers as percentage of the employment rate for their matched control workers. This measure can be expressed formally as:

$$\text{Relative Employment}_i = \frac{\frac{1}{N} \sum_{i=1}^N E_{i,t}^I}{\frac{1}{N} \sum_{i=1}^N E_{i,t}^C}$$

Relative at-injury employment, which is a measure of return to work at the at-injury employer, are defined analogously by replacing the indicators for employment anywhere with indicators for employment at the at-injury employer.

Regression Models for Earnings Loss Measures Using Medical-Only Controls

To estimate earnings losses due to injury, we also estimate difference-in-difference regression models that compare the earnings of individuals with indemnity benefits to those with medical-only claims, before and after the injury. Because the medical-only control workers are not individually matched to the indemnity claims, we use a differences-in-differences regression approach to estimate outcomes for indemnity injuries relative to the medical-only control group; details are presented in the appendix. We use Poisson regression to accommodate the heavily right-skewed distribution of earnings. This regression model can be written as follows:

$$y_{it} = \exp(\alpha + \beta \text{Indemnity}_i + \gamma \text{Post-Injury}_{it} + \delta \text{Indemnity}_i \times \text{Post-Injury}_{it} + X_{it} \phi) + \varepsilon_{it},$$

where y_{it} is worker i 's earnings at time t , α is a constant, Indemnity_i is an indicator equal to one if i has an indemnity claim and zero otherwise, Post-Injury_{it} is an indicator for post-injury time periods, X_{it} is a set of control variables including age and gender, and ε_{it} is a mean-zero error term uncorrelated with the included variables.

The variable of primary interest is the interaction term $\text{Indemnity}_i \times \text{Post-Injury}_{it}$ between indemnity injury and the post-injury time period, which captures the incremental change in earnings from before the injury to after the injury associated with indemnity (vs. medical-only) claims. Poisson regression coefficients are interpretable as percent changes associated with a unit change in the explanatory variable, and so we subtract the interaction coefficient δ from 100% to derive a relative earnings measure. Besides providing a framework for estimating earnings losses on data that is not individually matched, Poisson regression can accommodate additional control variables, and so we will add age, gender, and cause of injury variables to the regression model to assess whether outcome differences between firefighters and other groups are explained by these types of demographic or case-mix factors.

Our main specification interacts these terms with age dummies to capture the age distribution of earnings losses. To identify occupation-specific effects, we stratify our models by occupation. We also stratify by whether an injury is identified as being related to a musculoskeletal issue.

$$\begin{aligned} y_{it} &= \alpha_q + \sum_{a=2}^5 \beta_a^0 \times \mathbf{1}\{age = a\} \sum_{a=1}^5 \beta_a^1 \times I_i \times \mathbf{1}\{age = a\} + \sum_{a=1}^5 \beta_a^2 \times Post \times \mathbf{1}\{age = a\} \\ &+ \sum_{a=1}^5 \beta_a^3 \times I_i \times Post \times \mathbf{1}\{age = a\} + \sum_{t=0}^1 \beta_t^X \times X_i \times \mathbf{1}\{Post = t\} + \varepsilon_{it} \end{aligned}$$

In this equation, α_q is a fixed effect for quarter of injury, I_i is an indicator for having indemnity claims, $\mathbf{1}\{age = a\}$ is an indicator for whether an observation falls into age category a , $Post$ is an indicator for post-injury observations, and X_i is a vector of control variables, including age interacted with gender, cause of injury, and region in California. The β_a^3 coefficients are the main effects of interest.

