Industrial Cancers in California's Workers' Compensation System

Evidence on Earnings Losses and Disability Benefits

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SOCIAL AND ECONOMIC WELL-BEING

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Preface

Although cancer makes up a small proportion of the workers' compensation caseload in California, cancer is a serious disease that has the potential to cause severe work disability, catastrophic medical expenses, and death. The adequacy of disability benefits for workers with occupational cancer is thus an issue of considerable public concern. In recent years, California's approach to compensating workers with industrial cancer has become controversial. Permanent disability (PD) compensation in California is based on impairment ratings, which are assigned using a methodology that provides no specific guidance on how to rate cancer. Some observers have raised concerns that the impairment rating process may be overly subjective or unfair, resulting in disparities in benefits between similarly situated workers—specifically between men and women—with respect to the disability caused by their cancers.

In response to concerns over potential gender bias in disability compensation, the California State Legislature has passed several bills to modify the disability rating process for cancer. All of these bills were vetoed by the governor. This report, which was requested in Governor Jerry Brown's September 2018 veto message for Assembly Bill (AB) 749, was commissioned by the state Department of Industrial Relations (DIR) in order to inform the ongoing debate over compensation for industrial cancer in California. In this report, we provide new evidence on the following questions:

1. What level of earnings losses is experienced by workers who file workers' compensation claims for industrial cancer in California?
2. What are the average benefit payments and wage replacement rates for these workers?
3. Is there evidence of gender differences among workers with industrial cancer in earnings losses, benefits, or wage replacement rates?
4. How have reforms to PD benefits implemented in 2013 affected compensation for industrial cancers?

We address these research questions using administrative claims data from the California workers' compensation system. To track labor market outcomes of workers with industrial cancer, the workers' compensation claims were linked to quarterly earnings records collected by the state Employment Development Department (EDD).

This report builds on other recent research by the RAND Institute for Civil Justice (ICJ) on earnings losses and postinjury outcomes for workers who experience occupational injuries and illnesses in California, including a recent study on musculoskeletal disorders among firefighters. The intended audience consists of legislators and other policymakers in California, as well as various stakeholders with an interest in the health and safety of public safety workers in California. Because all state workers' compensation systems face similar challenges with respect to compensating occupational cancers, policymakers in other states may also find this research

informative. Questions about this report should be directed to the project leader, Michael Dworsky (email: mdworsky@rand.org).

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Summary

California's workers' compensation system requires employers to provide medical care and disability (or indemnity) benefits to workers who experience workplace injuries and illnesses, including occupational cancer. Although cancer makes up a very small proportion of the workers' compensation caseload in California, cancer is a serious disease that has the potential to cause severe work disability, catastrophic medical expenses, and death. The adequacy of benefits for workers with occupational cancer is thus an issue of considerable public concern. In addition, the near impossibility of tracing most cases of cancer to specific events or exposures creates challenges for workers' compensation policy and raises concerns about workers' ability to access the benefits provided to them under the law. Compared with workers who suffer from traumatic injuries or even occupational diseases with known, specific causes, workers with most types of cancer may face substantial difficulty in demonstrating that workplace exposures played a role in causing their cancers, opening the door to contentious disputes, delayed compensation, or outright claim denials.

California, like many other states, has sought to minimize the delays and transaction costs arising from such disputes by establishing legal *presumptions*. These presumptions, which apply only to specified groups of public safety workers, provide that cancers "developing or manifesting" within a specified period following workplace exposure are work related, and therefore covered by the workers' compensation system. For firefighters and peace officers with a demonstrated history of work-related exposure to known carcinogens, Sec. 3212.1 of the California Labor Code (LC) creates a broad presumption that any cancer is work related unless the worker's primary cancer site is established as one with no reasonable link to any carcinogens the worker encountered on the job. For lifeguards employed by public agencies, Sec. 3212.11 creates a similar presumption that is limited to skin cancer. Workers not covered by cancer presumptions can also file claims for occupational cancers, but these claims are compensable only if the worker can demonstrate that occupational exposures were a *contributing cause* to their cancers—a much higher evidentiary bar given the high latency and potentially complex causation of most cancers. Workers' compensation claims for occupational cancer in California are therefore largely—but not exclusively—filed by the three groups of public safety workers covered by the presumptions: peace officers, firefighters, and lifeguards.

In recent years, California's approach to compensating workers with occupational cancer has generated significant controversy and legislative attention. Much of this controversy stems from concerns about the fairness of permanent partial disability (PPD) benefits for workers with occupational cancer. Permanent disability (PD) compensation in California is based on impairment ratings, which are assigned using the methodology outlined in the fifth edition of the American Medical Association's (2001) *Guides to the Evaluation of Permanent Disability*

(hereafter *AMA Guides*). The *AMA Guides*, however, provide no specific guidance on how to rate cancer. Some observers have raised concerns that the impairment rating process may be overly subjective or unfair, resulting in disparities in benefits between similarly situated workers—specifically between men and women—with respect to the disability caused by their cancers. In response to these concerns over gender bias in disability compensation, the California State Legislature passed several bills between 2014 and 2018 that would have modified the disability rating process for cancer. All of these bills were vetoed by former Governor Jerry Brown.

The ongoing controversy over compensation for occupational cancers has proceeded largely without the benefit of quantitative evidence on many basic questions about the frequency and composition of occupational cancer claims, the extent of earnings loss resulting from occupational cancer, the average level of disability compensation provided, or the nature of gender differences in labor market outcomes or compensation for workers with occupational cancer. In Governor Brown's September 2018 veto message for Assembly Bill (AB) 749, the Department of Industrial Relations (DIR) was instructed to conduct an empirical study intended to provide legislators, stakeholders, and the general public with a common foundation of evidence on these questions. This study, which was commissioned by DIR, addresses the following research questions:

1. What level of earnings losses is experienced by workers who file workers' compensation claims for industrial cancer in California?
2. What are the average benefit payments and wage replacement rates for these workers?
3. Is there evidence of gender differences among workers with industrial cancer in earnings losses, benefits, or wage replacement rates?
4. How have reforms to PD benefits implemented in 2013 affected compensation for industrial cancers?

In this report, we address these research questions using administrative claims data from the California workers' compensation system. To measure the labor market outcomes of workers with industrial cancer, workers' compensation claims were linked to quarterly earnings records collected by the state Employment Development Department (EDD). Earnings losses for workers with occupational cancer claims were estimated by comparing changes in their earnings and employment after the date of injury with a control group consisting of demographically identical workers in the same occupations and industries who filed minor, or *medical-only*, workers' compensation claims expected to result in minimal long-term earnings losses. We used claims data to calculate the proportion of workers who received disability benefits for temporary disability (TD), PD, or death. We also estimated the dollar value of benefits paid to workers and compared these with our estimates of earnings losses, allowing us to describe pretax wage replacement rates. For a subsample of workers who received disability ratings from the state Disability Evaluation Unit (DEU), we also described average disability ratings for workers with cancer claims.

In order to provide sufficient follow-up data to estimate medium-term earnings losses, we focus on workers with a *date of injury* between 2005 and 2015 whose nature of injury, as indicated on the initial workers' compensation claim, is cancer.[1] Our sample includes all workers who filed claims for occupational cancer between these dates, including those whose claims encountered a full or partial claims denial. Estimates presented in this summary are for workers meeting this case definition who had reliable workers' compensation claims data, and who were linked to their earnings histories, yielding a cohort of 1,865 workers with occupational cancer.

Key Findings

The remainder of this summary highlights key findings of this study and identifies policy recommendations and top priorities for future research on occupational cancers in California's workers' compensation system.

Workers with cancer claims in California are overwhelmingly—but not exclusively—public safety workers covered by presumptions

Table S.1 presents descriptive statistics on the demographic and occupational makeup of workers who filed workers' compensation claims for cancer (*workers with cancer claims*). Forty-six percent of workers with cancer claims in our sample are peace officers, a category that includes police, sheriffs' deputies, certain correctional officers, and a variety of other law enforcement agents employed by state or local government.[2] Thirty-five percent of workers with cancer claims are firefighters, and 8 percent of workers with cancer claims are lifeguards. Workers in other occupations who are not employed by state or local government agencies—a group that comprises 94 percent of non-cancer workers' compensation claims in California—make up the remaining 11 percent of workers with cancer claims. Among these other occupations, manufacturing, utilities, construction, mining, quarrying, and gas extraction have elevated rates of cancer claims compared with their prevalence in the overall workers' compensation caseload. Workers with cancer claims are also an average of 6.3 years older than others in the workers' compensation system, as we would expect given that both cancer incidence and detection rise with age. They are also overwhelmingly male: just 13.6 percent of workers with cancer claims in our sample were female, while 41.2 percent of workers with a non-cancer claim were female. This gender breakdown largely reflects the demographics of

[1] In cancer and other occupational disease claims, LC Sec. 5412 defines the date of injury as the date when the employee first experienced disability from his or her disease *and* knew, or reasonably should have known, that the disease was work related. In the case of high-latency diseases such as cancer, where the worker may have stopped work before the cancer manifested or became disabling, the date of injury could be recorded as the date of diagnosis, the date of first attribution to occupational causes, or the worker's latest date of harmful exposure.

[2] The cancer presumption established by LC Sec. 3212.1 applies to peace officers as defined in the California Penal Code Secs. 830.1 and 830.2.

Table S.1. Demographics, Benefit Receipt, and Claim Outcomes of Workers' Compensation Claims, by Cancer vs. Non-Cancer Nature of Injury

	Cancer	All Non-Cancer Claims
Demographics		
Average age	45.9	39.6
Proportion female	13.6%	41.2%
Occupation		
Peace officers	46.1%	4.2%
Firefighters	34.7%	1.5%
Lifeguards	8.2%	0.1%
Other occupations	11.1%	94.3%
Benefit receipt		
Any indemnity benefits?	41.6%	28.3%
Temporary total disability	15.7%	23.4%
Permanent disability	36.2%	14.4%
Death benefits	2.2%	0.0%
Other claim outcomes		
Worker died	5.5%	0.1%
Any claim denial (full or partial)	28.5%	8.6%
Number of cases	1,865	3,177,505

the public safety occupations that account for the majority of cancer claims in the workers' compensation system.

Table S.1 also illustrates the severity of cancer in terms of disability and mortality. Workers with cancer are more than twice as likely than workers with non-cancer workers' compensation claims to receive PD benefits, and death benefits are paid to the survivors of 1 in 50 workers who files a cancer claim; the comparable figure for workers with non-cancer claims is 1 in 2,000. Death benefits are paid only when a worker dies and has surviving dependents, and so the receipt of death benefits understates mortality among workers with both cancer and non-cancer worker' compensation claims. When we construct a broader measure of mortality that includes workers with a reported date of death, we find that 5.5 percent of workers with cancer claims had their death reported to the claims administrator, versus 0.1 percent of non-cancer claims. Finally, cancer claims are far more likely (28.5 percent) to result in a full or partial denial than are other claims (8.6 percent).

There are substantial differences in worker characteristics and claim outcomes between workers with and without coverage by cancer presumptions

While it may be unsurprising that workers with cancer claims have very different characteristics from others with workers' compensation claims, there are also important differences in demographics, benefit receipt, and claim denial rates across occupational groups (Table S.2). Lifeguards with cancer are substantially younger than peace officers or firefighters,

Table S.2. Demographics, Benefit Receipt, and Claim Outcomes, and Annual Earnings for Workers with Cancer Claims, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations
Demographics				
Average age	45.8	47.4	37.1	48.5
Proportion female	17.1%	4.5%	17.1%	25.1%
Benefit receipt				
Any indemnity benefits?	41.9%	47.6%	17.8%	39.1%
Temporary total disability	17.0%	15.6%	0.0%	22.2%
Permanent disability	35.7%	43.1%	17.8%	30.4%
Death benefits	2.4%	1.9%	0.0%	3.9%
Other claim outcomes				
Any claim denial (full or partial)	29.1%	23.6%	2.6%	60.4%
Worker died	5.6%	4.3%	0.0%	13.0%
Annual earnings				
2 years before date of injury	$115,506	$143,799	$60,225	$51,094
1 year before date of injury	$118,706	$146,059	$62,745	$52,596
Number of cases				
Male	712	618	126	155
Female	147	29	26	52
Total	859	647	152	207

are much less likely to receive disability benefits, and actually experience claim denials at a lower rate than the average non-cancer claim. We suspect these differences reflect, among other factors, the fact that the cancer presumption for lifeguards is limited to skin cancer, which is often easier to detect than many other cancers, and, in the case of nonmelanoma skin cancers, are also generally easier to treat than other cancers.

Table S.2 also suggests important differences in severity and claim outcomes between workers in other occupations and public safety workers other than lifeguards. Besides being older at the date of injury, workers in occupations that lack cancer presumptions are more likely to receive TD benefits but are less likely to receive PD benefits. The impact of presumptions on claim outcomes is illustrated by comparing the claim denial rate among other occupations with the rates observed for peace officers and firefighters. While peace officers and firefighters with cancer claims face high claim denial rates (of 29 percent and 24 percent, respectively) the majority (60 percent) of cancer claims from workers in other occupations encounter a partial or full claim denial. Despite these high claim denial rates, workers in other occupations are the group most likely to receive death benefits. In fact, fully one in eight of these workers is reported to have died, more than double the rate observed among peace officers or firefighters. This pattern of high claim denial rates combined with high mortality may suggest that workers in other occupations may be less likely than public safety workers to file claims for low-severity or

early-stage cancers. This contrast suggests that the presumptions are succeeding in reducing the barriers for covered workers to access compensation for occupational cancers. However, other explanations for this pattern cannot be ruled out without more detailed information on primary cancer site or stage at diagnosis; such information was not available in the claims data used in this study.

Earnings prior to the date of injury—which is likely to reflect either the date of diagnosis or the date of last injurious exposure in cancer cases—also vary widely across occupations. The high annual earnings immediately before injury for firefighters ($146,000) and peace officers ($119,000) reflect, in part, the fact that claims are often filed at or very close to retirement, when these workers are likely to be at their peak career earnings. Lifeguards have lower average earnings ($63,000) prior to injury both because they are younger on average and because they may work only on a seasonal basis. Workers in other occupations, meanwhile, are older but earn less ($53,000) than the public safety workers, and they exhibit much slower earnings growth leading up to the date of injury.

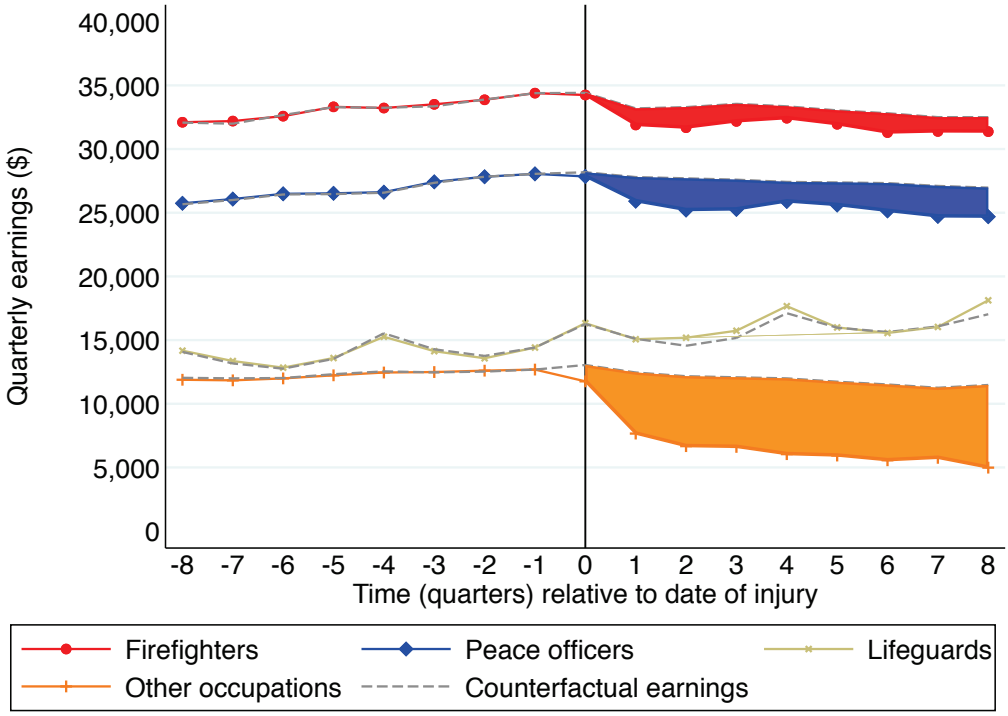
Table S.2 also documents differences in the gender distribution across occupations that constrained our analysis. Female workers with cancer claims are predominantly peace officers, although the highest proportion of female cancer claims is observed among workers in other occupations. The number of cancer claims filed by female firefighters or lifeguards, meanwhile, is too low for us to provide informative estimates of gender differences within these occupations, and so our analysis of gender differences is primarily limited to peace officers and workers in other occupations.

In short, the differences documented in Table S.2 suggest that the population of workers with cancer claims is likely to differ fundamentally across occupations in terms of severity, claim outcomes, and earnings dynamics. We accordingly analyze outcomes separately by occupation throughout this report.

Cancer leads to substantial earnings losses for most workers, but outcomes vary widely across occupation groups

Figure S.1 presents our estimates of the effect of cancer on earnings for the four occupation groups examined in this study. As indicated in Table S.2, preinjury earnings and patterns of earnings dynamics are very different across groups. Over the two years after injury, we estimate that firefighters lose 4.5 percent of earnings ($10,000) and peace officers lose 8.6 percent of earnings ($18,000). Lifeguards, remarkably, do not exhibit any adverse labor market impact after a cancer claim: Figure S.1 shows that the earnings trajectory for lifeguards is, if anything, slightly higher than what would be observed in the absence of a cancer claim. Workers in other occupations, meanwhile, lose two-thirds (66 percent) of their earnings on average after a cancer claim. Even though workers in other occupations have earnings less than half the level observed among peace officers and firefighters before the claim, their losses in dollar terms ($43,000) also exceed those for any occupation group examined in this study.

Figure S.1. Earnings Losses After Cancer Claims, by Occupation



NOTE: Figure plots average quarterly earnings for workers with cancer claims from two years before to two years after the date of injury, stratified by occupation. Date of injury in cancer claims represents the date of last known exposure, which is likely to be the date of diagnosis for workers who are diagnosed while employed. Counterfactual earnings are estimated based on weighted least squares regression models described in Chapter 3 and the Appendix using medical-only injuries from workers in the same occupation as a control group. Shaded areas represent earnings losses due to cancer.

Permanent disability and death benefits are responsive to differences in earnings losses across occupation groups, but pretax wage replacement rates still vary widely across occupations

It appears likely that these differences in earnings losses across occupations reflect differences in severity, as suggested by the patterns of benefit receipt and mortality reported in Table S.1. In the report, we confirm that disability ratings performed by qualified medical examiners at DEU are also lowest for lifeguards (average final rating 6.4 percent), are higher for firefighters (average final rating 16.2 percent), higher still for peace officers (average final rating 21 percent), and highest for workers in other occupations (average final rating 26.8 percent).[3]

[3] These figures refer to final ratings reflecting adjustments for occupation, age, and type of impairment, which are used to determine PPD benefits. By comparison, the average final disability rating for non-cancer claims with DEU ratings available was 19.1 percent.