We also estimated pooled difference-in-difference regressions to test whether occupation-specific earnings losses are statistically different from each other.

$$\begin{aligned}
 y_{it} &= \alpha_q + \sum_{o=2}^4 \beta_o^0 \times \mathbf{1}\{occ = o\} + \sum_{o=1}^4 \beta_o^1 \times Post \times \mathbf{1}\{occ = o\} + \sum_{o=1}^4 \beta_o^2 \times I_i \times \mathbf{1}\{occ = o\} \\
 &+ \sum_{o=1}^4 \beta_o^3 \times I_i \times Post \times \mathbf{1}\{occ = o\} + \sum_{t=0}^1 \beta_t^X \times X_i \times \mathbf{1}\{Post = t\} + \varepsilon_{it}
 \end{aligned}$$

In this equation, $\mathbf{1}\{occ = o\}$ indexes occupation dummy variables and X_i includes control variables such as age and age interacted with gender. The β_o^3 coefficients are the main effects of interest.

Additional Details on DEU Data Construction (Chapter 6)

DIR provided the RAND research team with data on DEU ratings. A member of the research team (Neuhauser) processed these data and produced a file with information on up to six reports per injured worker. In addition to final ratings before and after apportionment, each report contains detailed information (including impairment numbers, standard ratings, and applicable modifiers) on up to six rated impairments.

Some ratings were missing information on variables critical to our analysis; we considered these reports unusable and deleted these records from our analysis. We considered a report to contain a usable rating if it contained a final rating after apportionment for the overall report and at least one rated impairment with a non-missing final rating; information about rated impairments is necessary to assign ratings to body systems and otherwise characterize the rating process. For some analyses below (such as studying how apportionment affects ratings), missing data for specific variables required us to further narrow the sample definition by casewise-deleting ratings that were missing variables used in specific analyses. These additional sample restrictions generally had a trivial impact on sample sizes; observation counts are reported in table notes.

This study required us to further compress the information in the DEU to one rating per injured worker, which required additional data processing. We focused attention on the three most recently recorded disability rating reports; only 2.6 percent of injured workers rated at the DEU received more than three reports. When multiple reports using the same rating method (*AMA Guides* or *Almaraz*) appear in the DEU database, we use information from the most recent report. Across all years, 3.3 percent of workers have only an *Almaraz* rating in the DEU data and another 4.9 percent of workers received both *Almaraz* and *AMA Guides* reports.⁴⁵ We focus on

⁴⁵ These figures include workers who were rated at the DEU before the *Almaraz* rulings in 2009 affirmed the acceptability of alternative rating methods. For workers injured in 2010 and later years, one in eight (12.9 percent) of workers received an *Almaraz* rating at the DEU, with 5.6 percent receiving only an *Almaraz* rating and 7.4 percent receiving both *Almaraz* and *AMA Guides*.

AMA *AMA Guides* ratings since this is the rating method over which the legislature and the Director of DIR have the most direct control. However, we also report some findings on recent trends in the frequency of *Almaraz* ratings.

Finally, it was necessary to combine multiple reports in some cases because specialists often submit ratings for specific impairments to the DEU as separate reports. This practice is commonly observed for psychiatric impairments as well as other impairments (such as hearing loss) that might not be effectively evaluated by the primary treating physician or other non-specialist evaluating physician. Given our study's emphasis on comorbid psychiatric conditions among firefighters with musculoskeletal disorders, inclusion of these separately submitted specialist reports is important for the accuracy of our disability rating data. For cases with separately submitted specialist reports, we calculated a new final rating using the formula set forth in the PDRS for combining multiple ratings.

We linked the WCIS data described in earlier chapters to the DEU so that we could maintain consistency with the definitions of musculoskeletal disorders and occupational groups used elsewhere in this study. RAND and DIR used a number of direct and indirect identifiers to link DEU and WCIS data, since there is no unique claim ID number that appears in both datasets. Of 372,828 claims that had DEU ratings with usable data, we were able to match 334,421 (89.6 percent) to a WCIS claim.⁴⁶ Since DIR estimates that WCIS FROI data are 91 to 92 percent complete, we view a 90 percent match rate from DEU to WCIS as very close to the upper bound.