Table S.3 compares average paid benefit amounts with estimated earnings losses over five years after injury and reports pretax wage replacement rates. We caution that we did not have access to five years of follow-up data for most workers, and so five-year earnings losses were extrapolated from our estimates of two-year earnings losses under strong assumptions. Accounting for the tax exemption of workers' compensation benefits would also increase all wage replacement rates, and would do so differentially for higher-income workers. Notwithstanding those caveats, Table S.3 shows that pretax wage replacement rates for workers with cancer claims are 39 percent for workers in other occupations, 49 percent for peace officers, and 86 percent for firefighters.

Table S.3. Pretax Wage Replacement Rates over Five Years, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations
5-year earnings losses (extrapolated)	$40,826	$25,966	–$14,850	$103,669
(Standard error)	($5,205)	($6,536)	($5,778)	($6,920)
Average benefit payments	$19,860	$22,407	$3,266	$40,122
Pretax wage replacement rates	49%	86%	>100%	39%

Benefit adequacy for workers with PD is a perennial concern in California. Senate Bill (SB) 863, a major reform package enacted in 2012, used several policy levers to increase benefits. To assess the impacts of SB 863, we compared disability ratings performed at DEU for injuries with dates before and after SB 863 took effect in 2013. As expected, the average final disability rating increased substantially for workers injured in 2013 and later. However, due to the limited number of workers with cancer who receive ratings at the DEU, this change was not statistically significant despite being large in practical terms.

We did not find evidence of widespread gender differences in earnings losses, disability ratings, or benefit payments within occupation, but estimates were imprecise due to the limited number of female workers with cancer claims

Much of the controversy and legislative attention that led this study to be commissioned focused on concerns about gender bias in the disability rating system, which would result in unfair disparities in benefit payments to male and female workers with cancer. To provide evidence that can help inform this ongoing debate, we estimated gender differences in the earnings loss resulting from cancer, in disability ratings, and in paid benefit amounts. Among peace officers, we did not find any statistically significant difference in earnings losses between male and female workers with cancer claims. If anything, female peace officers with cancer had slightly smaller earnings losses (both in dollar terms and as a percentage of earnings) than male peace officers, but these gender differences were imprecisely estimated and were not statistically significant. Among workers in other occupations, we found that earnings losses were substantially

lower for female workers than for male workers with cancer claims, by $21,000 over two postinjury years. Gender differences in disability ratings and paid disability benefits, meanwhile, were statistically insignificant.

Policy Implications and Research Priorities

While the scope of this study was limited to establishing basic facts about the consequences of and compensation for occupational cancer in California, several findings with policy implications emerged. First, the sharp differences across occupations that we documented in mortality, claim denials, and earnings losses are consistent with patterns that we would expect to see if California's presumptions have succeeded in removing barriers to claim filing for public safety workers. Even for peace officers and firefighters, however, rates of full or partial denial on cancer claims are several times higher than those observed for the average workers' compensation claim. Detailed examination of delays in benefit payment or medical treatment, or of whether claim denials reflect full or partial denials, were beyond the scope of this study. Our ability to attribute differences across occupations to the cancer presumptions is also limited by our lack of data on type of cancer or stage at diagnosis. It is clear, however, that presumptions have not eliminated disputes over compensation; yet the contrast with workers in other occupations also suggests that disputes on public safety worker claims would be far more widespread in the absence of presumptions.

We also found that earnings losses experienced by workers who file cancer claims differ widely across occupations. Most strikingly, we detected no earnings losses for lifeguards who filed cancer claims. As a proportion of their earnings, the losses experienced by firefighters and peace officers with cancer claims were actually less severe than losses for the average injured worker who received indemnity benefits during this time period. An interim report from the RAND Corporation's ongoing Wage Loss Monitoring Study found that earnings losses for the average worker who received indemnity benefits for an injury between 2005 and 2015 ranged between 19 and 24 percent of earnings in the first year after injury and between 15 and 21 percent of earnings in the second year after injury—compared with losses of 4.5 percent of earnings for firefighters and 8.9 percent of earnings for peace officers over two years after injury. Workers in other occupations, meanwhile, experience much larger earnings losses in both percentage and dollar terms than we observed for other injured workers. Nonetheless, the earnings losses experienced by firefighters and peace officers are substantial in dollar terms.

Regarding gender bias, the data available for the present study do not support the conclusion that women who file cancer claims experience worse labor market outcomes than male workers in the same occupational groups who file cancer claims. Nor did we find strong evidence of gender differences in disability ratings, paid benefits, or claim denial rates. These gender differences were imprecisely estimated, however, due to the small numbers of female workers who filed cancer claims in most occupations. In contrast to gender differences, differences in

earnings losses between workers with cancer claims who were covered by cancer presumptions and those without cancer presumptions were remarkably large, and led to large disparities in pretax wage replacement rates across occupational groups. The proportion of average pretax earnings losses replaced by benefits was relatively high (86 percent) for firefighters, but was far lower for peace officers (49 percent) and lower still for workers in other occupations (39 percent). Workers in these other occupation groups had high disability ratings and also had the highest benefit payments of any occupation group examined here, but the benefits were not high enough to offset these workers' substantial earnings losses. A detailed analysis of impairment rating methods was beyond the scope of this study, but the differences in wage replacement rates between peace officers and firefighters may be of interest to stakeholders and policymakers.

Many questions of interest to California policymakers were beyond the scope of this study. In particular, the patterns of ratings and benefit payments reported here do not speak to the question of discrimination or gender bias in application of the disability rating system. A more detailed examination of rated impairments from a sample of cases with identical clinical characteristics would be necessary to address whether, for instance, evaluating physicians treat female and male workers with the same cancer and impairment severity differently. However, very few ratings of female workers with cancer claims are performed at DEU, and it is likely that we would not have been able to obtain informative estimates of differences in impairment rating methods with data available to DIR. A more fruitful approach might be to conduct an audit or correspondence study in which trained actors or hypothetical case files are submitted to practicing qualified medical examiners for rating. Similarly, there do not appear to be enough female workers who actually file cancer claims in California to obtain precise estimates—even with data on the entire population—of earnings losses associated with specific primary cancer sites or types of cancers by gender.

A more worrisome limitation of our study is that we lacked data on workers with occupational cancer—potentially including those who would meet the evidentiary standards applicable to their occupations—who do not file a workers' compensation claim for their cancer. Our case definition is also likely to omit claims that were filed prior to a cancer diagnosis, or where cancer was comorbid with other injuries or diseases. Unfortunately, our inability to capture medical claims and diagnoses outside workers' compensation (most notably from workers' group health coverage) means that alternative case definitions based on workers' compensation medical claims are unlikely to provide a valid estimate of the true number of cancer cases in the workers' compensation system.

Data sources beyond the workers' compensation system will be necessary to provide definitive answers to many of the questions raised by our findings, particularly those related to how presumptions affect claiming behavior, or how earnings losses vary with cancer site and staging. Linking workers' compensation data to group health claims with a consortium of large public employers or, potentially, a retiree health care system would dramatically improve the credibility of our claims-based case ascertainment approach. Notably, California is exploring the

development of a Health Care Cost Transparency Database, which could also be used to examine cancer treatment and patient out-of-pocket costs for commercially insured workers who do not file workers' compensation claims.

California also maintains a high-quality cancer registry, which would be vastly superior to claims data as a source of information on cancer site, stage at diagnosis, and clinical outcomes. Linkage of the data used in the present study to the cancer registry would be the most reliable way to produce the site-specific estimates of earnings losses that would be necessary to develop an empirically grounded benefit schedule or develop other alternatives to current rating methods. Finally, if policymakers wish to understand the effect of presumptions on claiming behavior or on the existence of barriers to claim filing among workers currently covered by presumptions, it may be necessary to link the state cancer registry to public agency personnel records or EDD data on earnings and employment. These efforts were far beyond the scope of the present study, but may represent valuable directions for future work on occupational cancer in California.

Acknowledgments

We wish to acknowledge staff at DIR who clarified numerous institutional details about the operation of cancer presumptions, standards of causation in the broader workers' compensation system, and technical details related to medical billing and date of injury in occupational disease cases, among other topics. Other staff at DIR and EDD also contributed to this study by providing RAND Corporation with the data used in our ongoing Wage Loss Monitoring Study, from which the analytic datasets used here were drawn. Nicholas Broten and Cheryl Montemayor at RAND did excellent work in preparing the extracts of data used for this study, and their efforts were critical to the completion of this report. We are also grateful to other staff at RAND for administrative support with this study. Finally, we wish to thank our peer reviewers, Stephanie Rennane of RAND and Ellen Meara of the Dartmouth Institute for Health Policy and Clinical Practice.

Abbreviations

AB	Assembly Bill
AMA	American Medical Association
BLS	Bureau of Labor Statistics
DEU	Disability Evaluation Unit
DIR	Department of Industrial Relations
EDD	Employment Development Department
FEC	future earnings capacity
FROI	First Report of Injury
ICD	International Classification of Diseases
LC	Labor Code
MMI	maximum medical improvement
NAICS	North American Industry Classification System
PD	permanent disability
PPD	permanent partial disability
PTD	permanent total disability
SB	Senate Bill
SROI	Subsequent Report of Injury
TD	temporary disability
TTD	temporary total disability
WCIS	Workers' Compensation Information System

1. Introduction

As in other states, California's workers' compensation system requires employers to provide medical payments and cash indemnity benefits to workers who experience job-related injuries or illnesses, defined to include injuries "arising out of and in the course of the employment" (Labor Code [LC] Sec. 3600[a]). In addition to injuries, workers' compensation covers occupational diseases arising out of and in the course of employment, including cancer. Due to the severity of cancer, workers with cancer are likely to suffer substantial earnings losses and may rely on permanent partial disability (PPD) benefits to offset these losses.

California's approach to compensating workers with permanent disability (PD) is based on the fifth edition of the American Medical Association's (2001) *Guides to the Evaluation of Permanent Impairment* (hereafter *AMA Guides*), which have a major limitation in the context of cancer, namely that cancer is not included as a ratable impairment in the *AMA Guides*. Instead, the impairment rating approach taken by the current LC means that evaluating physicians are responsible for examining cancer patients and rating all apparent impairments attributable to the cancer (including consequences of cancer treatment).

Policy Context and Research Questions

The *AMA Guides*' lack of specific guidance on how to rate cancer has raised concerns that the rating process may be overly subjective or unfair, resulting in disparities in benefits between similarly situated workers with respect to the disability caused by their cancers. In particular, some worker advocates have identified the treatment of cancers in gender-specific organs (such as the breast or prostate) as an area where the *AMA Guides* rating approach leads to unfairly low levels of compensation for women.

In response to these concerns, the California State Legislature passed three bills in four years (Assembly Bill [AB] 479 in 2018, AB 1643 in 2016, and AB 305 in 2015) that would have created statutory changes to the disability rating procedures applicable to breast cancer. The 2015 and 2016 bills would also have prohibited apportionment of disability to preexisting causes related to certain gender-specific factors; a bill passed in 2017, AB 570, would have addressed the use of gender in apportionment without directly addressing breast cancer rating procedures. All four of these bills were vetoed by former Governor Jerry Brown. In his veto message for AB 479 in 2018, the governor instructed the director of the state Department of Industrial Relations (DIR) to commission an "evidence-based study" of the issue. Three questions were articulated in the governor's veto message:

1. Do the standards for determining impairment due to occupational injury or illness accurately reflect the level of impairment caused by industrial cancer?

2. Study and compare the differences between the fifth and sixth editions of the *American Medical Association Guides* with respect to determining impairment resulting from industrial cancer.
3. Do the standards for determining impairment resulting from industrial cancer exhibit bias based on immutable characteristics such as gender, race, or ethnicity?

As a first step toward addressing these questions, DIR commissioned the present study.

Research Questions

The scope of this study was set forth by DIR as the first phase of an anticipated two-phase approach to addressing the governor's questions.[1] Specifically, this study consists of an empirical analysis of earnings losses, disability ratings, and benefit payments for occupational cancer claims in the California workers' compensation system. We address the following four empirical questions:

1. What level of earnings losses is experienced by workers who file workers' compensation claims for industrial cancer in California?
2. What are the average benefit payments and wage replacement rates for these workers?
3. Is there evidence of gender differences among workers with industrial cancer in losses, benefits, or wage replacement rates?
4. How have reforms to PD benefits implemented in 2013 affected compensation for industrial cancers?

By documenting the extent of earnings losses due to cancer and comparing these losses with benefit payments, this study is intended primarily to address the first question posed in the governor's veto message. Subgroup analyses comparing earnings losses, disability ratings, and benefit payments by gender can also shed light on one aspect of the third question posed in the governor's veto message. A full examination of questions related to different editions of the *AMA Guides*, or of bias in the rating system, is beyond the scope of the present study.

Background

In California, nonfatal workplace-related injuries or illnesses may be classified as *medical-only*, *temporary disability*, or *permanent disability*. Medical-only claims involve no lost time beyond the three-day waiting period, so the only benefits provided consist of medical treatment and earnings losses resulting from these injuries are negligible. A temporary work-related injury or illness is defined as one that prevents a worker from doing his or her usual work for more than

[1] The Invitation for Bid that specified the scope of this project identified the current study as the first of two anticipated phases of research on California's approach to occupational cancer: "The first phase includes an empirical analysis of wage loss, disability ratings, and benefit adequacy for workers with cancer claims in California. The second phase will follow with a closer examination of the *AMA Guides* and the rating process in California in relation to industrial cancer claims" (DIR, 2019, pp. 4–5).

three days or that requires an inpatient hospital admission. Workers with a temporary condition will collect weekly temporary total disability (TTD) or temporary partial disability benefits until they return to work at full wage or reach maximum medical improvement (MMI), at which time the worker can be evaluated for PD.

Workers' compensation also pays for all necessary medical care related to the injury or illness for the rest of the worker's lifetime. In contrast to most private health insurance and Medicare, there is no patient cost-sharing in workers' compensation: the entire cost of care is paid by employers or their workers' compensation insurers. As the cost of health care in the United States has risen, medical care has absorbed a growing share of total workers' compensation benefits: nationwide, workers' compensation spending on medical benefits has been roughly equal to spending on indemnity benefits since 2008 (Weiss, Murphy, and Boden, 2019).

The primary focus of this study is on earnings losses and benefits for workers with cancer claims. Research questions related to medical spending or treatment patterns were outside the scope of this study. Limitations in the quality and availability of medical billing data for cancer claims (which we discuss further in Chapter 2 and the Appendix) would have posed significant barriers to studying cancer treatment provided through the workers' compensation system even if these questions were in scope. Although we do not focus on medical care in this study, the basic structure of workers' compensation medical benefits is relevant context for the issues examined here.

Benefits and Permanent Disability Compensation in California's Workers' Compensation System

Injured workers who attain MMI but still have some residual disability as a result of the injury are potentially eligible for Permanent Partial Disability (PPD) or permanent total disability (PTD) benefits. The amount of PD benefits received by the injured worker is tied directly to the disability rating. After a disability rating is determined, the worker is eligible for regular weekly payments for a number of weeks that increases with the disability rating. The weekly benefit rate is two-thirds of the worker's preinjury wage subject to a maximum set by the LC. Workers with very high disability ratings (70 or more) are also eligible for a small weekly life pension in addition to their PPD benefits. Workers with a 100 percent disability rating receive PTD benefits.

Ultimately, around 15 percent of injured workers who file a workers' compensation claim—about half of those who receive indemnity benefits—will receive PPD benefits.[2] Because these

[2] Very few workers are determined to be 100 percent disabled, and PTD benefits are thus infrequently used. We estimate that 1.0 percent of cancer cases receive PTD benefits without also receiving PPD benefits. This group accounts for 3.4 percent of workers with PD (i.e., those with either PPD or PTD benefits). In this report, we refer to workers who receive either type of disability benefits as "workers with PD," even though the vast majority of these workers receive PPD benefits and not PTD benefits.

workers represent the most severe nonfatal injuries in the system, they require a disproportionate share of medical care and receive 80 percent or more of total indemnity benefits—including PD and TD—paid for nonfatal injuries in the system. In total, PPD benefits accounted for about 38 percent of indemnity benefits paid to injuries that occurred in 2013. In light of the severity of these injuries, providing adequate and fair compensation to these workers is one of the most important policy challenges facing the workers' compensation system. Not surprisingly, given the inherent complexity of disability rating and the proportion of indemnity benefit expenditures that go to permanently disabled workers, disability evaluation and compensation have also proven to be reliably controversial elements of California's workers' compensation policy.

Since 2005, the basis for disability ratings in the state has been impairment ratings conducted according to the fifth edition of the *AMA Guides* (LC Sec. 4660[b]1). In this report, we refer to unadjusted *AMA Guides* impairment ratings as *standard ratings*, following historical usage in California. In order to assign a worker a final disability rating that can be used to determine PPD benefits, impairment ratings based on the *AMA Guides* ratings are adjusted according to rules specified in the state's Permanent Disability Rating Schedule (PDRS). For workers injured between 2005 and 2012, the PDRS included adjustments for three factors: age, occupation, and future earnings capacity (FEC). FEC adjustments scaled up disability ratings by a factor ranging between 1.1 and 1.4, with the factor depending on the type of impairment. After calculating a final disability rating, evaluating physicians are required to apportion PD to nonindustrial cause, meaning that disability ratings are scaled down in proportion to the percentage of disability that the physician determines to be attributable to preexisting health conditions. While these adjustments are important, *AMA Guides* impairment ratings are the most important factor determining a worker's final disability rating, and thus their level of PPD compensation.

The adoption of the *AMA Guides* is widely thought to have improved the consistency of California's disability rating system compared with the state's pre-2005 disability rating schedule. However, the net effect of the changes to the PD rating system brought about by Senate Bill (SB) 899 was a substantial reduction in the size of PD ratings: the adoption of the *AMA Guides* led to a reduction because the average rating in the *AMA Guides* is lower than the rating assigned to a similar impairment evaluated using the pre-2005 PDRS. Neuhauser (2007) found that the average permanent disability rating in California after adoption of the *AMA Guides* system was 41.7 percent lower than under the PDRS prior to adoption. Additionally, he found that 9.8 percent of all PD cases included apportionment in 2006, leading to an average reduction in ratings of 40.1 percent in apportioned cases. Overall, the apportioning of PD to causation reduced total PPD benefit payments by almost 6 percent, and the total decline in PD awards that could be attributed to lower disability ratings was more than 50 percent.