An additional concern with our analysis had to do with differences between firefighters and other occupations in the types of ratings performed at the DEU. In comparison to other occupations, firefighters were much less likely to receive Consult ratings from the DEU. 24 percent of constant-maturity ratings for firefighters are Consult ratings, versus 42 percent for police, 36 percent for other public-sector workers, and 44 percent for private-sector workers. We were not able to determine if this pattern reflected a difference in legal representation rates between firefighters and other occupations, or a difference in the share of represented cases that reach the DEU--the latter might indicate differences in the representativeness of DEU data between firefighters and other occupations.

To examine this question, we used data provided by DIR indicating whether a WCIS claim matched to a record in the Electronic Adjudication Management System (EAMS), a case management system used for scheduling proceedings in disputed cases. Having an EAMS record is a reasonable proxy for disputes requiring legal representation. In the WCIS, firefighters and police with paid PD benefits are both much less likely than the other occupations to have representation as measured in the EAMS. Since police are much more likely to have consult ratings at the DEU, this pattern does raise the possibility that firefighters with legal representation are more likely to bypass the DEU. The mix of rating types within occupations is stable over time, however, so we do not believe there is evidence of changes over time in selection into the DEU that would bias analysis of changes in ratings after SB 863.

⁴⁶ 90.3% of these cases were matched to a unique WCIS record by DIR programmers, 7% were disambiguated by RAND based on information on the WCIS data, and 2.7% were randomized.

In light of these issues, we do not attempt to reweight DEU records to obtain representative estimates for the full population of permanently disabled workers. Instead, results presented in this chapter reflect unweighted calculations and are intended to represent disability rating outcomes for cases that are rated by the DEU. When analyzing ratings and benefits, we stratify most analyses by the type of rating, providing estimates separately for consult and summary ratings. Notwithstanding these concerns about the representativeness of the DEU, it is, by far, the most complete and detailed data source on permanent disability ratings in California workers' compensation. There is no feasible alternative dataset capable of addressing the research questions posed here.

Additional Details on Counting Visits Subject to Treatment Caps (Chapter 7)

We classified all outpatient medical bills reported to the WCIS as falling into one of the three capped categories or falling outside the caps. We defined two criteria to identify chiropractic, OT, and PT visits subject to the treatment caps established under LC 4604.5. This section provides additional detail on our methods.

First, we used specialty codes to identify providers likely to be targeted by each treatment cap. We used the following definitions

- Chiropractic: provider specialty code begins with 111N ("Chiropractic Providers")
- PT: provider specialty code begins with:
 - 2081 ("Physical Medicine & Rehabilitation")
 - 2251 ("physical therapist")
 - 2252 ("physical therapy assistant")
- OT: *among providers not identified as PT*, provider specialty code begins with:
 - 225X or 224Z ("Occupational Medicine - Therapist")

In addition to flagging claims based on the specialty of the provider, we developed a list of procedure (HCPCS) codes corresponding to chiropractic manipulation, occupational therapy, and physical therapy. We compiled this list by reviewing professional society websites and consulting CMS's Physical Therapy Multiple Procedure Payment Reduction code lists, which were used by Swedlow (2005) to identify Physical Therapy and Chiropractic Manipulation bills. Our full list of included codes is in Table A.2:

Table A.2: Procedure Codes Used to Identify Capped Services

PT	C	Description	Chiropra ctic	T	T
8940	9	Spinal Chiropractic Manipulative Treatment	X		
8941	9	Spinal Chiropractic Manipulative Treatment	X		
8942	9	Spinal Chiropractic Manipulative Treatment	X		
8943	9	Extraspinal Chiropractic Manipulative Treatment	X		
8771	9	Phys Ther Assess/Eval; Limited New Pt			
8772	9	Phys Ther Assess/Eval; Intermed New Pt			
8773	9	Phys Ther Assess/Eval; Extended New Pt			
8774	9	Phys Therapist Assess/Eval; Comprehen New Pt			
8775	9	Phys Ther Assess/Eval; Limited Estab Pt			
8776	9	Phys Therapist Assess/Eval; Intermed Estab Pt			
8777	9	Phys Ther Assess/Eval; Extended Estab Pt			
8778	9	Phys Ther Assess/Eval; Comprehen Estab Pt			
7001	9	Pt Evaluation			
7002	9	Pt Re-Evaluation			
7003	9	Ot Evaluation			
7004	9	Ot Re-Evaluation			
7110	9	Therapeutic Exercises	X		
7112	9	Neuromuscular Reeducation			
7113	9	Aquatic Therapy/Exercises			
7116	9	Gait Training Therapy			
7124	9	Massage Therapy			
7140	9	Manual Therapy	X		