Permanent Disability Rating and Other Reforms Included in Senate Bill 863

In September 2012, California adopted SB 863 as an attempt to contain medical costs for injured workers while restoring some of the PPD benefits that had been reduced by the adoption of the *AMA Guides*. The SB 863 reforms to both medical treatment and PD were complex and far reaching; we describe the medical treatment reforms only briefly here.[3] Several provisions of SB 863 established processes related to dispute resolution (including independent medical review and independent bill review) and made changes to the qualified medical examiner process and the regulation of medical provider networks. Reimbursement for medical services also shifted dramatically with the adoption of the Resource-Based Relative Value Scale. In comparison to California's previous fee schedule, adoption of RBRVS increased payments for evaluation and management services and reduced payments to specialists. There were also changes to facility fees for ambulatory surgery centers and payment for spinal hardware. Some of these reforms to medical treatment might be anticipated to affect provider incentives to provide care to cancer patients through the workers' compensation system. The effects of SB 863 on medical treatment were outside the scope of this study, however, and the statewide implementation of SB 863 makes it challenging, if not impossible, to disentangle the effects of these policy changes from other factors that changed over time, such as the state of the labor market or broader health care reforms. We do not examine the medical treatment provisions of SB 863 in this report, but we note them here to provide context for our analysis of changes in labor market outcomes for injured workers following implementation of SB 863.

SB 863 also made several important changes to PD benefits. First, the FEC adjustment was eliminated by setting the FEC adjustment factor to 1.4 for all impairments. At any given standard rating, this change to the FEC mechanically increased the final disability ratings for all workers except those whose impairments already had an adjustment factor of 1.4.[4] Second, the maximum weekly wage used to calculate PPD benefits was raised for the first time since 2006. Workers injured between January 1, 2006, and December 31, 2012, were eligible for up to $230 per week in PPD benefits if their final disability ratings were under 50 percent, and up to $270 per week if their disability ratings were 50 percent to 99 percent. SB 863, enacted in 2012, phased in a higher maximum weekly wage, resulting in a maximum weekly benefit of $290 for all workers with PD; this higher maximum benefit was fully phased in for injuries occurring in 2014 or later years. The maximum weekly wage is far below typical earnings in California, so the vast

[3] This discussion draws heavily on Chapter 1 of Dworsky, Rennane, and Broten, 2018. For additional background information, including a more detailed summary of SB 863's main provisions, see DIR, 2013.

[4] Prior to SB 863, psychiatric impairments and hearing loss were the only two types of impairments that received the maximum FEC adjustment of 1.4. Another provision of SB 863 limited compensation based on certain types of secondary impairments (i.e., impairments for sexual dysfunction, psychological disorders, and sleep disorders that were reported as sequelae of another primary impairment). These secondary impairments were rarely used, however, and so the overall impact on ratings of these limitations was expected to be limited (Dworsky et al., 2016).

majority of workers stood to benefit from the increased maximum benefit; over two in three permanently disabled workers injured in 2012 had weekly wages above the pre-SB 863 cap (Dworsky et al., 2016). Third, SB 863 created a return-to-work program to be funded at $120 million per year that would provide supplemental payments to injured workers whose PD benefits were disproportionately low in comparison to their earnings losses. In April 2015, DIR established the Return-to-Work Supplement Program, which provides a flat $5,000 payment to permanently disabled workers who do not receive a qualifying return-to-work offer from their at-injury employers.

In short, SB 863 was designed to increase PPD benefits, by increasing both the final rating assigned to a worker with a given standard rating and the amount of weekly benefit payments for most workers. It was not clear a priori whether workers with cancer claims would experience larger or smaller increases in PPD benefits than the average worker in the system. As noted above, cancer is not listed as a ratable impairment in the *AMA Guides*, and so a wide variety of impairments might be rated in different cancer claims, depending on the body systems affected and the nature of impairments that result.

Occupational Cancers and Cancer Presumptions in California

In addition to injuries, workers' compensation covers occupational diseases arising out of and in the course of employment, including cancer. The most likely mechanism for work to cause cancer is exposure to carcinogens in the workplace or while carrying out job duties. The National Institute of Occupational Safety and Health (2019) reports that 3–6 percent of cancers worldwide are estimated to be caused by occupational exposures.

Many factors affect an individual's risk of developing cancer, however, and it may be impossible to demonstrate with "reasonable medical probability" that work exposure contributed to any particular individual's cancer. It can also take a long time for cancer to develop, further complicating the process of determining compensability for cancer as a generic occupational disease for most workers. As a consequence, the volume of cancer claims filed in the California workers' compensation system is limited (roughly 500 cases per year since 2005 identified as cancer on the First Report of Injury [FROI]) compared with a statewide yearly average of about 70,000 new cancer diagnoses in adults aged 20–64.[5]

For specific public safety workers with a history of exposure to known carcinogens, however, the California LC significantly lowers this evidentiary threshold by establishing a disputable presumption that cancer is work related. LC Sec. 3212.1 establishes a presumption that cancer is work related for firefighters and peace officers; a similar presumption covering skin cancer in lifeguards is established by LC Sec. 3212.11. When Sec. 3212.1 was added to the

[5] Workers' compensation case count with nature of injury reported as cancer (74) from DIR, 2018; statewide case count from Department of Public Health, 2018.

LC in 1982, California became the first state in the nation to establish a legal presumption that cancer in firefighters was work related and compensable under workers' compensation; legal presumptions covering occupational cancer and other occupational diseases in firefighters have since been adopted in most states (Forrest, 2016).

Due to these presumptions, workers' compensation claims for cancer are overwhelmingly filed by firefighters, peace officers, and lifeguards. The analysis in this report emphasizes these three groups of public safety workers. Workers not covered by presumptions can also file workers' compensation claims for occupational cancer, however, and there is a meaningful volume of these claims in the data. While we were not able to study how presumptions affect claiming behavior in this report, we know from a large body of evidence that underclaiming (i.e., workers failing to file workers' compensation claims for truly work-related injury and illness) is widespread throughout workers' compensation. A study from Michigan that linked workers' compensation claims to occupational disease cases ascertained by the state Department of Public Health found that fewer than half of workers with occupational disease filed a workers' compensation claim (Biddle et al., 1998). We note that these estimates were derived from data on cases identified between 1992 and 1994 in Michigan, and so the external validity of these findings for the present-day California labor market is uncertain. Furthermore, it is impossible to know a priori if underclaiming for cancer would be more or less extensive than for other occupational diseases. On the one hand, the relatively high latency and complex causation of cancer may suggest that workers would be less likely to attribute cancer to occupational causes and file a claim. On the other hand, the severity and high financial burden of cancer treatment could incentivize workers to pursue workers' compensation claims for cancer when the transaction costs and uncertainty involved might deter them from filing claims for less serious occupational diseases.

While it was far beyond the scope of this study to identify workers with occupational cancers who did not file workers' compensation claims, we expect that there are major differences in claim-filing behavior between firefighters and peace officers (who have broad cancer presumptions), lifeguards (who have a narrow cancer presumption applying only to skin cancer), and workers in all other jobs (who have no presumptions and must establish that workplace exposures were a contributing cause to their cancer). These differences are likely to influence the mix of cases observed in the workers' compensation system in each occupation group. Given the potential for disputes, delays in care, and other transaction costs, we also conjecture that workers in other occupations may be more likely than public safety workers to base their claim-filing decisions, in part, on both the severity of their cancer and the extent of disability and earnings losses that they experience. We have no way of directly testing this hypothesis with the data at hand or within the scope of this study, however.

To sum up, all findings in this study must be interpreted carefully in the context of California's cancer presumptions. All research on the outcomes for workers who file workers' compensation claims must contend with threats to validity posed by the potential self-selection

inherent in a worker's claim-filing decision, but the sharp differences in evidentiary standards across occupational groups make this issue far more acute for cancer claims than for most other occupational injuries or illnesses. Notwithstanding these limitations of our study, earnings losses and benefits for workers who file workers' compensation claims for cancer can still play an important role in informing ongoing policy deliberations. In particular, differences in earnings losses across occupation groups can indirectly illuminate the importance of cancer presumptions in making compensation and medical care available to workers with cancer.

2. Data and Methods for Studying Earnings Loss and Benefits Due to Occupational Cancer

This chapter provides an overview of the data sources used in this study and our analytic methods. Our analysis of earnings losses compares workers with cancer with workers in the same occupation who filed minor, medical-only injury claims. The use of a control group of workers in the same occupation (e.g., comparing firefighters with cancer with other firefighters who had only minor injuries) ensures that differences in earnings due to cancer are not attributable to unobserved differences across occupations in labor market dynamics.

Because identification of cancer claims and assignment of workers to occupational groups are central to our methods, this chapter emphasizes our definitions of these concepts and how we applied these to the administrative data used here. We then present summary statistics on the characteristics of workers with and without cancer, and the characteristics of workers with cancer claims in different occupational groups. Finally, provide an overview of our estimation strategy for measuring earnings losses due to cancer.[1]

Data Sources

In order to make efficient use of resources and enable completion of this study within the timeline set by former Governor Brown's veto message, we did not engage in additional data collection specifically for this study. Rather, we used several datasets that are currently being analyzed at the RAND Corporation as part of the ongoing Wage Loss Monitoring Study and the recently completed Firefighter Musculoskeletal Injuries Study. A comprehensive discussion of these data sources is presented in Chapter 2 of Dworsky, Rennane, and Broten (2018). Our approach to identifying active firefighters was developed and is comprehensively described in Chapter 3 of Dworsky, Seabury, and Broten (2019).

We make use of several administrative data sources for this project, all of which have been used for prior RAND studies (e.g., Dworsky et al., 2016; Peterson et al., 1998; Reville et al., 2005; Seabury et al., 2011). The key DIR databases used in this study include the Workers' Compensation Information System (WCIS) FROIs and Subsequent Reports of Injury (SROIs), and ratings performed at the state Disability Evaluation Unit (DEU). We use these data to identify cancer claims and injury dates (FROI), measure relevant worker and case characteristics and covariates (FROI and SROI), construct measures of benefit payments (SROI), and describe disability ratings and statutory benefit levels (DEU). Finally, to estimate earnings losses due to

[1] Technical details related to estimation of earnings losses are presented in the Appendix.

injury, we use data and methods currently in use for RAND's Wage Loss Monitoring Study. In particular, we relied on earnings and employment records provided by the state Employment Development Department (EDD) to measure postinjury labor market outcomes.

The WCIS FROI/SROI and EDD data used in this study, which are quite complex, are described at length in Chapter 2 and Appendix A of Dworsky, Rennane, and Broten (2018). We provide only a limited introduction to these data here; interested readers should consult that report for further details on the WCIS FROI/SROI and EDD data. The discussion here draws heavily on the more extensive presentation of data and methods in that report. Instead, we use this chapter to provide more detail on techniques specific to the current study, such as cancer case ascertainment and the use of occupation and industry codes to identify worker subgroups of interest—these techniques are described in the subsections below on case ascertainment and defining occupation groups.

We also extracted medical billing data reported to the WCIS, which we used to develop alternative definitions of cancer for sensitivity analyses. However, as we discuss below, the value of the medical claims data for this study was severely limited because the WCIS is unlikely to capture medical care that is not initially billed to the compensation system, even if it is eventually paid for by workers' compensation. Thus, while many workers with cancer claims did not have workers' compensation medical bills consistent with cancer diagnoses or sustained cancer treatment, we were unable to rule out the possibility that workers without cancer diagnoses on their workers' compensation medical bills were simply seeking cancer treatment through their group health coverage instead of through workers' compensation.

Workers' Compensation Information System

The WCIS, which was developed and is managed by DIR, was legislated in 1993 and implemented starting in 2001. Information at the individual claim level is transferred from claims administrators to DIR using the Electronic Data Interchange formats developed by the International Association of Industrial Accident Boards and Commissions. In 2001, DIR began collecting EDI versions of the FROI and SROI. In 2007, DIR began collecting transaction-level medical treatment data at the claim level, including procedures, diagnoses, and payments. In addition, claims administrators are required to report at least annually on individual claim-level data on benefits paid to date, including both medical payments and indemnity payments by type of indemnity.

Workers' Compensation Information System First Reports of Injury

The 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, the employer, and the injury. Key information on the FROI that is particularly relevant for this study includes key dates in the claim history (including date of injury, date reported to employer, and date reported to claim administrator), worker demographics (i.e., age and sex), job and employer characteristics

(i.e., weekly wage, class code, and location), and information about the type of injury (nature, cause, and body part of injury). After a FROI is filed, each new claim is assigned a jurisdictional claim number, a unique identifier used to link all files across the lifetime of the claim. The most recently available data on the completeness of FROI reporting indicate that over 90 percent of claims are reported to the WCIS as a FROI (DIR, 2016). Despite this imperfect reporting, there is no other source of individual-level claims data in California that directly captures all market segments (including self-insured and public sector employers). Given the absence of any more reliable benchmark, this study will follow Dworsky, Rennane, and Broten (2018) in treating FROIs reported to the WCIS as a representative sample of injuries in the state workers' compensation system.

Workers' Compensation Information System Subsequent Reports of Injury

Each SROI must be filed within 15 days of a change to benefit or claim status. SROI and FROI data are matched using the claim JCN. The SROI provides transaction-level data on indemnity payments and lost time, which are the main way to observe benefit receipt and payment levels in the WCIS. The SROI also collects information about the timing of important events on a claim such as MMI, end date of TTD payments, date and receipt of PPD payments, return to work, and claim closure. Our ongoing monitoring approach uses information from the SROI to identify claims with indemnity payments. It is also possible to produce wage loss estimates for permanently disabled workers after sufficient time has elapsed for most cases to reach the PD phase.

Unfortunately, compliance with reporting standards remains imperfect, and the data reported on the SROI is less complete than the FROI: a recent assessment published by the Division of Workers' Compensation indicated that SROI reporting was only about two-thirds complete (DIR, 2016). Where appropriate, we will conduct analyses to assess the representativeness of claims with valid information from the SROI and apply analytic adjustments, weights, or sample restrictions as needed to address issues with incomplete records. This is especially problematic in the current study. In comparison to insurers, SROI reporting problems are somewhat more pronounced among public agencies—the primary employer of public safety workers. We address this limitation of the SROI data by restricting attention to claims administrators that have a consistent track record of reporting SROI to the WCIS.

Disability Evaluation Unit

Because of imperfect SROI reporting, the WCIS can also be limited in terms of assessing the severity of an injury, particularly with respect to the specific impairments rated and the resulting disability rating. To supplement the WCIS, we will use data on ratings from the California DEU. DEU is a state agency that performs between 60,000 and 80,000 ratings of permanent disabilities each year. The DEU data contain specific information about the type of impairment, the severity of the impairment, and important demographic data including age at injury and occupation.

While detailed analysis of DEU rating methods (such as the frequency with which specific impairments are rated for different cancer sites and the implications for disability ratings) would appear to fit better with the anticipated second phase of this research than with the current scope of work, the DEU data are an important source for information about statutory ratings. These data will also be used to analyze the impact of SB 863 by describing workers' exposure to rating and benefit changes enacted in that law and by modeling the differences in final ratings attributable to SB 863.

Employment Development Department

As part of RAND's ongoing Wage Loss Monitoring study, RAND has linked the WCIS to earnings data from the base wage file maintained by the California EDD. Every quarter, employers covered by unemployment insurance (UI) in California are required to report the quarterly earnings of every employee to EDD. These reports are stored in the base wage file. The industries covered by UI are virtually identical to the industries covered by workers' compensation, and therefore a worker injured at a firm for which he or she can make a workers' compensation claim should also have a record for that quarter in the base wage file. With roughly 95 percent of employees in California covered by the UI system, the matched data provide a substantially complete and accurate California quarterly earnings history for workers' compensation claimants.

These data were used to estimate average earnings losses among workers with claims for cancer. Our primary analysis uses medical-only cases as a control group for workers with cancer. This alternative method will be important here because of the project's emphasis on gender differences in losses, benefits, and wage replacement rates; as we discuss below, medical-only controls are necessary to obtain valid estimates of the effect of gender on outcomes. RAND is currently using a medical-only control group in the ongoing Firefighter Musculoskeletal Injury Study.

Identifying Cancer Claims in Workers' Compensation Data

To define our primary analysis sample of cancer cases, we rely on the nature of injury codes reported on the FROI. Several limitations of this approach must be noted. Some of these cases may be misdiagnosed or ultimately determined not to be compensable. Meanwhile, some cancer cases may be initially reported as different types of injuries or might be impossible to discern on the FROI because they are reported as multiple injuries when other occupational injuries have occurred or occupational diseases are present.

To address the shortcomings of our primary case definition, we conducted sensitivity analyses in which we used medical bills reported to the WCIS to develop an alternative approach to identifying cancer cases. In particular, we used diagnosis codes reported on workers' compensation medical bills to identify cancer cases independently of the FROI nature of injury

field. Details on this approach are presented in the Appendix. We explored other possible approaches, including the use of other variables from the FROI and analysis of the narrative "accident description" field on the FROI, but these were determined to be infeasible and uninformative.

Despite these limitations, the population of cases identified as cancer on the FROI is a group of considerable policy interest. All wage losses for these cases are presumably attributable to the cancer (as opposed to other concurrent injuries). Claim denials among cancer claims are also an outcome of interest.

Assigning Workers to Occupation Groups

As a result of the cancer presumptions in the California LC, workers in different occupations face very different evidentiary standards for demonstrating that cancer is work related and compensable under workers' compensation. We therefore identified three groups of public safety workers and a residual category containing all other workers with cancer claims:

- firefighters
- peace officers
- lifeguards
- other occupations.

Peace officers, firefighters, and lifeguards represent the three occupational groups covered by cancer presumptions in California. The fourth category includes most workers not falling into the first three categories. Although these other workers face a much higher evidentiary bar in demonstrating that their cancers are work related and compensable, we identified a non-negligible number of workers' compensation claims for cancer that did not come from public safety workers.

We assigned workers to these four occupation groups using an extension of a classification approach originally developed for RAND's recent study on firefighter musculoskeletal disorders, where we also identified police officers and sheriffs as a comparison group for firefighters (Dworsky, Seabury, and Broten, 2019). Further details are given in the Appendix, and more extensive discussion of the original method (which used occupation descriptions and class codes, but not industry codes) is presented in Dworsky, Seabury, and Broten (2019).

Occupation coding in this study proceeded in two stages. First, we used the occupation description field and classification codes on the workers' compensation claim to produce an initial assignment; this step simply applied the methods in Dworsky, Seabury, and Broten (2019) with some modifications to add lifeguards and to expand the peace officer occupation group beyond police and sheriff's deputies. However, this initial approach led to a small, but nontrivial number of public safety workers (primarily peace officers with less common job titles, such as special agents or investigators employed by district attorneys' offices) who were omitted from our peace officer definition and incorrectly included in the residual, other occupations category.

We therefore added a second stage to our occupation assignment process, which incorporated North American Industry Classification System (NAICS) codes reported to EDD to refine our definition of public safety workers by limiting the categories of firefighters, peace officers, and lifeguards to workers employed in one of ten detailed (six-digit) NAICS industries that accounted for over 98 percent of workers initially identified as public safety workers.[2] For the residual category of workers in other occupations, we excluded workers in any of the detailed industry categories used to identify public safety workers or who were employed at any industry in the Public Administration sector (NAICS 92).