9		
7150	Group Therapeutic Procedures	X
9		
7530	Therapeutic Activities	X
9		
7533	Sensory Integration	
9		
7535	Self Care Mngment Training	
9		
7537	Community/Work Reintegration	
9		
7542	Wheelchair Mngment Training	
9		
7750	Physical Performance Test	
9		
7755	Assistive Technology Assess	
9		
7760	Orthotic Mgmt and Training	
9		
7761	Prosthetic Training	
9		
7762	C/O for Orthotic/Prosth Use	

Analysis in Chapter 7 uses the specialist code alone to identify capped services. A stricter definition that requires both the specialty of the treating provider and the procedure code to indicate that a service was utilized was constructed for sensitivity analysis. In practice, these definitions were similar. The proportion of specialist visits that also matched our list of procedure codes was 60 to 87 percent for chiropractic, 81 to 87 percent for OT, and 78 to 88 percent for PT, depending on the injured worker's occupation and whether the claim was a musculoskeletal disorder case. We emphasize findings based on provider specialty because this more inclusive definition would be more likely to identify high utilizers affected by the treatment caps.

Table A.3 replicates Table 7.1 from the text using the more restrictive definition of capped services based on procedure codes as well as specialty codes. Utilization rates and patterns are very similar to those presented in Table 7.1, although firefighter OT utilization appears to be much lower when we restrict our OT visit count to OT procedure codes.

Table A.3: Share of Injured Workers with Indemnity Benefits Receiving Any Capped Services, by Injury Type, Service Type, and Occupation, Alternative Service Definition

		Active Firefighters	Active Police	Other Public-Sector	Private- Sector Comparison
Chiropractic	MSD	7.3%	7.8%	9.7%	11.4%
	Non-MSD	3.3%	5.6%	6.4%	5.9%
Occupational Therapy	MSD	3.1%	3.9%	5.1%	3.3%
	Non-MSD	2.1%	3.0%	5.0%	7.5%
Physical Therapy	MSD	45.6%	47.9%	55.7%	52.2%
	Non-MSD	18.8%	25.7%	38.3%	34.4%
Number of Observations					
	Non-MSD	2977	9796	44758	4039
	MSD	4744	8451	59863	4824

Table A.4 replicates Table 7.2 from the text using the more restrictive definition of capped services based on procedure codes as well as specialty codes. Mean utilization is very similar to that reported in Chapter 7.

Table A.4: Average Visit Counts for Injured Workers with Indemnity Benefits Receiving Any Capped Services, by Injury Type, Service Type, and Occupation, Alternative Service Definition

	Active Firefighters	Active Police	Other Public-Sector	Private- Sector Comparison
Non-MSD	8.7	9.5	9.2	8.2
MSD	9.1	8.9	9.0	7.7
Non-MSD	6.0	8.4	8.8	9.6
MSD	6.5	7.0	7.8	5.6
Non-MSD	12.1	11.8	11.4	12.4
MSD	12.5	12.8	12.0	11.5

B. Appendix: Sensitivity Analyses and Additional Results

This appendix contains additional results referenced in the main text, as well as sensitivity analyses.

Additional Results and Sensitivity Analyses for Earnings Loss Analysis (Chapter 4)

Additional Results for Earnings Loss Chapter

Table B.0 shows unadjusted earnings and employment outcomes (analogous to Table 4.2) for non-MSD injuries by occupation. Labor market outcomes for firefighters with non-MSD injuries are worse than those observed among MSD injuries, yet remain generally better than those observed in the comparison occupations.

Non-MSK Injuries	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison
Earnings (\$)				
1 Year Pre-Injury	\$122,495	\$65,284	\$57,197	\$65,082
1 Year Post-Injury	\$114,170	\$57,774	\$48,310	\$54,993
2 Years Post-Injury	\$109,632	\$57,072	\$46,805	\$54,634
Relative Earnings				
1 Year Post-Injury	93%	88%	84%	85%
2 Years Post-Injury	92%	90%	84%	89%
Relative Employment				
1 Year Post-Injury	96%	91%	91%	90%
2 Years Post-Injury	91%	91%	89%	91%
Relative At-Injury Employment				
1 Year Post-Injury	95%	87%	89%	83%
2 Years Post-Injury	90%	83%	85%	76%

Source: 2005-2015 WCIS-EDD

Sensitivity Analysis for Earnings Loss Chapter

We were concerned that reporting of 4850 benefits might not be uniform across jurisdictions. Underreporting of 4850 benefits to the WCIS would lead us to underestimate benefit payments to firefighters, while reporting of 4850 benefits as wage and salary income might lead us to underestimate earnings losses. After inquiring with an occupational safety director at a public agency, we confirmed that 4850 benefits are to be reported to the WCIS as "Employer Paid" benefits (benefit type code 240). Similarly, examination of the EDD employers' handbook makes

it clear that disability benefits should not be counted as wage and salary income. Given that 4850 benefits are tax-exempt, it would seem inappropriate for these payments to be reported to the base wage file since they should not be subject to UI tax withholding or other payroll taxes.

That said, the previous RAND study suggested that some fire departments and local governments may erroneously report 4850 benefits as wage and salary income, which would tend to mask earnings losses for the duration of 4850 time. In particular, the previous study found a drop in firefighter earnings at one year post-injury, which corresponds to the time limit for 4850 benefits.

To evaluate the robustness of our analysis to this form of misreporting, we produced earnings loss estimates focusing solely on the second year after injury, after the expiration of 4850 time. We also defined a stricter medical-only control group intended to guard against the possible misclassification of lost-time injuries as medical-only cases due to misreporting of 4850 benefits. Specifically, we used a variable on the first report of injury indicating the date when disability began to identify a number of cases without indemnity benefits that may have experienced some lost time. We reasoned that workers who receive 4850 time and no other indemnity benefits might also have a disability date reported. We note that this is a somewhat conservative approach to identifying medical-only control group: because of California's three-day waiting period for temporary disability benefits, we think that most, if not all, of these workers are correctly classified as medical-only cases.

We find that earnings loss estimates focusing on the second year after injury are very similar to those focusing on the first two years after injury: proportional earnings losses for firefighters with indemnity benefits (6.08 percent reduction in earnings) are about 7 percentage points less than losses for police (13.7 percent reduction in earnings), while losses for other public-sector workers and private-sector workers are larger still (14.5 and 14.9 percent reduction in earnings, respectively). Removing medical-only claims with a disability start date reported does not have a meaningful effect on these estimates. While we cannot rule out the possibility that misreporting of 4850 benefits occurs in some situations, these results indicate to us that such misreporting does not drive our findings.