It is important to note the implications of this occupation coding approach for our analysis sample, in particular the composition of the other occupations group. We divided the labor force into two categories on the basis of industry: public agencies with significant public safety worker employment, and all other employers. We made this choice in order to ensure that the other occupations category did not contain public safety workers covered by presumptions. A trade-off inherent in this approach is that our analysis excludes public agency employees who are not public safety workers, along with private sector workers in the specific education and recreation industry codes that we used to refine our public safety worker definitions.[3]

Despite these limitations, the other occupations category can provide insight into the outcomes of workers who file cancer claims without being covered by presumptions. The differences in evidentiary standards between public safety workers and those in other occupations mean that cancer claims from occupations not covered by a presumption are likely to reflect more severe and disabling cancers. The population of other workers who file cancer claims is also likely to be limited to groups of workers who can most readily demonstrate occupational exposure to carcinogens without the benefit of presumptions. The decision to file a workers' compensation claim for cancer involves fundamentally different costs and benefits for public safety workers and other workers, as one would expect disputes and delays related to establishing causation to be more common in the absence of a presumption.

Our choice to include workers in other occupations was also motivated by this study's aim to examine gender differences in outcomes: the firefighter workforce remains overwhelmingly male, and there were too few cancer claims from female lifeguards to provide informative estimates of gender differences; the other occupations group, meanwhile, had a higher proportion of female workers with cancer claims than we observed for any public safety worker group, and

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[2] These industries are mostly concentrated in NAICS 92 (Public Administration), but we also found that colleges and universities employ some peace officers, and that the industry containing state and local parks employs some peace officers and lifeguards. See the Appendix for further details.

[3] We also note that, while the other occupations group is likely to contain mostly private sector workers, our data did not contain information on public versus private sector ownership. Within industries that have mixed ownership, most notably education, utilities, and health care and social assistance, it is possible that some workers in the other occupation group are public sector employees.

so a meaningful volume of cancer claims filed by female workers fell into the other occupations category.[4]

Throughout this study, we estimate earnings losses and other outcomes separately by occupation group rather than pooling together occupations. Although public safety workers as a group have many commonalities (such as public sector employment and high unionization rates), differences between occupations in job demands, case mix, and opportunities for modified duty seem likely to result in potentially different earnings and employment losses due to cancer. Most notably, lifeguards are covered by a much narrower presumption applying only to skin cancer; we also found that lifeguards have much lower earnings and fundamentally different earnings dynamics from the other public safety workers considered in this study. Even though firefighters and peace officers may be more comparable to one another than to lifeguards, we were concerned that these groups would have very different career trajectories and employment dynamics for reasons unrelated to injury or cancer. In the presence of such potential differences across occupations, we did not think that producing average estimates for the effect of cancer would be informative.

Characteristics of Workers with Cancer Claims

Between 2005 and 2015, claims administrators submitted 5,439 FROIs to the WCIS with cancer indicated as the nature of injury, or an average of 494 cancer claims per year. This total includes all FROIs regardless of data quality. Due to missing data on the FROI and incomplete reporting of SROI by some claims administrators, many of these records were not usable for our analysis. We excluded an FROI from our analysis sample if data were missing on key variables (particularly age at injury, gender, and occupation), or if the claim was submitted by a claims administrator that did not demonstrate reliable reporting of the SROI.[5] We dropped 1,283 cases due to missing data or because they were submitted by claims administrators that systematically failed to report benefit payments and other claim outcomes, leaving 4,156 cases with complete records on case characteristics and benefit receipt.

Since the primary focus of this study is earnings losses, we were also unable to use data on workers who could not be linked to their earnings histories in the EDD base wage file. Of the

[4] The most recent nationwide estimates indicate that the proportion of workers who are female is just 22.1 percent in protective service occupations (the broad occupational group containing firefighters, peace officers, and lifeguards), compared with 46.9 percent of the overall U.S. workforce. Police and sheriff's patrol officers were 15.4 percent female, and firefighters were just 5.1 percent female. Comparable demographics specifically for lifeguards were not reported (see Bureau of Labor Statistics [BLS], 2019).

[5] As discussed in Dworsky, Seabury, and Broten, 2019, incomplete reporting of SROI is especially widespread among self-administered public agencies. This fact somewhat undermines our ability to study outcomes for public safety workers and other public sector employees using the WCIS, but no other statewide data capturing self-insured public agencies were available for this study.

4,156 workers with complete data on workers' compensation claims, 2,010 (48 percent) were not linked to earnings data, or were excluded from the file available for this study due to a failure to link to matched controls. This is a higher rate of match failure than is typical in these data—for the overall population of workers' compensation claims, only 28 percent of FROIs with complete data from reliable claims administrators were dropped because of a failure to match to earnings data. The best explanation we have for this pattern suggests that our sample will underrepresent cases where cancer is diagnosed (or attribution to occupational causes is first made) at a time when the worker has retired or stopped working for other reasons.[6] Excluding workers without earnings data, and who were not matched to control workers, left us with 2,146 cancer claims.

We excluded an additional 281 of these cases (13 percent) after using industry codes reported to EDD to refine our occupation classifications. These restrictions left us with a sample of 1,865 cancer claims for analyses of earnings losses and benefits, which are the primary focus of this study. In the Appendix, we present descriptive statistics for the larger sample of 4,156 cancer claims with reliable FROI and SROI data. Workers whom we dropped from our analysis sample were older and more likely to be initially classified in the other occupations category. Given that our use of industry codes to refine the occupation classification was motivated by concerns about cases in the other occupations category that appeared likely to be misclassified public safety workers or were otherwise ambiguous, it is not surprising that many of the cases dropped were in the other occupations category. Otherwise, our sample had broadly comparable rates of benefit receipt and a similar occupation distribution to the sample included in Table 2.1.[7] While the rate of attrition between the FROIs and our main analysis sample was higher than we would have liked, a more extensive study with sufficient resources to allow new data collection would be necessary to address these issues.

Workers with claims for industrial cancer are substantially older at the time of injury than other workers in the workers' compensation system. The average age at injury for cancer claims is 45.9, versus 39.6 for all other claims in the workers' compensation system. Workers with

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[6] To identify workers in the EDD data, we use the social security number and the date of injury, which implies that workers will be linked to their wage data only if they are employed at the date of injury: we did not have access to the full EDD base wage file for this study, and we were instead allowed only to extract data for workers who matched to a workers' compensation claim. It is possible—but unverifiable with the data available for this study—that workers who learn that they have occupational cancer after stopping work would have the date of injury reported as the date of diagnosis or attribution to occupational cause, rather than the date of the worker's most recent on-the-job exposure to carcinogens. To examine this issue and collect earnings data on these workers, however, we would need to extract additional earnings data from EDD, an effort that was beyond the scope of the present study.

[7] Compared with the full sample of cancer claims in the WCIS, our analysis sample is younger and contains more public safety workers and fewer workers in other occupations. Workers with cancer claims in our analysis sample were also more likely to receive TD and PD benefits, but slightly less likely to receive death benefits and less likely to encounter claim denials. These differences in benefit receipt appear to be driven by differences in the occupational composition between the full WCIS and our analysis sample, however.

Table 2.1. Demographics, Benefit Receipt, and Employer Characteristics of Workers' Compensation Claims, by Cancer vs. Non-Cancer Nature of Injury

	Cancer	All Non-Cancer Claims
Demographics		
Average age	45.9	39.6
Percentage female	13.6%	41.2%
Occupation		
Peace officers	46.1%	4.2%
Firefighters	34.7%	1.5%
Lifeguard	8.2%	0.1%
Other occupations	11.1%	94.3%
Benefit receipt		
Any indemnity benefits?	41.6%	28.3%
Temporary total disability	15.7%	23.4%
Permanent disability	36.2%	14.4%
Death benefits	2.2%	0.0%
Other claim outcomes		
Worker died	5.5%	0.1%
Any claim denial (full or partial)	28.5%	8.6%
Number of employees at at-injury employer		
1,000 or fewer	20.6%	46.2%
1,001 to 5,000	16.9%	23.6%
Over 5,000	62.5%	30.2%
NAICS sector		
Agriculture, Forestry, Fishing and Hunting (11)	0.3%	3.0%
Mining, Quarrying, and Oil and Gas Extraction (21)	0.1%	0.1%
Utilities (22)	0.5%	1.3%
Construction (23)	0.8%	4.7%
Manufacturing (31–33)	3.2%	11.9%
Wholesale Trade (42)	0.6%	5.2%
Retail Trade (44–45)	0.6%	18.6%
Transportation and Warehousing (48–49)	0.5%	5.9%
Information (51)	0.4%	2.6%
Finance and Insurance (52)	0.3%	2.2%
Real Estate and Rental and Leasing (53)	0.2%	1.8%
Professional, Scientific, and Technical Services (54)	0.5%	3.1%
Management of Companies and Enterprises (55)	0.0%	0.1%
Administrative and Support and Waste Management and Remediation Services (56)	0.9%	7.7%
Educational Services (61)	1.1%	0.4%
Health Care and Social Assistance (62)	1.1%	12.8%
Arts, Entertainment, and Recreation (71)	0.5%	1.8%
Accommodation and Food Services (72)	0.2%	7.9%
Other Services (except Public Administration) (81)	0.3%	2.1%
Public Administration (92)	87.9%	5.9%
Number of cases	1,865	3,177,505

NOTE: Table reports sample characteristics for workers' compensation claims with injury dates between 2005 and 2015 that were successfully linked to EDD earnings loss data.

cancer claims are older even when compared with workers with non-cancer claims that result in PD benefits (who have an average age at injury of 44.1).

Table 2.1 also shows that workers with claims for industrial cancer are overwhelmingly male, with just one out of eight (13.6 percent) of cancer claims filed by female workers. In the rest of the workers' compensation system, the proportion of claims filed by female workers is 41.6 percent. To some extent, the heavily male composition of workers with cancer claims is to be expected given the workforce of the public safety worker classes covered by cancer presumptions. BLS (2019) reports that, nationwide, workers in protective service occupations were 78 percent male in 2018; police and sheriff's patrol officers were 85 percent male, while firefighters were 95 percent male; other occupations likely to be covered by the peace officer presumptions were slightly more female, including correctional officers (70 percent male) and detectives and criminal investigators (76 percent male).

Table 2.1 also shows the proportion of cancer claims that result in payment of TD, PD, or death benefits. Temporary disability benefits are actually less common among workers with cancer claims (15.7 percent of claims) than among other injured workers (23.4 percent of claims). However, the severity of cancer compared with the average injury is apparent in the high proportion of cancer claims receiving PD benefits (36.2 percent vs. 14.4 percent among other injured workers). Similarly, less than 0.1 percent of workers' compensation claims other than cancer result in payment of death benefits, versus 2.8 percent of cancer claims.[8]

The above calculations include all cancer claims filed, including denied claims. Table 2.1 also makes it clear that cancer claims are subject to full or partial denials at over double the rate observed for other claims that result in permanent disability: three in ten cancer claims (29.1 percent) encounter a full or partial denial at some stage in the claims process. However, the data available for this study do not distinguish between partial and full denials. A full denial would indicate that the employer or insurer considers the claim not to be work related, and thus not to be compensable. But claims can also be denied in part (e.g., if a certain category of benefits are denied), and a claim can also be denied after benefits are paid.

Table 2.1 also presents employer characteristics for cancer claims and other workers' compensation claims. Reflecting the predominance of public safety workers among those with cancer claims, workers with cancer claims are unlikely to be employed by small or medium-sized employers: only 21 percent of workers with cancer claims are at employers with 1,000 or fewer employees, compared with 46 percent of other workers' compensation claims. Similarly,

[8] The proportion of non-cancer claims resulting in death benefits is 0.04 percent, or about 5 in 10,000 workers' compensation claims versus 220 in 10,000 claims for cancer. Even among non-cancer injuries resulting in PD, which represent the most severe nonfatal cases in the system, death benefits are paid to just 7 in 10,000 claims. As we discuss in the Appendix, death benefits are more common (279 per 10,000 cases vs. 220 per 10,000) when we include cases that failed to match to the EDD. We also note that we included only fatality benefits, and not funeral expenses, in our measure of death benefit receipt.

88 percent of cancer claims come from the Public Administration sector, compared with 6 percent in the rest of the workers' compensation system. These employer characteristics are associated with substantial differences in postinjury labor market outcomes, with large employers and public sector workers generally associated with better return-to-work rates and smaller earnings losses.

Table 2.2 presents descriptive statistics by occupation for workers with cancer claims. A number of striking differences between occupation groups are apparent. Firefighters and workers in other occupations are older at the date of injury than are peace officers, while lifeguards are substantially younger. While cancer claims are overwhelmingly male in all occupation groups, the proportion of workers with cancer claims who are female varies from 25.1 percent of other occupations to 17.1 percent each of peace officers and lifeguards, to just 4.5 percent of firefighters. These demographics prevented us from obtaining meaningful estimates of gender differences in postinjury outcomes for firefighters or lifeguards.

Table 2.2. Demographics, Benefit Receipt, and Employer Characteristics of Workers' Compensation Claims, by Cancer vs. Non-Cancer Nature of Injury

	Peace Officers	Firefighters	Lifeguards	Other Occupations
Demographics				
Average age	45.8	47.4	37.1	48.5
Percentage female	17.1%	4.5%	17.1%	25.1%
Benefit receipt				
Any indemnity benefits?	41.9%	47.6%	17.8%	39.1%
Temporary total disability	17.0%	15.6%	0.0%	22.2%
Permanent partial disability	35.7%	43.1%	17.8%	30.4%
Death	2.4%	1.9%	0.0%	3.9%
Other claim outcomes				
Any claim denial (full or partial)	29.1%	23.6%	2.6%	60.4%
Worker died	5.6%	4.3%	0.0%	13.0%
Number of employees at at-injury employer				
1,000 or fewer	15.5%	17.3%	5.3%	63.3%
1,001 to 5,000	16.9%	19.5%	5.3%	17.4%
Over 5,000	67.6%	63.2%	89.5%	18.8%
Number of cases	859	647	152	207

Table 2.2 also indicates notable differences in benefit receipt and claim denial rates across occupations. Nearly half of firefighters with cancer claims (48 percent) receive indemnity benefits, while slightly lower proportions of peace officers (42 percent) and workers in other occupations (39 percent) receive indemnity benefits. As noted above, these are substantially higher rates of indemnity benefit receipt than are observed among non-cancer claims. Lifeguards

with cancer claims, in contrast, receive indemnity benefits at a lower rate than is observed in the workers' compensation system as a whole (28 percent, as reported in Table 2.1). There are also important differences in the type of benefits paid to workers with cancer claims across different occupations. Rates of TTD receipt for peace officers and firefighters with cancer claims are lower than observed elsewhere in the workers' compensation system, and we did not observe any lifeguards with paid TTD benefits on a cancer claim. TTD benefit receipt for workers in other occupations with cancer claims (22 percent) was similar to the system-wide rate of 23 percent. There were also sharp differences across occupations in the proportion of cancer claims that result in paid PPD benefits. Forty-three percent of firefighters, 36 percent of peace officers, and 30 percent of other occupations with cancer claims received paid PPD benefits—all rates more than twice as high as the overall rate for non-cancer workers' compensation claims (14 percent). PPD benefit receipt among lifeguards (17 percent) was only slightly higher than observed in the overall population of non-cancer workers' compensation claims, however.

Table 2.2 also reports the proportion of claims with paid death benefits. As noted above, the vast majority of workplace injuries and illnesses are nonfatal, and death benefits are paid far more often on cancer claims than on other types of workers' compensation claims. While this is unsurprising given the severity of cancer, we found major differences across occupations in the probability that claims resulted in paid death benefits. We did not observe paid death benefits for any lifeguards in our sample, while 2.4 percent of peace officers (1 in 40) and 1.9 percent of firefighters (1 in 50) had claims that resulted in payment of death benefits to the workers' surviving dependents. These rates of death benefit receipt are 59 and 45 times higher, respectively, than the average for non-cancer workers' compensation claims. The highest rates of paid death benefits were observed for other occupations: 3.9 percent (1 in 25) of cancer claims in other occupations resulted in payment of death benefits, a rate 94 times higher than the average for non-cancer claims.

We also documented sharp differences in claim denial rates across occupations. Denials of lifeguard claims are exceptionally rare (only 2.6 percent of claims), while denial rates for peace officers (29 percent) and firefighters (24 percent) were much higher than observed for non-cancer claims (9 percent). Meanwhile, the majority—60 percent—of workers in other occupations experienced a partial or full claim denial.

As noted above, the FROI and SROI data contain little useful information about the type of cancer. To provide some insight into case mix differences across occupations, we examined the sample of workers in each occupation with linked medical claims who had at least one medical bill with a primary diagnosis of cancer. The full distribution of cases across primary cancer sites for this group of workers is reported in Table A.5. As we discuss at length in the Appendix, this is a very loose standard for ascertaining cancer from medical claims, and the sample included in

these calculations intersects, but is not contained by, our primary analysis sample.[9] Despite these limitations, we do not have any other available data indicating primary cancer site or case mix.

For peace officers and firefighters, skin cancer other than melanoma is the most common primary cancer site, accounting for about one in three cancer cases. There are also substantial volumes of cases in both occupation groups with melanoma, prostate cancer, and colon cancer. In other occupations, skin cancer other than melanoma accounts for only 3 percent of cases. Melanoma is the most common primary cancer site in this occupation group, followed by cancers of the endocrine system, bone cancer, gynecological cancers, and cancers of the head, neck, and brain. The high frequency of skin cancer claims among public safety workers other than lifeguards likely contributes to the relatively limited earnings losses observed among these groups in comparison to workers in other occupations.

The very different patterns of benefit receipt, claim denial, and case mix observed across occupations seem likely to reflect the availability and scope of legal presumptions for cancer. Presumptions for lifeguards are limited to skin cancer, which can frequently be treated with limited side effects. It is therefore unsurprising that lifeguards with cancer claims experience very low rates of claim denials and do not receive TD or death benefits in the population of cases examined here. The experience of workers in other occupations with cancer claims, meanwhile, suggests that workers not covered by presumptions are very likely to face claim denials and disputes. The fact that, in spite of high claim denial rates, these workers are much more likely to receive death benefits than the other occupations examined here suggests that workers in other occupations may refrain from filing workers' compensation claims in all but the most severe cases. Claim denial rates and death benefit receipt for peace officers and firefighters fall between those observed among lifeguards and other occupations, and we think it is plausible that the breadth of the presumptions available to peace officers and firefighters may contribute to this pattern.

These marked differences across occupations suggest that claim filing and the availability of benefits for cancer are shaped powerfully by the availability of presumptions. However, exposures, worker demographics, and numerous other factors also differ across the occupational groups examined here, and so we cannot conclusively attribute differences in claiming behavior or outcomes across occupations to the effects of presumptions. In the absence of detailed clinical information about staging, responsiveness to treatment, functional status, and other dimensions of severity, it would be difficult to disentangle the impact of factors such as job demands, employer policies, or return-to-work incentives even if evidentiary standards were equivalent across occupations. The differences in evidentiary standards that result from presumptions make it even more challenging to interpret differences in outcomes and case mix across occupations,

[9] See the Appendix for further discussion of issues related to case ascertainment.

since we lack data on workers with occupational cancer who do not file workers' compensation claims.