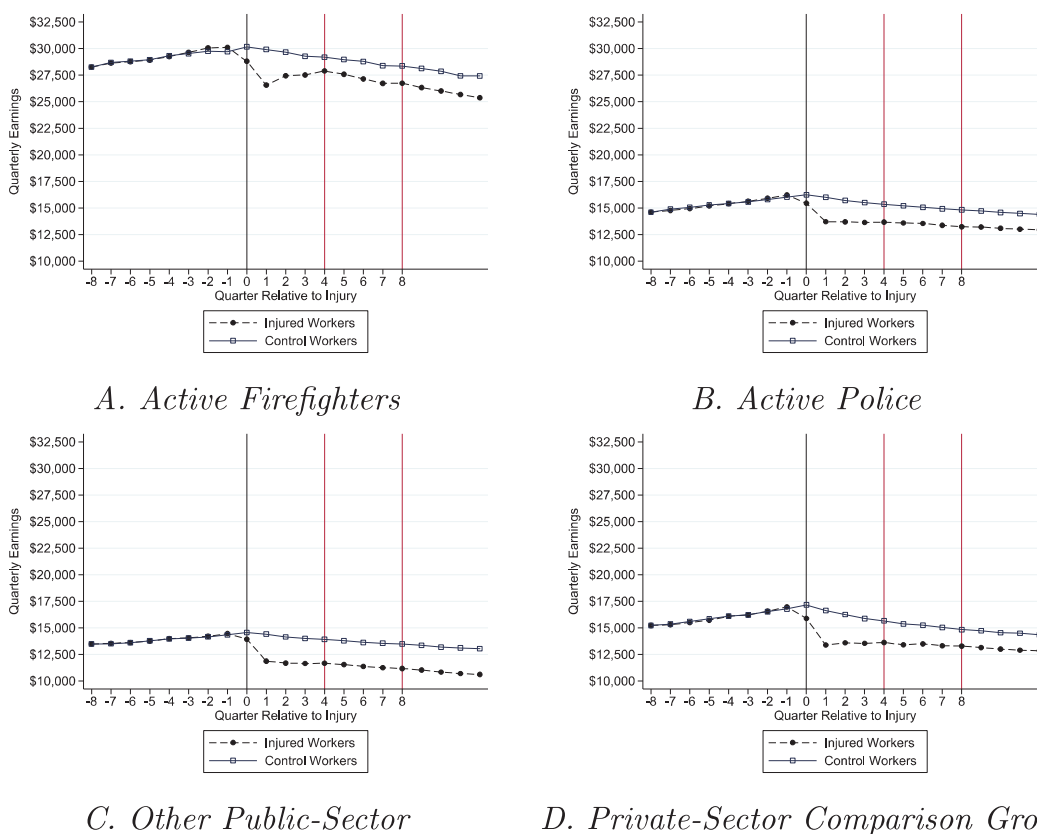
Table B.1: Sensitivity Analysis of Earnings Loss Estimates Accounting for Potential Misreporting of LC §4850 Benefits

Effect of Indemnity Injury on Earnings in Second Post-Injury Year				
	Active Firefighters	Active Police	Other Public-Sector	Private-Sector Comparison Group
No Covariates	0.0669*** (0.0105)	0.152*** (0.0104)	0.153*** (0.00460)	-0.160*** (0.0224)
Adjusted for Gender and Age at Injury	0.0608*** (0.0100)	0.137*** (0.00984)	0.145*** (0.00443)	-0.149*** (0.0220)
Effect of Indemnity Injury on Earnings in Second Post-Injury Year, Control Group Limited to Cases with No Disability Date Reported				

No Covariates	0.0647*** (0.0110)	0.161*** (0.0107)	0.150*** (0.00509)	-0.171*** (0.0235)
Adjusted for Gender and Age at Injury	0.0628*** (0.0105)	0.145*** (0.0100)	0.145*** (0.00490)	-0.164*** (0.0232)

As noted in Chapter 4, stakeholder concerns were also voiced that earnings losses might not materialize in the first two years after injury. Figure B.1 presents earnings trajectories for injured and control workers up to three years post-injury.

Figure B.1: Injured and Control Worker Earnings to Three Years Post-Injury, by Occupation



Additional Results for Disability Rating Analysis (Chapter 6)

Table B.2A presents summary statistics on DEU ratings by occupation for all injuries (including both MSD and non-MSD injuries). Average ratings on non-MSD injuries are higher than on MSD injuries.