Overview of Methods for Earnings Loss Estimation

To estimate the effect of occupational injury or illness on workers' labor market outcomes, it is necessary to compare injured workers with a control group of workers who were also employed at the time of injury. Because workers must be employed in order to be at risk of a workplace injury, natural attrition from the workforce due to both voluntary and involuntary job separations tends to reduce average earnings for a population of workers as their employment status reverts toward a long-run average that may be well below 100 percent.[10] While wages tend to rise over time for workers who remain continuously employed, the inclusion of workers who leave employment after the quarter of injury outweighs wage growth (see Dworsky et al., 2016, for an example). Furthermore, wage growth and the risk of job loss are highly sensitive to economic conditions, which we know fluctuated significantly over the time period under consideration in this study. These labor market dynamics affect uninjured workers as well as injured workers, and so a control group is needed to distinguish between the effect of mean reversion and business cycle effects from earnings losses due to the injury.

In RAND's previous work on earnings losses for injured workers, we have typically constructed a control group for each injured worker consisting of workers at the same employer who have similar earnings and who did not file a workers' compensation claim (i.e., uninjured workers). This approach, which we have used successfully in numerous past studies, had important limitations for the purpose of studying occupational cancers, however. Most notably, age and gender are not included in the EDD data. In studies—like this one—where the effect of gender is of primary interest, it is important that personal characteristics be observable for both injured and control workers. Controlling for age at injury is also critically important in this context because cancer claim volumes spike at ages when many public sector workers experience increases in pension benefits, which may independently affect labor supply incentives and employment rates.

Similarly, public safety workers have very different earnings dynamics and career paths from private sector workers; even public sector workers outside the public safety occupations studied here have systematically different disability benefits and job requirements. Preliminary comparisons of public safety workers with cancer to uninjured control workers selected using our typical methodology confirmed that some subgroups of public safety workers—most notably lifeguards—were being matched to uninjured controls with visibly different earnings dynamics

[10] Prior calculations in Dworsky et al., 2016, found that the employment-population ratio for adults ages 18–64 in California for the years 2005–2012 was 64.4 percent. (Authors' calculations from U.S. Census Bureau population estimates and BLS Quarterly Census of Earnings and Wages data.)

prior to injury, calling into question the validity of our typical method for studying earnings losses due to occupational cancer within specific public safety occupations.

Instead, we relied on an alternative methodology comparing workers with cancer with workers who also filed workers' compensation claims at the same time, but for low-severity *medical-only* injury claims filed by workers in the same occupation.[11] We adopted this methodology as a sensitivity analysis in Dworsky, Seabury, and Broten (2019), which was also focused narrowly on injuries and labor market outcomes for firefighters and other groups of public safety workers.

The great advantage of using workers with medical-only injuries is that the filing of a workers' compensation claim provides data for the control group on the same worker and case characteristics that we observe for workers with cancer. This allows us to ensure that we are comparing workers with cancer with a control group that has the same age, gender, and occupation. Because retirement pensions for public safety workers with sufficient years of service often involve sharp changes in benefit eligibility and retirement incentives at specific ages, controlling for age is particularly important when studying these occupations. Finally, the aims of the current study emphasize gender to a greater degree than has been the case in earlier studies of injured workers in California.

Statistical Methods

Our main results use a differences-in-differences specification using weighted least squares regression to contrast the change in total labor earnings from the two years before the date of injury with the two years following the injury between workers with cancer claims and workers with medical-only injuries.

We used linear regression and related statistical models to estimate the impact of cancer claims on earnings and employment.[12] We specified these models to control for the potentially confounding effects on earnings after injury of a rich set of individual demographics and employer characteristics, including the following:

- gender
- age
- region within California
- industry
- firm size
- injury date.

[11] All workers with cancer reported as the nature of injury were excluded from the medical-only control group even if they did not receive indemnity benefits.

[12] Equations and additional details of model specification are presented in the Appendix.

Demographic controls are necessary given the substantial differences between workers with cancer claims and other injured workers documented in Tables 2.1 and 2.2 above. We control for workers' age at injury in years separately by gender, so that changes in earnings after injury for each worker with cancer are compared with changes observed among workers of the same gender who are the same age (e.g., 51-year-old male firefighters are compared with other 51-year-old male firefighters). These controls are particularly important in the present study because retirement can generate sharp reductions in employment for public safety workers at the same ages when cancer is likely to be detected.

We also include controls for industry and number of workers at the employer at injury. For public safety workers, we control for the six-digit NAICS code (so that, e.g., firefighters employed by fire departments, general county governments, and state government are compared with other firefighters with the same type of employer). For other occupations, we control for the two-digit NAICS code (e.g., manufacturing, utilities, construction, or health care). We include similar controls for seven categories of employer size at the time of injury, which is particularly important in the more heterogeneous other occupations group. Finally, we include controls for ten regions of California and the date (year and quarter) of injury in order to adjust for the effects of local economic conditions and the business cycle on workers' labor market outcomes.

The central assumption of our differences-in-differences approach is that if the workers with cancer claims had not developed cancer, their earnings would have continued to evolve in parallel with the control group of workers with medical-only injuries. We indirectly tested this assumption by estimating unweighted (ordinary least squares) event-study regression models to capture the differential change in quarterly earnings in each calendar quarter from two years before injury through two years after injury. We found some evidence that this assumption was not valid for some occupations; that is, that the average worker with a medical-only injury was on a slightly different trajectory from the average worker with a cancer claim over the two years leading up to injury.[13]

In order to provide valid differences-in-differences estimates of earnings losses, we first estimated the probability of making a cancer claim using the control variables. We then reweighted the control group using these probabilities to reflect the characteristics in the cancer claim group, upweighting individuals who were likely to have made a claim (based on observed characteristics), and downweighting individuals who were unlikely to have made a cancer claim. This approach minimizes the divergence in preinjury earnings trajectories between workers with cancer and workers with medical-only claims and is similar in spirit to inverse propensity weights.[14] For comparison, unweighted (ordinary least squares) estimates are also reported in the Appendix.

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[13] Formally, we tested for the joint equality of all preinjury event study coefficients to zero using a Wald test. See the Appendix for further details and test statistics.

[14] See the Appendix for details.

As an additional sensitivity analysis, we also used Poisson regression to estimate earnings losses in proportional terms; that is, as a percentage change relative to what a worker would otherwise have earned. Poisson regression is more robust than linear regression to outliers and thus is a useful model for studying labor earnings. These specifications may be particularly relevant for estimation of gender differences in earnings losses: female workers with cancer claims have lower earnings than male workers, and so we were concerned that comparing earnings losses between genders in dollar terms could be misleading. We use the Poisson regression estimates when we describe earnings losses in percentage terms.

Methods for Calculating Pretax Wage Replacement Rates

Estimating wage replacement rates for this study posed some additional challenges. Disability and death benefits are intended to compensate workers and their families for losses caused by injury, including long-term earnings losses. Yet no timely study can directly observe long-term outcomes for injured workers, and so analysts seeking to describe replacement rates face unavoidable trade-offs in choosing the time period after injury over which to calculate wage replacement rates: the longer the time period considered in estimating wage replacement rates, the stronger the assumptions needed to justify the estimates. For most of the workers in our sample, we did not have long-term follow-up data with which to estimate earnings losses beyond two years after injury. This was similar to the situation we faced in a previous RAND study on workers with PD, and we followed assumptions used in that study (Dworsky et al., 2016).

We also note that we report pretax, not after-tax, wage replacement rates. Workers' compensation benefits are tax exempt, and so our estimates will understate the proportion of after-tax income replaced by benefits. Unfortunately, workers' compensation data lack the information on family income, exemptions and deductions, and nonlabor income needed to calculate tax rates, and we determined that imputation of tax rates was beyond the scope of this study. Marginal income tax rates increase with income, and so this approach will tend to understate wage replacement rates by a greater margin for higher-income workers.

While this approach involves strong assumptions, the collection and analysis of data needed to provide more empirical guidance on whether earnings losses for workers with cancer might evolve differently in the long run from the average for all workers with PD was far beyond the scope of the current study.

3. Earnings Losses and Benefit Payments for Workers with Occupational Cancer Claims

This chapter presents our main findings on earnings losses, disability ratings, paid benefits, and wage replacement rates for workers who filed workers' compensation claims for cancer in California with injury dates between 2005 and 2015. Because of differences across occupations in earnings dynamics and coverage by cancer presumptions, all estimates are presented separately by occupation for the four occupation groups defined in Chapter 2: peace officers, firefighters, lifeguards, and other occupations.

Earnings and Employment Changes After Cancer Claims

Table 3.1 reports annual earnings for workers who filed cancer claims over the two years before and after the date of injury. Peace officers, firefighters, and workers in other occupations all experience sharp reductions in earnings in the years following a cancer claim. Employment rates for these groups of workers are reported in the second panel of the table. Compared with workers in other occupations, public safety workers have very high employment rates two years prior to injury. Two years after injury, employment has dropped substantially for public safety workers, from nearly 100 percent to 83 percent for peace officers and 84 percent for firefighters. Declines in employment for lifeguards are more muted, with 92 percent employed two years after injury. Workers in other occupations are very likely to stop working in the two years following a cancer claim: only 37 percent are employed two years after the date of injury. While this group also has less stable employment than public safety workers prior to injury (with

Table 3.1. Earnings and Employment for Workers with Cancer Claims, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations	All Cancer Claims
Annual earnings					
2 years before injury	$115,506	$143,799	$60,225	$51,094	$113,667
1 year before injury	$118,706	$146,059	$62,745	$52,596	$116,296
1 year after injury	$100,380	$124,451	$64,234	$24,264	$97,337
2 years after injury	$81,789	$104,687	$56,816	$17,599	$80,573
Employment					
2 years before injury	99.5%	98.6%	96.7%	88.4%	97.7%
1 year before injury	99.2%	99.1%	97.4%	93.7%	98.4%
1 year after injury	90.8%	90.7%	96.1%	45.9%	86.2%
2 years after injury	82.8%	84.1%	92.1%	36.7%	78.9%
Number of cases	859	647	152	207	1,865

88 percent employed two years before the date of injury), the drop in employment for these other occupations is far steeper than is typically observed for most groups of injured workers.[1]

While Table 3.1 shows how earnings and employment change after a cancer claim, these estimates are not sufficient to tell us how much of the reduction in earnings was caused by cancer as opposed to other factors affecting labor market dynamics. As we discussed in Chapter 2, a control group is needed to isolate earnings and employment losses due to cancer. We present these estimates in the following section.

Earnings Losses Due to Cancer for Workers Filing Cancer Claims

Our main estimates of earnings losses focus on total earnings over two years after the date of injury. Before turning to these estimates, we present event-study estimates to illustrate how the earnings of workers with cancer claims changed in comparison to similar workers with medical-only claims from two years before to two years after injury.[2] Because this regression model captures how differences between workers with cancer claims and workers with medical-only injuries evolve over the two years leading up to the date of injury, it allows an indirect, graphical evaluation of our key assumption that earnings for workers with and without cancer claims would move in parallel in the absence of cancer.

Figure 3.1 presents these event-study estimates by plotting two lines for each occupation. The solid colored lines with markers show the actual earnings of workers with cancer claims in each of the four occupation groups.[3] The light gray dashed line plotted for each occupation shows our estimate of what workers in each occupation group would have earned if they had not developed cancer based on the reweighted sample of workers who filed medical claims (or *counterfactual* earnings).[4] We have shaded the area between actual and counterfactual earnings to highlight lost earnings for each group. The estimates in Table 3.2, which reflect earnings losses over two years after injury, can be interpreted as capturing the size of the shaded area for each occupation depicted in Figure 3.1.

Figure 3.1 shows that during the two years prior to a cancer claim there is little, if any, difference in earnings of workers with cancer claims and our counterfactual estimated from

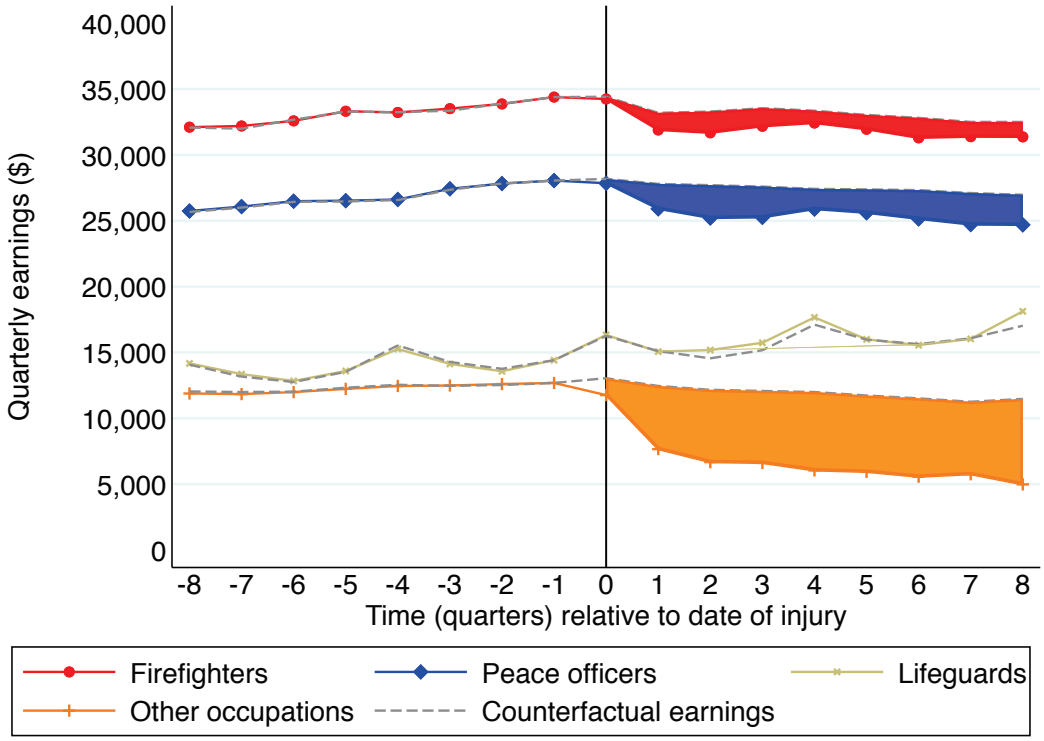
[1] See Dworsky, Rennane, and Broten, 2018, for a broader overview of earnings dynamics before and after injury for workers in California.

[2] See the Appendix for details on event-study specification.

[3] As indicated by Table 2.2, earnings before the date of injury are different enough across these four groups that they can be plotted on the same axes.

[4] Actual earnings are simply sample averages; counterfactual earnings were constructed by subtracting event-study coefficients from our weighted least squares regression models from actual earnings.

Figure 3.1. Earnings Losses After Cancer Claims, by Occupation



NOTES: Figure plots average quarterly earnings for workers with cancer claims from two years before to two years after the date of injury, stratified by occupation. Date of injury in cancer claims represents the date of last known exposure, which is likely to be the date of diagnosis for workers who are diagnosed while employed. Counterfactual earnings are estimated based on weighted least squares regression models described in Chapter 3 and the Appendix using medical-only injuries from workers in the same occupation as a control group. Shaded areas represent earnings losses due to cancer.

the reweighted sample of workers with medical-only injuries in the evolution of earnings before injury. As is typical when studying how earnings evolve before and after a workers' compensation claim, earnings for all workers are rising leading up to the injury. This pattern reflects both normal earnings growth for workers who are steadily employed and the movement from nonemployment to employment of workers who were out of work prior to their injuries. The pattern observed for lifeguards reflects the seasonality of lifeguard employment; this distinctive pattern underscores the importance for the present study of using a control group of workers with medical-only injuries whose occupations can be observed.

The very close match between actual earnings for workers with cancer and our estimated counterfactual gives us high confidence in the validity of our earnings loss estimates based on the weighted control group. After the date of injury, earnings for workers with cancer claims in three out of four occupation groups diverge from earnings for the (weighted) medical-only control group. For peace officers and especially for firefighters, the date of injury corresponds

to a noticeable drop in earnings even for workers with minor injuries. We believe the pattern observed for firefighters is likely to reflect retirement. In the Appendix, we show that there is a marked concentration (over 25 percent) of cancer claims among firefighters between ages 50 and 55, an age range that often corresponds closely to increases in pension benefits for firefighters and other public safety workers and also corresponds to the recommended ages to initiate screening for colorectal, lung, breast, and prostate cancer. While we do not have data directly indicating why injured workers exit the labor force, our regression specification is effectively comparing workers with cancer claims with workers with other claims of the same age. It is plausible that some of the firefighters with cancer claims at these ages would have retired even in the absence of cancer; the data on medical-only claims suggest that this is the case.

Table 3.2. Effects of Cancer on Earnings, Employment, and At-Injury Employment over Two Years After Date of Injury, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations
Change in earnings over two postinjury years ($)	–$18,159	–$10,499	$3,194	–$43,058
[95% confidence interval]	[–$23,204, –$13,114]	[–$16,275, –$4,723]	[–$2,774, $9,162]	[–$49,099, –$37,017]
Change in employment two years after injury	–9.7%	–3.1%	–0.8%	–37.3%
[95% confidence interval]	[–12.2%, –7.2%]	[–5.7%, –0.4%]	[–6.0%, 4.3%]	[–41.4%, –33.2%]
Change in at-injury employment two years after injury	–11.1%	–4.6%	0.7%	–38.3%
[95% confidence interval]	[–13.8%, –8.4%]	[–7.6%, –1.7%]	[–5.5%, 6.9%]	[–42.3%, –34.3%]

Lifeguards do not exhibit earnings losses after cancer claims: earnings trajectory for lifeguards is, if anything, slightly higher than what would be observed in the absence of a cancer claim, though we emphasize that these estimates are very close to zero and statistically insignificant. Workers in other occupations, meanwhile, lose two-thirds (66 percent) of their earnings on average after a cancer claim. Even though workers in other occupations have earnings less than half the level observed among peace officers and firefighters before the claim, their losses in dollar terms ($43,000) exceed those for any occupation group examined in this study.

Table 3.2 summarizes the earnings losses depicted in Figure 3.1 by reporting the results from our regression models for the change in earnings from the two years before the injury to the two years after the injury. Other than lifeguards, workers who file cancer claims experience sizable earnings losses over the two years after the date of injury. In the two years after the date of injury, firefighters lose $10,500, peace officers lose $18,000, and workers in other occupations

lose $43,000. While the 95-percent confidence intervals in Table 3.2 indicate that there is a range of uncertainty surrounding these estimates, earnings losses for peace officers, firefighters, and other occupations are highly statistically significant.[5]

Table 3.2 also reports regression results for changes in employment from two years before to two years after injury. A cancer claim reduces the probability of employment by 3 percent for firefighters, 10 percent for peace officers, and 37 percent for workers in other occupations. We also examined the probability that workers remained employed at the same employer where they filed the cancer claim and found that reductions in employment at the at-injury employer were very close to reductions in overall employment.

Disability Ratings

Table 3.3 reports average disability ratings for workers with cancer claims who received ratings at the state DEU. The first panel reports combined standard ratings, which reflect the *AMA Guides* impairment rating assigned to all of an individual's rated impairments prior to adjustments for other factors that determine disability ratings in California. These other factors include modifiers for age and occupation, as well as the impact of apportionment.