Table B.2.A: Summary Statistics on Disability Ratings for by Rating Type for All Injuries, Complete-Records and Constant-Maturity Samples

A. All Ratings (2005-2015 Injuries, Any Maturity)

	Consult	Summary	Formal	Total
Final Rating	28.0	13.1	39.0	20.6
N	26,679	28,373	676	55,728

Number of Impairments

0	6.1	3.3	1.2	4.6
1	47.8	79.8	40.1	64.0
2	21.7	13.0	20.6	17.2
3	10.7	2.6	12.1	6.6
4+	13.6	1.4	26.0	7.5

Duration to Rating from Injury Date

Mean	1079	682	1376	881
Median	902	569	1218	713

B. Constant-Maturity Ratings

	Consult	Summary	Formal	Total
Final Rating	24.1	12.2	35.0	16.9
N	15,178	23,547	268	38,993

Number of Impairments

0	5.1	3.0	1.5	3.8
1	54.5	81.9	51.5	71.0
2	21.0	11.8	20.2	15.5
3	9.1	2.2	9.3	4.9
4+	10.2	1.1	17.5	4.7

Duration to Rating from Injury Date

Mean	632	521	679	565
Median	636	502	699.5	556

Table B.2 reports the ten most common impairment numbers for firefighters rated at the DEU, as discussed in Chapter 6.

Table B.2: Top 10 Permanent Impairments for Firefighters with Musculoskeletal Disorders

	Active Firefighters	%	Cumulat ive
Lumbar – Diagnosis-related Estimate	15.03. 01.00	25.7%	25.7%
Knee – Diagnosis-based Estimate – Meniscectomy	17.05. 10.04	14.9%	40.5%
Shoulder – Other	16.02. 02.00	9.8%	50.3%
Shoulder – Range of Motion	16.02. 01.00	9.2%	59.5%
Cervical – Diagnosis-related Estimate (DRE)	15.01. 01.00	6.7%	66.2%
Knee – Other	17.05. 06.00	5.2%	71.4%
Knee – Arthritis	17.05. 03.00	3.9%	75.3%
Knee – Muscle Atrophy	17.05. 01.00	2.7%	78.0%
Lumbar – Range of Motion – Soft Tissue Lesio	15.03. 02.02	1.9%	79.9%
Knee – Diagnosis-based Estimate – Cruciate/collateral Ligament	17.05. 10.05	1.7%	81.6%

To assess the statistical significance of pre- to post-SB 863 changes in final ratings, we regressed final ratings on date of injury fully interacted with occupation. To test whether changes were significantly different between firefighters and other occupations, we replaced the firefighter and firefighter*post-863 dummy variables with a constant and an uninteracted post-863 dummy variable. As discussed in Chapter 6, we provide two sets of estimates: one using the full 2005-2012 period as the pre-863 baseline, and one using only 2010-2012 injuries as the baseline. Table B.3 reports estimates for Consult ratings, and Table B.4 reports estimates for Summary ratings.

Table B.3: Post-SB 863 Changes in Ratings and Differences Across Occupations, Consult Ratings

A. Post-SB 863 Difference from...	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012 Average	3.033 (1.928)	3.897*** (0.916)	2.114*** (0.477)	1.519 (2.103)
2010-2012 Average	0.497	3.459***	0.0709	-0.490

	(2.523)	(1.071)	(0.575)	(2.646)
B. Difference from Firefighters				
2005-2012 Average	-	0.864	-0.919	-1.514
	-	(2.135)	(1.986)	(2.853)
2010-2012 Average	-	2.963	-0.426	-0.987
	-	(2.741)	(2.588)	(3.656)

Post-SB 863 Differences Panel (A) presents linear regression coefficients from regression of final rating after apportionment on interaction between post-SB 863 indicator and full set of occupation indicators (with no excluded category), with no constant. First row of table (Difference from 2005-2012 Average) reports regression including 2005-2015 injury dates. Second row of table (Difference from 2010-2012 Average) restricts sample to 2010-2015 injury dates. Difference from Firefighters Panel (B) uses same outcome and samples as Panel A, but reparametrizes regression to test differences between comparison occupations and firefighters by replacing the firefighter indicator and firefighter*Post-SB 863 interaction term with a constant and an uninteracted Post-SB 863 indicator.

Table B.4: Post-SB 863 Changes in Ratings and Differences Across Occupations, Summary Ratings

A. Post-SB 863 Difference from...	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012 Average	3.152*** (0.574)	2.101*** (0.459)	1.887*** (0.238)	2.915** (1.260)
2010-2012 Average	2.674*** (0.669)	1.941*** (0.541)	1.733*** (0.274)	2.810* (1.442)
B. Difference from Firefighters				
2005-2012 Average	-	-1.051 (0.735)	-1.266** (0.622)	-0.238 (1.385)
2010-2012 Average	-	-0.733 (0.860)	-0.941 (0.723)	0.136 (1.589)

Post-SB 863 Differences Panel (A) presents linear regression coefficients from regression of final rating after apportionment on interaction between post-SB 863 indicator and full set of occupation indicators (with no excluded category), with no constant. First row of table (Difference from 2005-2012 Average) reports regression including 2005-2015 injury dates. Second row of table (Difference from 2010-2012 Average) restricts sample to 2010-2015 injury dates. Difference from Firefighters Panel (B) uses same outcome and samples as Panel A, but reparametrizes regression to test differences between comparison occupations and firefighters by replacing the firefighter indicator and firefighter*Post-SB 863 interaction term with a constant and an uninteracted Post-SB 863 indicator.

Tables B.5 and B.6 report the proportion of consult and summary ratings that were performed using alternative rating procedures authorized by the *Almaraz* decisions and codified in SB 863. *Almaraz* ratings increased for both types of ratings in all occupations. Particularly sharp increases were apparent for firefighters and other public-sector workers with Summary ratings.

Table B.5: Almaraz Ratings by Injury Date and Occupation, Consult Ratings

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	7.8%	10.8%	12.0%	9.8%
2013-2015	10.3%	13.9%	14.5%	10.6%
2005-2015	8.6%	11.9%	12.8%	10.0%
Change	2.5%	3.1%	2.5%	0.9%

Table B.5: Almaraz Ratings by Injury Date and Occupation, Summary Ratings

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	2.9%	2.5%	3.7%	2.4%
2013-2015	7.0%	4.1%	8.7%	3.1%
2005-2015	4.2%	3.0%	4.9%	2.5%
Change	4.1%	1.5%	5.0%	0.7%

Finally, Tables B.6 and B.7 report the percentage of consult and summary ratings on which apportionment to non-occupational cause was recommended by the evaluating physician. As noted in the text, apportionment increased sharply on Consult ratings. While firefighters experienced the largest increase in apportionment, a comparable increase was observed among the private-sector comparison group, and apportionment more than doubled in three of the four occupation groups examined. Meanwhile, there were no major changes in the frequency with which apportionment was recommended on summary ratings. Unfortunately, consult ratings are not reported to the DEU in a format that allows measurement of the rating before apportionment, and so it is not possible with the data at hand to determine how large an impact apportionment has on ratings and benefits.

Table B.6: Proportion of Ratings with Apportionment Recommended by Injury Date and Occupation, Consult Ratings

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	9.2%	6.4%	11.1%	7.3%
2013-2015	19.4%	12.4%	15.4%	16.0%
2005-2015	12.4%	8.5%	12.6%	9.7%
Change	10.1%	6.0%	4.2%	8.6%

Table B.7: Proportion of Ratings with Apportionment Recommended by Injury Date and Occupation, Summary Ratings

Injury Date	Active Firefighters	Active Police	Other Public Sector	Private-Sector Comparison Group
2005-2012	8.6%	8.3%	13.5%	9.2%
2013-2015	8.0%	10.1%	14.4%	7.2%
2005-2015	8.4%	8.8%	13.7%	8.7%
Change	-0.6%	1.8%	0.9%	-2.0%