Considering all available DEU ratings performed on cancer claims with injury dates between 2005 and 2015, we find that the average rating was 5.6 percent for lifeguards, 12.1 percent for firefighters, 15.9 percent for peace officers, and 26.4 percent for workers in other occupations. The ranking of occupations by average standard rating is identical to the ranking of occupations by average earnings loss.[6]

Table 3.3 also reports final impairment ratings by occupation. The average final rating was 6.4 for lifeguards, 16.2 for firefighters, 21 for peace officers, and 26.8 for other occupations. As with standard ratings, average ratings in the constant-maturity sample were slightly lower.

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[5] Many cancer claims are reported later (relative to the date of injury) than is the norm for injury claims (which must typically be reported within 30 days of injury) or even for other occupational illnesses (which must typically be reported within one year of the date of diagnosis or attribution to occupational exposures). To evaluate the robustness of our estimates to reverse causation associated with claims that are filed with a substantial delay, we estimated our main regression models on a sample that excluded all claims (both cancer claims and medical-only claims) filed more than 90 days (approximately three months) after the date of injury. Earnings losses are smaller for firefighters and workers in other occupations when we exclude claims filed more than 90 days after the date of injury, but the significance and relative magnitude of earnings losses across occupations remain broadly similar to those estimated on the full sample of claims. See the Appendix for estimates.

[6] Table 3.3 also reports average standard ratings for a constant-maturity sample of ratings, which were performed within three years of the date of injury; attention must be restricted to constant-maturity ratings to make comparisons over time, as we will to describe changes in ratings following implementation of SB 863. Average constant-maturity standard ratings are 1 to 2 rating points lower than the overall average for public safety workers, and 5 rating points lower for workers in other occupations.

Table 3.3. Disability Ratings for Cancer Cases Evaluated at the State Disability Evaluation Unit

	Peace Officers	Active Firefighters	Lifeguards	Other Occupations
Average combined rating				
All ratings	15.9	12.1	5.6	26.4
N	98	129	18	42
Constant-maturity ratings	14.1	10.6	4.7	21.6
N	77	101	15	26
Average final rating				
All ratings	21	16.2	6.4	26.8
N	117	145	26	50
Constant-maturity ratings	19.7	14.3	5.4	22.3
N	91	115	22	31

In Table 3.4, we compared ratings performed before and after rating changes were implemented, beginning in 2013, under SB 863. Three of the four occupations had too few ratings from injuries rated under the SB 863 reforms to be reported, but we were able to provide such a comparison for peace officers. This table is limited to the constant-maturity sample of ratings introduced in Table 3.3 in order to allow a valid comparison of ratings over time.[7]

Standard ratings for peace officers, which should not have been affected by SB 863, were two rating points higher on average for cancer cases with dates of injury in 2013–2015, although this difference was not statistically significant. While this difference in ratings in the sample observed here is important because it affects the distribution of final ratings, the statistical insignificance of this difference means that we could see an increase this large due to chance (and not due to any systematic change in case mix or rating practices).

Turning to the final rating, which determines PD benefits, the average rating increased over 5 rating points, from 17.5 percent for cancer claims with an injury date between 2005 and 2012 to 23.1 percent for cancer claims with an injury date between 2013 and 2015. This difference is quite large in substantive terms and is consistent with our expectation that SB 863 would have increased final ratings substantially. However, the sample of ratings performed at DEU was limited, and this difference was not statistically significant either.[8]

[7] More complex and severe cases systematically take longer to reach MMI and to reach DEU, and so cases with a higher lag between injury date and rating date generally represent more severe disability and receive higher ratings. As a result, comparison of ratings over time can be very misleading unless a constant-maturity sample of ratings is used.

[8] We also attempted to pool data on DEU ratings across all occupations and test for changes in ratings after SB 863 implementation while controlling for occupation and gender. Estimates from this exercise were also very imprecise and failed to reject equality of ratings before and after SB 863.

Table 3.4. Disability Ratings for Constant-Maturity Cancer Cases Evaluated at the State Disability Evaluation Unit, by Injury Date

	Peace Officers
Average combined standard rating	
2005–2012 injuries (constant-maturity)	13.3
N	47
2013–2015 injuries (constant-maturity)	15.2
N	30
p-value for difference	0.57
Average final rating	
2005–2012 injuries (constant-maturity)	17.5
N	56
2013–2015 injuries (constant-maturity)	23.1
N	35
p-value for difference	0.22

Benefit Payments

Table 3.5 presents data on average payments of indemnity benefits, both for the average worker with a cancer claim and for workers who received benefits in each of three categories: TTD benefits, PD benefits, and death benefits. The proportion of workers receiving each type of benefits is reproduced from Table 2.2 for reference.

Table 3.5. Benefit Receipt Rates and Paid Indemnity Benefits, by Type of Benefit and Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations	All Cancer Claims
Proportion receiving benefits	41.9%	47.6%	17.8%	39.1%	41.6%
Any indemnity					
TTD	17.0%	15.6%	0.0%	22.2%	15.7%
PD	35.7%	43.1%	17.8%	30.4%	36.2%
Fatality	2.4%	1.9%	0.0%	3.9%	2.2%
Mean benefits (unconditional)					
Total indemnity	$19,860	$22,407	$3,266	$40,122	$21,640
TTD	$8,022	$9,105	$0	$2,326	$7,161
PD	$5,242	$6,876	$1,887	$16,609	$6,797
Fatality	$5,047	$3,883	$0	$6,554	$4,399
Mean benefits (conditional on receipt)					
Total indemnity	$47,387	$47,070	$18,385	$102,535	$52,009
TTD	$47,197	$58,326	N/A	$10,469	$45,584
PD	$14,667	$15,945	$10,621	$54,572	$18,752
Fatality	$206,449	$209,340	N/A	$169,587	$200,103

NOTES: TTD = temporary total disability. PD = permanent disability. PD benefits include both permanent partial disability (PPD) and permanent total disability (PTD) benefits.

Total indemnity benefit payments averaged $19,860 for peace officers, $22,407 for firefighters, $3,266 for lifeguards, and $40,122 for workers in other occupations. When we examine TD and PD payments separately, we see that rates of benefit receipt and average paid amounts for those receiving benefits differ sharply between public safety workers and those in other occupations. TTD payments for those receiving TTD benefits averaged $47,197 for peace officers and $58,326 for firefighters, compared with $10,469 for workers in other occupations.[9] Levels of PD payments, meanwhile, were much higher for workers in other occupations ($54,572 on average) compared with $14,667 for peace officers and $15,945 for firefighters.

It might initially be surprising that workers in other occupations are more likely to receive TTD benefits (22 percent of cancer claims with paid TTD benefits) than peace officers (17 percent) or firefighters (16 percent) yet receive just one-quarter of the average TD payments received by these groups of public safety workers. However, the structure of California's formula for calculating TTD benefits, and the availability of additional TD benefits for public safety workers, likely explains much of this apparent discrepancy. TTD benefits are paid at two-thirds of the injured worker's average weekly wage until the weekly benefit reaches a benefit cap set at the state average weekly wage (SAWW). Workers with a preinjury weekly wage above 150 percent of the SAWW are paid TTD benefits at the SAWW. Lower paid TTD benefit amounts for workers in other occupations are thus likely to reflect the fact that these workers are far more likely than peace officers or firefighters with cancer claims to have earnings below 150 percent of the SAWW ($1,654.94 per week for workers injured in 2015).

Meanwhile, Sec. 4850 of the LC provides peace officers and firefighters with additional TD benefits at 100 percent of the worker's preinjury weekly wage. Benefits paid under Sec. 4850 are reported to the WCIS, and we include them in our measure of TD payments since they are an important source of compensation for public safety workers. This is particularly true for those with high weekly wages who would otherwise face extremely low wage replacement rates during TD because weekly benefit payments are capped at the SAWW. Between the TTD benefit formula and Sec. 4850 benefits, then, it is likely that public safety workers are paid TD benefits at a much higher weekly rate than are workers in other occupations, differences that could substantially raise paid amounts for public safety workers even without major differences in disability duration among those receiving total disability benefits.

The average paid PD benefit amount for those receiving PD benefits, in contrast, is dramatically higher for workers in other occupations than for public safety workers. Unlike TD benefits, differences in the weekly PD benefit payment rate between public safety workers and other workers are likely to be minimal. Sec. 4850 does not apply to PD compensation, and weekly benefit payment rates are likely identical across occupations for the vast majority

[9] As noted above, we observed no lifeguards who received TTD benefits for cancer claims.

of workers; while SB 863 raised the maximum weekly PD benefit substantially between 2012 and 2014, most workers with PD are likely to receive PD benefits at the weekly maximum rate.

Rather than differences in the weekly benefit rate, differences in PD benefit payments among workers with cancer claims are likely to be driven by differences in final disability ratings. We saw above that final ratings for workers rated at DEU were highest in other occupations, followed by peace officers and firefighters. We were not able to explain why firefighters are more likely than peace officers to receive PD benefits, or why the average PD benefit payment for firefighters with PD was similar to the average for peace officers even when the average final rating at DEU was markedly higher for peace officers (21 percent impaired) than for firefighters (16.2 percent impaired). It is quite possible firefighters and peace officers with PD differ in their propensity to seek ratings at DEU, which could suggest that caution should be exercised in using comparisons of DEU ratings across occupations to infer disability severity for the overall injured worker population.[10]

In contrast to disability benefits, death benefits are assigned based on the number of dependent survivors the worker has, rather than on the basis of disability duration or impairment ratings; the death benefit amount also does not depend on the worker's preinjury wage. As a result, average death benefits are more comparable across occupations, averaging $206,449 for peace officers with death benefits, $209,340 for firefighters with death benefits, and $169,587 for workers in other occupations with death benefits. While this last amount is slightly lower than the minimum death benefit, we note that we analyzed both paid amounts (which are still ongoing at the time of data collection in some cases) and settled amounts (which may be lower than the statutory benefit amount); public safety workers may also have more dependents at the time of death than workers in other occupations. Differences in death benefit payments for the average cancer claim are driven primarily by differences in the proportion of workers whose dependents receive death benefits, rather than differences in the paid amount.

To sum up, patterns of benefit receipt and average paid amounts were broadly similar for firefighters and peace officers, but look quite different for workers in other occupations. These differences reflect a variety of reasons, including differences in the provisions of the LC that apply to different occupation groups and differences in the severity of disability (which is reflected in impairment ratings and PD benefits) and in survival (which is reflected in death benefits).

In Table 3.6, we compare benefit payments with earnings losses in order to derive a measure of the pretax wage replacement rate provided to the average worker with a cancer claim in each

[10] Unfortunately, we did not have access to any other reliable source of disability ratings for this study.

Table 3.6. Pretax Wage Replacement Rates over Five Years, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations
5-year earnings losses (extrapolated)	$40,826	$25,966	–$14,850	$103,669
(Standard error)	($5,205)	($6,536)	($5,778)	($6,920)
Average benefit payments	$19,860	$22,407	$3,266	$40,122
Pretax wage replacement rates	49%	86%	>100%	39%

occupation. As noted above, we use a very simple rule of thumb derived in Dworsky et al. (2016) and multiply estimates of earnings losses in the second year after injury by 4.74 to approximate total losses over five years after injury.[11] Dividing the average total amount of benefits paid (including TD, PD, and fatality benefits) by five-year earnings losses yields a pretax wage replacement rate. We estimate that the pretax wage replacement rate is 86 percent for firefighters, 49 percent for peace officers, and 39 percent for workers in other occupations.

Comparison to Existing Studies of Earnings and Employment Among Cancer Patients

Our estimates provide California policymakers with new evidence on the extent of earnings losses for the population of workers who file workers' compensation claims for cancer in the state. Both to assess the credibility of these estimates and to provide context, we compare these estimates with a small number of high-quality peer-reviewed studies on the earnings and employment of cancer survivors. In particular, we focus findings from cohort studies that used longitudinal data on cancer patients with a valid control group (similar to the research design available for this study). These studies have typically focused on a general nonelderly cancer patient population recruited through a set of hospitals or other treatment centers; comparison groups are typically composed of cancer-free individuals in public-use surveys.

Much of the best evidence comes from Scandinavian countries, where researchers have had great success in linking administrative income data to a wide range of datasets on health and disability. Hauglann et al. (2012) estimated the effect of breast cancer on the probability of disability pension receipt (a PD benefit analogous to Social Security Disability Insurance in the United States) for a cohort of patients identified using the Cancer Registry of Norway. They found that breast cancer diagnosis led to a substantially higher probability that women would

[11] In Dworsky et al. (2016), we used an earlier vintage of this data that had a longer follow-up period available to calculate the ratio between total losses over five years after injury and earnings losses in the second year after injury for workers injured between 2005 and 2008, for whom five-year losses were directly observable. This ratio was 4.74, meaning that the dollar value of losses over five years after injury is 4.74 times the value of losses in the second year after injury, with no discounting.

transition to disability pension, and that the effect on the risk of disability increased with stage at diagnosis and with receipt of mastectomy compared with breast-conserving surgery. They do not report earnings effects, but they do find that, among women who remained employed, the probability that a breast cancer patient's income would fall by 10 percent or more relative to her own income the year before diagnosis was about 10 percentage points higher than for the control group in the first two full years after diagnosis. Reduced earnings relative to the control group faded over time and were statistically insignificant by five years after diagnosis.

An earlier study using the Finnish Cancer Registry examined all cases diagnosed in 1987–1988 regardless of cancer type and compared employment probabilities between cancer survivors and workers the same age and gender (Taskila-Abrandt et al., 2005). This study's methodology and study population is most comparable to that used in the present report since they examined a diverse mix of cancer cases using administrative data and compared patients with controls with the same exact age and gender. On average, cancer reduced the probability that a worker's "main activity" in 1990 was employment (2–3 years after diagnosis) by 9 percentage points, an estimate that is very similar to the reduction in employment two years after the date of injury that we observe for peace officers.[12] The researchers examined heterogeneity by educational attainment and occupation and found larger reductions in employment for less educated workers. Occupation-specific reductions in employment were larger in certain high-demand occupations (such as mining, agriculture, forestry, fishing, manufacturing, transportation, and communication) as well as in service occupations, but estimates specifically for public sector or protective services occupations were not reported.

Another study from Norway provided the only longitudinal estimates we were able to locate of earnings losses due to cancer. Syse, Tretli, and Kravdal (2008) used the Cancer Registry of Norway linked to administrative earnings data to study employment and earnings differences between cancer survivors and cancer-free patients. While the study is primarily cross-sectional in nature, differences-in-differences estimates showed earnings losses of 8–16 percent of median earnings for men and 10–15 percent of median earnings for women, depending on the year of diagnosis and the follow-up period (between 1 and 9 years) after diagnosis. Similar to Taskila-Abrandt et al. (2005), they found that less-educated cancer patients experienced more severe earnings and employment losses. Occupational differences between blue-collar and white-collar workers were also substantial.

Other studies that did not provide longitudinal estimates of cancer's effects on labor market outcomes nonetheless provide useful context. Disability due to breast and prostate cancer seems to be more severe in the domain of physical disability (Oberst et al., 2010), including capacity for lifting (Duijts et al., 2014). These findings might lead us to anticipate more severe earnings

[12] Taskila-Abrandt et al., 2005, rely on a classification of workers' "primary activity" over the entire calendar year as "employed" or "not employed," but these categories add up to 94 percent of the cancer-free control group and 87 percent of the group with cancer.

losses for public safety workers due to the physical demands inherent in their work, although certain industries that may have high physical demands (such as utilities, manufacturing, and construction) were also overrepresented among cancer claims filed by workers in other occupations. A systematic review by van Muijen et al. (2013), which pooled studies on longer-term labor market outcomes with studies on the timing of initial return to work, also found that heavy physical job demands, older age, lower education, and lower income all predicted worse return-to-work outcomes. Return to work is a necessary, but not sufficient, condition for a worker to avoid long-term earnings losses, and so this body of work is less directly relevant to the questions of earnings loss and compensation that are the focus of the present study.

A body of U.S.-based studies, many of which are based on the nationally representative Health and Retirement Study, also study the labor market outcomes of cancer survivors. The only study we reviewed that examined income of cancer survivors was Norredam et al. (2009), a cross-sectional study that compared older adults who had survived cancer for at least four years with observably similar adults who had never been diagnosed with cancer.[13] They found no significant evidence of differences in household income, wealth, or employment above age 55. We were not able to locate any U.S.-based longitudinal studies on the effects of cancer on labor earnings at a specified time horizon relative to diagnosis, however.

More U.S.-based studies have examined employment and hours worked as outcomes, however, including studies with longitudinal designs more comparable to ours. Bradley et al. (2007) examined labor market outcomes at 6, 12, and 18 months after diagnosis for a cohort of breast cancer and prostate cancer patients recruited from a cancer surveillance system based in Michigan. They compared labor market outcomes for these patients with a comparison group of Current Population Survey respondents in Michigan. Bradley et al. (2007) found substantial reductions in employment at 6 months for both breast cancer patients (17-percentage-point reduction) and prostate cancer patients (10-percentage-point reduction), but that reductions in employment relative to the control group disappeared by 12 and 18 months after diagnosis.

Several studies based on the HRS data methods to isolate changes in employment over time for cancer survivors and control groups of cancer-free workers. Bradley, Bednarek, and Neumark (2002) estimated the effects of cancer on the probability of employment and the number of hours worked. Breast cancer survivors were about 10 percentage points less likely to work than women without breast cancer, but worked more hours on average. Short, Vasey, and Moran (2008) examined changes in employment and hours worked for older adults (aged 50–62 at cancer diagnosis) compared with other employed adults the same age who were not diagnosed with cancer: outcomes were observed two to six years after diagnosis. Cancer reduced full-time employment and hours worked for both male and female workers: full-time employment were

[13] Although panel data methods were not used in Norredam et al., 2009, the authors applied propensity score matching to baseline characteristics observed prior to the cancer diagnosis.

6–8 percentage points lower for women, and 8–12 percentage points lower for men, depending on the specification. Both female and male workers who remained employed reduced hours by 3–5 hours per week. Effects of cancer on the probability of any employment were significant for women (4–7 percentage points lower); estimated reductions in employment were only slightly smaller for men, but were statistically insignificant.

While Short, Vasey, and Moran (2008) did not estimate effects on labor earnings, reduced hours and reduced employment of the magnitudes they estimated could easily reduce earnings by amounts comparable to the reductions we estimated for public safety workers. Another important finding from the study was that cancer survivors who did not experience recurrence showed little evidence of reduced employment or hours at the two- to six-year time horizon; the average effect of cancer on labor supply was driven largely by patients who experienced a new cancer (including recurrence).

Discussion

The U.S.-based longitudinal studies on employment suggest larger reductions in employment than we observe in the short run. However, the EDD data aggregate time to the quarterly frequency, and so a worker would need to be out of work for three months to be observed as nonemployed in our data. The survey data used in the U.S.-based studies appear likely to use point-in-time measures of employment status, which could enable them to capture short spells of nonemployment that would not be reflected in the quarterly data we use.

However, it is notable that we find persistently lower employment for all occupation groups other than lifeguards, when the U.S.-based studies on outcomes at two or more years after diagnosis generally do not find strong evidence of reduced employment. The peace officers and firefighters in our study represent a larger and more homogeneous sample of cancer patients (with respect to occupation, job demands, and retirement incentives) than the sample used in Short, Vasey, and Moran (2008), but our estimates also reflect an average across all cancer sites associated with cancer claims and thus are probably not comparable to the breast cancer or prostate cancer estimates produced by Bradley and coauthors.

Some of the difference between our findings of reduced employment at two years after the date of injury and findings in the U.S.-based literature is also likely to reflect the fact that we have included deceased patients in the sample used for our earnings loss estimates. Cumulative mortality is large enough to account for the reduction in employment estimated among firefighters, although our mortality measure is not limited to patients who died within two years of the injury date, and so we cannot conclude that all the reduction in employment for firefighters is due to mortality. For peace officers and workers in other occupations, however, reductions in employment are at least several times larger than the cumulative mortality rate.

Unfortunately, workers' compensation data are not suitable for studying some of the important mechanisms of earnings loss identified in the literature, including side effects of

treatment and, most importantly, recurrence or new cancers. A review by Munir, Mansur, and Furuoka (2009) indicated that outcomes differ systematically according to treatment modality, an important modifier that we were not able to study reliably with the data available to us. While we had hoped to conduct some analyses of these mechanisms using medical claims data, the low and variable proportions of workers with cancer claims who received sustained care through workers' compensation led us to conclude that attempts to classify patients' clinical outcomes or recurrence using the medical claims data in the WCIS could be very misleading.

Our inability to observe clinical outcomes or recurrence among the workers in our sample also limits our analysis of wage replacement rates and the appropriateness of California's approach to disability compensation for cancer. California relies on disability ratings performed when the patient reaches MMI, which thus reflect a patient's impairment at a specific point in time. If, as suggested by Short, Vasey, and Moran (2008), the long-term income risks posed by cancer derive from new cancers and recurrence, then compensation that is adequate for a population of similarly situated patients at the point of MMI may turn out to be generous for patients who remain cancer-free, but inadequate for patients who experience recurrence or new cancers in the future. While the potential for long-term complications that lead to reduced work capacity in the future is relevant for a wide range of occupational injuries and illnesses, these risks seem especially important in the context of cancer.

We did not explore these legal issues that shape the availability of additional compensation for workers who have new or recurrent cancers, since these nuances fell far outside the scope of our empirical analysis. It is plausible that workers would file a new workers' compensation claim or seek to reopen their original claim in the event of recurrence, although we emphasize that we did not explore whether this is common or even possible. The addition of data from the California Cancer Registry to future research on earnings losses due to cancer would likely be needed to facilitate a more reliable and detailed examination of these issues.

4. Earnings Losses and Benefit Payments for Workers with Occupational Cancer Claims by Gender

The evidence presented in Chapter 3 addresses three of this study's four research questions. In this chapter, we describe earnings losses and benefit payments for workers with cancer claims by gender. However, our ability to characterize gender differences in losses and benefits was constrained by the relatively limited number of cancer claims filed by female workers. We lacked sufficient data to obtain precise estimates for lifeguards or firefighters. Among peace officers and other occupations, there were more female workers with cancer claims, and so estimates of gender differences in these occupations were more informative.

Earnings and Employment Changes After Cancer Claims by Gender

Table 4.1 reports the levels of annual earnings and employment over two years before and two years after a cancer claim by gender and occupation. Across all occupation groups, female workers with cancer claims have lower earnings than male workers in the same occupation groups prior to the date of injury. Employment rates before injury are very similar for male and female workers within each occupation group, suggesting that lower earnings reflect gender differences in wages or hours. Labor earnings drop sharply after the date of injury in all occupation and gender groups except for lifeguards. Employment rates two years after the date of injury are broadly similar between male and female workers within each occupation group except for the other occupations: two years after the date of injury, 50 percent of female workers in other occupations with cancer claims were employed, compared with just 32 percent of male workers.

Table 4.1. Earnings and Employment for Workers with Cancer Claims, by Occupation and Gender

		Peace Officers		Firefighters		Lifeguards		Other Occupations	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Annual earnings									
	2 years before injury	$116,880	$108,850	$145,417	$109,324	$63,411	$44,786	$52,952	$45,557
	1 year before injury	$119,724	$113,772	$147,521	$114,891	$66,102	$46,478	$54,112	$48,079
	1 year after injury	$101,363	$95,619	$126,783	$74,749	$67,440	$48,696	$22,620	$29,164
	2 years after injury	$82,591	$77,905	$107,053	$54,257	$59,383	$44,378	$15,174	$24,827
Employment									
	2 years before injury	99.6%	99.3%	98.7%	96.6%	96.8%	96.2%	88.4%	88.5%
	1 year before injury	99.0%	100.0%	99.2%	96.6%	96.8%	100.0%	96.1%	86.5%
	1 year after injury	90.0%	94.6%	90.9%	86.2%	95.2%	100.0%	41.3%	59.6%
	2 years after injury	81.7%	87.8%	84.3%	79.3%	92.1%	92.3%	32.3%	50.0%
Number of cases		712	147	618	29	126	26	155	52

Table 4.1 indicates that peace officers, firefighters, and workers in other occupations can expect a substantial drop in earnings and employment after filing a cancer claim. However, the differences in preinjury earnings reported in the table may reflect compositional differences that need to be accounted for to provide a valid comparison of how similar workers of different genders fare after a cancer claim. In public safety occupations, the employment of female workers in peace officer or active firefighting jobs that would lead to coverage by cancer presumptions has been rising over time, and male and female cancer claims are thus likely to be filed by different cohorts of workers with different seniority, career length, and pension eligibility. In the other occupations, meanwhile, we need to adjust for differences in the distribution of employment across industries and other worker or employer characteristics that can affect claim outcomes. We therefore used regression models that control for the same individual and employer characteristics included in Chapter 3 to isolate differences in earnings losses by gender for otherwise similar workers.

Earnings Losses Due to Cancer for Workers Filing Cancer Claims by Gender

Table 4.2 reports estimates earnings losses for male and female workers with cancer claims in each occupation group. The first row of estimates shows the earnings loss over two years experienced by male workers with cancer claims in each occupation. The second row shows our estimate of the additional earnings loss experienced by women in that occupation; positive estimates indicate that women have higher earnings after injury (i.e., smaller earnings losses), while negative estimates indicate that women have lower earnings after injury (i.e., larger earnings losses).

Table 4.2. Effects of Cancer on Earnings over Two Years After Date of Injury, by Occupation and Gender

	Peace Officers	Firefighters	Lifeguards	Other
Change in earnings over two postinjury years for men ($)	–19,370***	–10,219***	4,330	–51,096***
	(2,703)	(3,029)	(3,433)	(3,796)
Difference in earnings for women compared to men ($)	7,339	–6,497	–8,011	20,994***
	(5,439)	(12,823)	(6,397)	(5,372)
Number of observations	171,774	58,088	1,970	3,199,352

NOTES: *** $p < 0.01$. Standard errors appear in parentheses.

For the three groups of public safety workers we examine, we do not detect any statistically significant differences in earnings loss between male and female workers who file cancer claims. Among peace officers, the group with the largest number of female workers who file cancer

claims, the estimate suggests slightly higher earnings (smaller earnings losses) for women, but the estimate is not significantly different from zero and the data do not conclusively rule out the possibility of no difference or greater losses for female workers. Our estimates of incremental earnings losses for firefighters and lifeguards are even more imprecise, reflecting the fact that a very small volume of claims from women (fewer than 30) were observed in each occupation. Among other occupations, in contrast, we found substantially higher earnings (smaller earnings losses) among men than among women, by $21,000 over two years after injury.[1] While our estimates control for differences in observable demographics and employer characteristics, we were not able to control for other factors, such as differences in the type of cancer, that may also contribute to these gender differences.

Gender Differences in Benefits and Disability Ratings

Our analysis of earnings losses by gender found no statistically significant evidence of gender differences in earnings losses due to cancer, although the precision of these estimates was limited by the number of cancer claims filed by women. We also examined disability ratings performed at DEU. However, we were able to report estimates only for peace officers; firefighters, lifeguards, and workers in other occupations had an insufficient number of DEU ratings performed on female workers for us to report the estimates without creating risks to confidentiality.[2] Table 4.3 reports average DEU ratings by gender for peace officers. The data

Table 4.3. Disability Ratings for Peace Officer Cancer Cases Evaluated at the State Disability Evaluation Unit, by Gender

	Male	Female	*p*-value for Difference
Average combined rating			
All ratings	15.2	18.4	0.55
N	78	20	
Constant-maturity ratings	14.2	13.7	0.92
N	62	15	
Average final rating			
All ratings	19.9	25.5	0.39
N	95	22	
Constant-maturity ratings	19.3	21.2	0.76
N	75	16	

[1] While we were concerned that smaller earnings losses for women were driven by their lower preinjury earnings, Poisson regression estimates that capture the effect of injury in percentage terms rather than dollar terms yield very similar findings. See the Appendix for estimates and further details.

[2] Throughout this study, we suppress results based on ten or fewer injured workers, a policy that limits our ability to report estimates for disability ratings and benefit payments conditional on benefit receipt by gender.

seem to suggest that female peace officers have, on average, slightly higher standard and final ratings compared with male peace officers. However, no gender differences in average ratings were statistically significant, and so the available data do not support the conclusion that there are gender differences in average ratings.

Gender Differences in Disability Ratings Performed at Disability Evaluation Unit

More data were available on benefit payments by gender, and we were able to report estimates for peace officers and workers in other occupations in Table 4.4. Table 4.4 is structured similarly to Table 3.5 but also includes estimates of the proportion of workers who died and the proportion who encountered a full or partial claim denial. Gender differences in all measures of disability or death benefits were statistically insignificant for peace officers. No female workers in other occupations received death benefits, and so we did detect a statistically significant gender difference in the receipt of death benefits and the unconditional average amount of death benefits paid. The lower panel of Table 4.4, however, also indicates that male workers with cancer claims are much more likely than female workers with cancer claims to have died, with mortality three times higher for male than female peace officers and four times higher for male than female workers in other occupations. Rates of full or partial claim denial, meanwhile, were not statistically significantly different between male and female workers within either peace officers or other occupations.

Table 4.4. Benefit Receipt Rates and Paid Indemnity Benefits, by Type of Benefit, Occupation, and Gender

	Peace Officers			Other Occupations		
Percentage with benefits	**Male**	**Female**	***p*-value**	**Male**	**Female**	***p*-value**
Any indemnity	41.9%	46.3%	0.24	39.1%	42.3%	0.59
TTD	17.0%	21.1%	0.15	22.2%	25.0%	0.58
PPD	35.7%	39.5%	0.30	30.4%	32.7%	0.68
Fatality	2.4%	1.4%	0.35	3.9%	0.0%	0.09
	Peace Officers			**Other Occupations**		
Average paid benefits (unconditional)	**Male**	**Female**	***p*-value**	**Male**	**Female**	***p*-value**
Total indemnity	$20,136	$18,523	0.74	$44,141	$28,143	0.38
TTD	$7,263	$11,696	0.19	$2,748	$1,069	0.11
PPD	$5,349	$4,722	0.62	$17,153	$14,988	0.78
Fatality	–	–	0.28	–	–	0.04

	Peace Officers			Other Occupations		
Average paid benefits (conditional on receiving benefits)	**Male**	**Female**	***p*-value**	**Male**	**Female**	***p*-value**
Total indemnity	$48,046	$40,043	0.93	$112,805	$66,520	0.40
TTD	$42,734	$55,462	0.66	$12,368	$4,275	0.05
PPD	$14,968	$11,967	0.29	$56,359	$45,846	0.60
Fatality	–	–	–	–	–	–
Other claim outcomes	Male	Female	*p*-value	Male	Female	*p*-value
Worker died	6.3%	2.0%	0.04	16.1%	3.8%	0.02
Any claim denial (full or partial)	29.8%	25.9%	0.34	60.0%	61.5%	0.84
Number of cases	712	147		155	52	

NOTES: *p*-values are for significance of difference between male and female workers in each occupation. Significance of differences in percentage with benefits was assessed using a chi-squared test. Significance of differences in dollar amounts was assessed using a two-sample t-test with unequal variances. Fatality benefit payments are suppressed to protect confidentiality.

Discussion

The estimates presented in this chapter fail to reveal evidence that female workers who file cancer claims have worse labor market outcomes than male workers in the same occupation groups, or that disability ratings or benefit payments differed meaningfully between male and female workers. However, our ability to provide precise estimates of gender differences was constrained by the fact that workers who filed cancer claims in California are overwhelmingly male.

Some other limitations of the analysis in this chapter are also important to bear in mind. First, our estimates are applicable only to the population of workers who file workers' compensation claims for cancer. It is plausible that claim-filing decisions, cancer detection, or attribution of cancers to occupational causes could differ by gender within each occupation group. We suspect this is less of a concern for public safety workers since cancer presumptions are likely to be well understood by workers in these occupations. The near equality of claim denial rates between male and female workers within occupations also does not suggest major gender differences in the extent to which male versus female workers are willing to file claims for cancers that are more likely to be questioned by their claims administrators.

The clearest gender differences documented in this chapter were in the probability that the worker died, particularly for workers in other occupations. The much higher death rate observed among male workers in other occupations would be consistent with higher severity of cancer for male workers, a difference that is also suggested by the much larger earnings losses we estimated for male workers. Unfortunately, our data lack the detailed information on staging, treatment outcomes, and other clinical measures of cancer severity that would be needed to disentangle case mix differences from differences in labor market outcomes that might reflect differences in job demands or, potentially, discrimination.

5. Conclusion and Policy Implications

While the scope of this study was limited to establishing basic facts about the consequences of and compensation for occupational cancer in California, several findings with policy implications emerged. First, the sharp differences across occupations that we documented in mortality, claim denials, and earnings losses suggest that California's presumptions exert a powerful influence on claiming behavior and have succeeded in removing barriers to claim filing for public safety workers covered by the presumptions. Even for peace officers and firefighters, however, rates of full or partial denial on cancer claims are several times higher than those observed for the average workers' compensation claim. Detailed examination of delays in benefit payment or medical treatment, or of whether claim denials reflect full or partial denials, were beyond the scope of this study. It is clear, however, that presumptions have not eliminated disputes over compensation; yet the contrast with workers in other occupations also suggests that disputes on public safety worker claims would be far more widespread in the absence of presumptions.

We also found that earnings losses experienced by workers who file cancer claims differ widely across occupations. Most strikingly, we detected no earnings losses for lifeguards who filed cancer claims. As a proportion of their earnings, the losses experienced by firefighters and peace officers with cancer claims are actually less severe than losses for the average injured worker who received indemnity benefits during this time period: an interim report from RAND's ongoing Wage Loss Monitoring Study found that earnings losses for the average worker who received indemnity benefits for an injury between 2005 and 2015 ranged between 19 and 24 percent of earnings in the first year after injury and 15 to 21 percent of earnings in the second year after injury—compared with losses of 4.5 percent of earnings for firefighters and 8.9 percent of earnings for peace officers over two years after injury. Workers in other occupations, meanwhile, experience much larger earnings losses in both percentage and dollar terms than do injured workers in the public safety occupations examined in this study. Nonetheless, the earnings losses experienced by firefighters and peace officers are substantial in dollar terms.

Regarding gender bias, the data available for the present study do not support the conclusion that women who file cancer claims experience worse labor market outcomes than male workers in the same occupational groups who file cancer claims. Nor did we find strong evidence of gender differences in disability ratings or paid benefits. These gender differences were imprecisely estimated, however, due to the small numbers of female workers who filed cancer claims in most occupations: we found that seven of eight workers who filed workers' compensation claims for cancer in California between 2005 and 2015 were male. It seems likely that female workers will make up more of the occupational cancer caseload in the future, since frontline public safety occupations have become more integrated by gender in recent decades. Compared with workers

who were in their 40s and 50s over the past decade, recently hired cohorts of firefighters and peace officers—who have not yet reached ages when cancer incidence and detection escalate sharply—are likely to contain more women. For the time being, however, the small number of women who filed workers' compensation claims for cancer poses a major challenge to research on the role of gender in the workers' compensation system's treatment of cancer cases.

In contrast to gender differences, differences in earnings losses between workers with cancer claims who were covered by cancer presumptions and those without cancer presumptions were remarkably large, and led to large disparities in pretax wage replacement rates across occupational groups. The proportion of average pretax earnings losses replaced by benefits was relatively high (86 percent) for firefighters, but was far lower for peace officers (49 percent) and lower still for workers in other occupations (39 percent). Workers in these other occupation groups had high disability ratings and also had the highest benefit payments of any occupation group examined here, but the benefits were not high enough to offset these workers' substantial earnings losses. A detailed analysis of impairment rating methods was beyond the scope of this study, but the differences in wage replacement rates between peace officers and firefighters may be a topic of interest to stakeholders and policymakers.

Many questions of interest to California policymakers were beyond the scope of this study. In particular, the patterns of ratings and benefit payments reported here do not speak to the question of discrimination or gender bias in application of the disability rating system. A more detailed examination of rated impairments from a sample of cases with identical clinical characteristics would be necessary to address whether, for instance, evaluating physicians treat female and male workers with the same cancer and impairment severity differently. However, very few ratings of female workers with cancer claims are performed at DEU, and it is likely that we would not have been able to obtain informative estimates of differences in impairment rating methods with data available to DIR. A more fruitful approach might be to conduct an audit or correspondence study in which trained actors or hypothetical case files are submitted to practicing qualified medical examiners for rating. Similarly, there do not appear to be enough female workers who actually file cancer claims in California to obtain precise estimates—even with data on the entire population—of earnings losses associated with specific primary cancer sites or types of cancers.

A more worrisome limitation of our study is that we lacked data on workers with occupational cancer—potentially including those who would meet the evidentiary standards applicable to their occupations—who do not file a workers' compensation claim for their cancer. Our case definition is also likely to omit cases where cancer was diagnosed subsequent to claim filing, or where cancer was comorbid with other injuries or diseases. Unfortunately, our inability to capture medical claims and diagnoses outside workers' compensation (most notably from workers' group health coverage) means that our case definitions based on medical claims are almost certainly an underestimate of the true number of cancer cases in the workers' compensation system.

Data sources beyond the workers' compensation system will be necessary to provide definitive answers to many of the questions raised by our findings, particularly those related to how presumptions affect claiming behavior, or how earnings losses vary with cancer site and staging. Linking workers' compensation data to group health claims with a consortium of large public employers or, potentially, a retiree health care system would dramatically improve the credibility of our claims-based case ascertainment approach. Notably, California is exploring the development of a Health Care Cost Transparency Database, which could also be used to examine cancer treatment and patient out-of-pocket costs for commercially insured workers who do not file workers' compensation claims.

California also maintains a high-quality cancer registry, which would be vastly superior to claims data as a source of information on cancer site, stage at diagnosis, and clinical outcomes. Linkage of the data used in the present study to the cancer registry would be the most reliable way to produce the site-specific estimates of earnings losses that would be necessary to develop an empirically grounded benefit schedule or other alternative to current rating methods.

Appendix

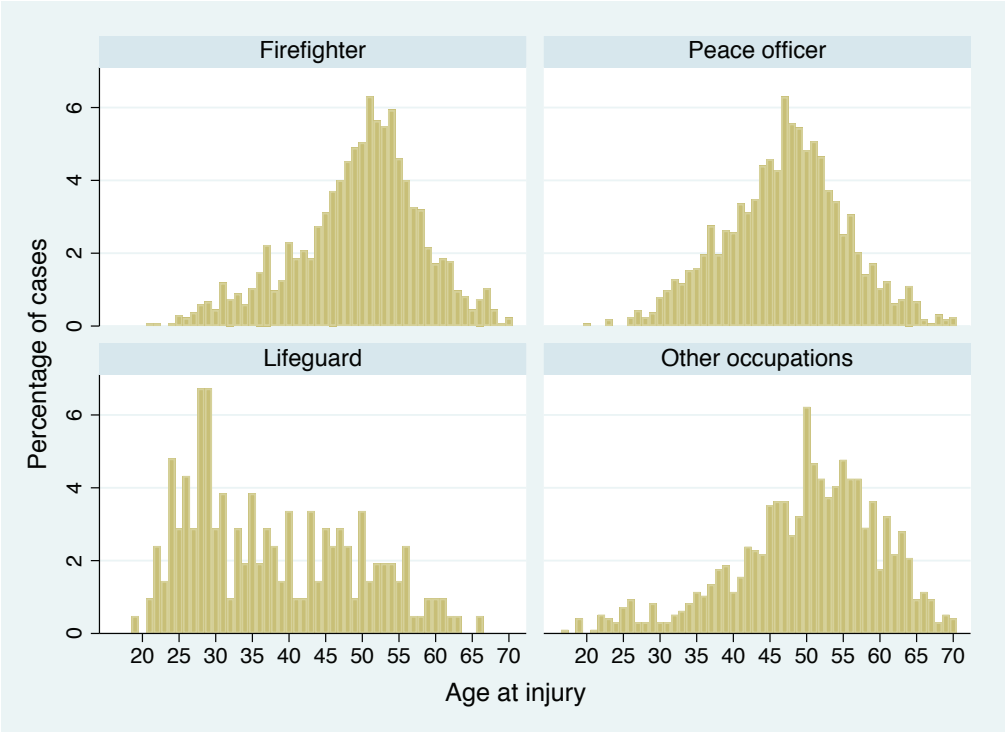
Table A.1 shows demographics and rates of benefit receipt for the broader sample of 4,156 cancer claims that had complete records, but which were either not linked to earnings histories or were excluded from our four occupation groups based on industry codes. Differences between this sample and our analysis sample are discussed briefly in Chapter 2.

Table A.1. Demographics and Benefit Receipt for Workers' Compensation Claims, Including Claims Without Earnings Data Available, by Cancer vs. Non-Cancer Nature of Injury

	Cancer	Non-Cancer
Demographics		
Average age	48.1	40.1
Percentage female	12.9%	42.1%
Occupation		
Police	39.4%	3.4%
Fire	32.4%	1.3%
Lifeguard	5.0%	0.1%
Other	23.2%	95.3%
Benefit receipt		
Any indemnity benefits?		
Temporary total disability	14.3%	22.5%
Permanent disability	30.1%	13.1%
Death benefits	2.8%	0.0%
Worker died		
Other claim outcomes		
Any claim denial (full or partial)	33.8%	10.7%
Worker died	8.0%	0.1%
Number of cases	4,156	6,427,621

Figure A.1 presents histograms of age at the date of injury for workers with cancer claims in the four occupations we examine. A large proportion (over 25 percent) of claims from firefighters are filed between ages 50 and 55, an age range that is likely to coincide with sharp increases in retirement incentives due to pension eligibility. However, multiple cancer screening guidelines are keyed to ages 40, 45, and 50, and these guidelines generate sharp increases in screening that are likely to translate into increased detection at exactly the same ages when public safety workers are likely to be ending their careers (Kadiyala and Strumpf, 2011). The age distribution at the date of injury for workers in other occupations displays, if anything, an even more pronounced spike in cancer claims at age 50 than we observe for any of the public safety workers, suggesting that screening and detection patterns are an important influence on the timing of cancer claims.

Figure A.1. Age at Injury for Workers with Cancer Claims, by Occupation



Additional Details of Occupation Coding

As described more fully in Dworsky, Seabury, and Broten (2019), we used fuzzy matching between the occupation description on the workers' compensation claim and a sample of verbatim job titles reported by respondents to the Occupational Information Network survey sponsored by BLS. A preliminary list of job titles was reviewed by a fire chief in California to finalize our classification of active versus nonactive firefighting jobs. Because many job titles that might be used on a firefighter workers' compensation claim (e.g., "lieutenant," "public safety officer") are not unique to firefighting, we used risk classification codes ("class codes") on the workers' compensation claim to restrict attention to workers in class codes with a large volume of firefighting claims.

The methods used in Dworsky, Seabury, and Broten (2019) had to be modified to match the groups of workers covered by California's cancer presumptions. The definition of peace officers covered by LC Sec. 3212.1 is much broader than police and sheriffs' deputies: peace officers also include the California Highway Patrol, certain corrections workers, and investigators or enforcement agents employed by district attorneys, among others.[1] After reviewing the California

[1] The definition of peace officers relevant to LC Sec. 3212.1 is specified in Penal Code Secs. 830.1, 830.2(a), 830.37(a) and 830.37(b). We consulted with DIR staff to confirm the applicability of Sec. 3212.1 to specific job titles referenced in the Penal Code.

Penal Code and consulting with legal experts at DIR on the applicability of Sec. 3212.1 to specific occupation titles, we expanded the definition of peace officers used in Dworsky, Seabury, and Broten (2019) to include these additional occupations. Lifeguards were also identified using the occupation description field.

Finally, because the only information about occupation in the WCIS is an unstructured text field, there were many cases with ambiguous occupation descriptions that we were unable to conclusively assign to one of our four occupational categories. When possible, we followed the approach taken in Dworsky, Seabury, and Broten (2019), which used occupation descriptions in combination with class codes reported on the FROI to distinguish firefighters and police officers from other workers. This method is labor intensive, however, and extending it to include other peace officers, lifeguards, and other occupations was beyond the scope of this project.

To refine our occupation definitions, we also used industry codes from the EDD data to distinguish between public safety workers and those in other occupations. Specifically, we found that the top ten six-digit NAICS industries accounted for over 98 percent of public safety worker cancer claims. These were largely concentrated in the NAICS Public Administration sector (92), which includes police and fire protection as well as other state and local government agencies. Detailed industries outside the Public Administration sector with public safety worker cancer claims included several types of educational institutions[2] and the "Nature Parks and Other Similar Institutions" industry (NAICS 712190). Finally, in order to ensure that public safety workers were not mistakenly included in the "Other Occupations" category, we excluded cancer cases from workers in the Public Administration sector who were not identified as public safety workers.

For reference, Table A.2 lists the most common verbatim (unedited) occupation descriptions in each of the four occupation groups included in our analysis, along with the number of observations and the number of unique occupation descriptions reported. The top ten occupation titles in the peace officer, firefighter, and lifeguard categories appear to clearly belong in those categories. The other occupations category, meanwhile, contains no more than a handful of cases with any particular occupation title, and we observe 193 unique occupation titles in 223 claims, indicating that most occupation titles in this category appear on only a single claim.

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[2] A small number of peace officers with cancer claims were employed by Elementary and Secondary Schools (611110), Colleges, Universities, and Professional Schools (611310), and Junior Colleges (611210). Campus police officers are identified as peace officers in Penal Code Sec. 830.2(b) not referenced by LC Sec. 3212.1, but it is likely that these officers may file cancer claims despite not being explicitly covered by the cancer presumption.

The "Nature Parks and Other Similar Institutions" industry (NAICS 712190), which may contain some county and state beaches, employed over 3 percent of lifeguards with cancer claims.

Table A.2. Top 10 Verbatim Occupation Titles, by Occupational Group

Rank	Peace Officer	Percentage of Cases	Firefighter	Percentage of Cases	Lifeguard	Percentage of Cases	Other	Percentage of Cases
1	Police officer	19.7	Fire captain/56 hours/	12.98	Ocean lifeguard	40.79	Registered nurse	1.93
2	Deputy sheriff	16.5	Firefighter/56 hours/	12.83	Senior ocean lifeguard	33.55	Foreman	1.45
3	Officer	11.9	Fire fighter specialist/56 hours	12.21	Lifeguard	5.92	General labor	1.45
4	Police department	8.3	Fire captain	11.75	Lake lifeguard, parks and recreation	5.26	Laborer	1.45
5	Sergeant	8.3	Firefighter	8.35	Lieutenant, ocean lifeguards	4.61	Machinist	1.45
6	Police sergeant	5.9	Fire department	8.04	Senior lake lifeguard	4.61	Splicing technician	1.45
7	Police detective	2.7	Fire engineer	3.86			Unknown	1.45
8	Deputy sheriff II	2.3	Firefighter	2.94			Welder	1.45
9	Correctional officer	2.1	Firefighters/not volunteers	2.63			Cook	0.97
10	Deputy sheriff	1.8	Lieutenant	1.7			Field technician	0.97
Number of cases	859		647		152		223	
Number of unique occupation titles	92		81		14		195	

Alternative Definitions of Cancer Claims Based on Diagnosis Codes

We also used medical claims reported to the WCIS to develop alternative definitions of cancer cases that did not depend on FROI. In this report, we analyze one loose definition and one strict definition. The loose definition includes any injury with one or more bill lines on which neoplasm was indicated as the *primary* diagnosis, *excluding benign and unspecified neoplasms*; that is, limited to International Classification of Diseases (ICD)-9 codes 140–209 and 230–234). A comparison of this definition to our main definition is presented in Table A.3.

Table A.3. Comparison of First Report of Injury vs. Medical Claims Case Definitions for Loose Medical Claims Case Definition

	Claim Included in Definition?		
Case definition			
FROI nature of injury	Y	Y	N
Medical claims (loose)	Y	N	Y
Occupation			
Peace officer	27%	29%	43%
Firefighter	37%	39%	24%
Lifeguard	12%	81%	7%
Other occupations	2%	3%	95%
Total	8%	10%	81%

NOTE: Percentages in table report percent of cases in each occupation (row) meeting each case definition or combination of case definitions (column). "Nature of injury" definition includes claims for which nature of injury on FROI is 74 (Cancer). "Medical claims (loose)" definition includes claims with 1+ bill line reported to WCIS medical with primary diagnosis of neoplasm (ICD-9 codes 140–239), excluding benign and unspecified neoplasms. Sample limited to claims from 2007–2014 injury dates with medical claims available.

A limitation of this loose definition is that cancer can frequently appear on medical bills as a comorbidity (including in cases when an individual has a history of cancer or is in remission), or as a *rule-out* diagnosis used to justify billing for screening or diagnostic procedures. We therefore also applied a more strict definition that required one or more bill line with neoplasm as a *primary* diagnosis, *excluding benign and unspecified neoplasms* (i.e., limited to ICD-9 codes 140–209 and 230–234) *in three or more consecutive calendar quarters*. This definition was chosen to select cases with a pattern of medical care over time that was very unlikely to reflect rule-out diagnoses, and more likely to reflect cancer treatment spanning more than three months. Table A.4 compares the results of this definition with our main case definition based on FROI.

We think our loose definition is likely to overestimate the incidence of cancer in the workers' compensation system, while our strict definition may omit some cases with less typical patterns of care receipt, including cases where patients receive cancer care outside workers' compensation or where nonworkers' compensation payers seek reimbursement for cancer care from workers' compensation payers. Indeed, Tables A.3 and A.4 indicate that many—and in some occupations,

Table A.4. Comparison of First Report of Injury vs. Medical Claims Case Definitions for Strict Medical Claims Case Definition

	Claim Included in Definition?		
Case definition			
Nature of injury	Y	Y	N
Medical claims (strict)	Y	N	Y
Occupation			
Peace officer	10%	85%	5%
Firefighter	14%	82%	3%
Lifeguard	0%	100%	0%
Other occupations	4%	69%	27%
Total	9%	81%	10%

NOTE: Percentages in table report percent of cases in each occupation (row) meeting each case definition or combination of case definitions (column). "Nature of injury" definition includes claims for which nature of injury on FROI is 74 (Cancer). "Medical claims (strict)" definition includes claims with 3+ consecutive calendar quarters with 1+ bill line reported to WCIS medical with primary diagnosis of neoplasm (ICD-9 codes 140–239), excluding benign and unspecified neoplasms. Sample limited to claims from 2007–2014 injury dates with medical claims available.

most—workers who file cancer claims are not receiving treatment for their cancer directly through the workers' compensation system. We suspect that many of these workers are receiving care through their group health coverage, which is likely to provide access to a wider range of oncologists and other relevant specialists than the group of providers available through workers' compensation medical provider networks. Unfortunately, such care leaves no record in the WCIS medical data, which collect only bills that are submitted by providers directly to workers' compensation payers. Such care may be provided on a lien basis (which we also would not observe in the WCIS medical claims), but we think it is also likely that group health plans or other payers might pay providers and then seek to recover from workers' compensation payers. Even though, in the case of self-insured public agencies, group health and workers' compensation might ultimately be financed out of the same pool of funds, care not initially billed to workers' compensation is likely to be missing from our data, limiting our ability to definitively identify the full population of cancer cases on the basis of medical bills reported to the WCIS.

Despite these limitations, the WCIS medical bills provide us with the best available information about the case mix of occupational cancer claims, which we describe in Table A.5. The sample for this table consists of workers meeting our loose case definition (1+ medical bill with a primary cancer diagnosis, excluding benign and unspecified neoplasms). Only seven lifeguards had any cancer diagnoses in the WCIS medical bills, and we omit results for lifeguards from this table. These estimates are discussed in Chapter 3.

Table A.5. Distribution of Primary Cancer Site by Occupation for Workers' Compensation Claims with 1+ Cancer Diagnosis in Medical Bills Reported to Workers' Compensation

Primary Cancer Site	Peace Officer	Firefighter	Lifeguard	Other Occupations
Melanoma	9%	13%	–	16%
Breast	6%	2%	–	4%
Colon	7%	10%	–	4%
Gynecological	1%	1%	–	10%
Prostate	8%	10%	–	2%
Testes	2%	5%	–	1%
Head	6%	2%	–	9%
Urinary	3%	4%	–	3%
Skin	34%	31%	–	3%
Gastrointestinal	5%	3%	–	6%
Lung	1%	0%	–	0%
Brain	2%	7%	–	9%
Bones	7%	3%	–	12%
Endocrine	7%	5%	–	14%
Pleura/mediastinum	0%	1%	–	0%
Non-specific	2%	3%	–	6%
Lymph node	0%	0%	–	0%
Secondary	0%	0%	–	0%
Total	322	175	–	3,698

NOTE: Primary cancer site assigned using ICD-9 code lists and site hierarchy from Weiner et al., 2003. Sample contains all claims linked to WCIS medical with primary diagnosis of neoplasm (ICD-9 codes 140–239), excluding benign neoplasms, on one or more bill lines. Case mix for lifeguards not reported due to small sample size (N = 7).

Additional Details of Estimation Methods

This section presents technical details of the regression models we used to estimate changes in earnings and employment for workers with cancer claims.

Regression Specification for Earnings Loss Estimates

We used a differences-in-differences estimation strategy to estimate earnings losses due to cancer over two years after injury. For each occupation group, we formed a separate estimation sample consisting of workers with cancer claims (regardless of indemnity benefit receipt) and workers in the same occupation group with medical-only claims. That is, all workers who received any indemnity benefits or settlements for TD, PD, vocational rehabilitation, or death were excluded from the control group.

We then constructed a panel dataset containing two observations (indexed by time $t = 0, 1$) for each worker (indexed by i) in our estimation sample. One observation contained measures of labor market outcomes before the date of injury, and one contained measures of labor market outcomes after the date of injury. For earnings, we inflated quarterly earnings to real 2016

dollars using the Consumer Price Index for All Urban Consumers and summed real earnings over two years before injury and two years after injury to measure preinjury earnings and postinjury earnings. We assigned employment outcomes (both employment at any firm in California and employment specifically at the at-injury employer) from eight quarters before the date of injury to $t = 0$ and eight quarters after the injury to $t = 1$. Our differences-in-differences model for labor market outcomes y_{it} can be expressed as

$$y_{it} = \alpha + \beta^C C_i + \delta^C C_i \text{Post} - \text{Injury}_{it} + X_i \beta_0^X + \text{Post} - \text{Injury}_{it} \times X_i \beta_1^X + \varepsilon_{it},$$

where C_i is an indicator variable equal to 1 if worker *i* filed a cancer claim and 0 if worker *i* filed a medical-only claim, $\text{Post} - \text{Injury}_{it}$ is an indicator equal to 1 for post-injury observations ($t = 1$) and 0 for pre-injury observations ($t = 0$), X_i is a vector containing control variables for worker *i*, α is a constant, and ε_{it} is an error term that is mean-zero conditional on the explanatory variables. β^C captures the pre-injury difference in outcomes between workers with cancer claims and the control group; β_0^X captures pre-injury differences explained by the control variables X_i; and β_1^X allows each control variable X_i to have an independent effect on earnings dynamics (e.g., capturing the drop in earnings associated with retirement for firefighters who file claims at age 50). We note that allowing the control variables to have time-varying effects on the outcome substantially increases the flexibility of the regression model and is recommended in differences-in-differences studies by (Jaeger, Joyce, and Kaestner, 2018).

The coefficient of primary interest, which captures the effect of cancer on labor earnings, is δ^C. We report δ^C as our main estimate of earnings losses over two years post-injury in Chapter 3. We use this model for earnings (a continuous, non-negative variable) and for employment (a binary variable). Estimates reported in the report are weighted least squares estimates; our weighting method is described below. Standard errors account for clustering of outcomes within individual workers and allow for arbitrary correlation of each individual's error terms across multiple time periods.

We include the following control variables in X_i:

- gender (indicator equal to 1 for female workers and 0 for male workers)
- age (full set of indicators for age in years at the date of injury, both uninteracted and interacted with gender)
- region within California (full set of indicators for worker residence in ten regions defined by the Division of Workers' Compensation: Bay Area, Central Coast, Central Valley, Eastern Sierra, Inland Empire, Los Angeles, North Sacramento Valley, North State-Shasta, Sacramento Valley, San Diego)
- industry (full set of indicators for six-digit NAICS industry of at-injury employer for public safety worker models; model for other occupations also includes full set of indicators for NAICS two-digit industry of at-injury employer)
- firm size (full set of indicators for seven categories of firm size, with cutpoints at 10, 50, 100, 500, 1,000, and 5,000 employees)
- injury date (full set of indicators for calendar quarter of injury, from 2005Q1 to 2015Q4).

To estimate gender differences in earnings losses, we expanded this model to include interaction terms between an indicator for whether worker *i* is female and the cancer indicator, the postinjury indicator, and the interaction between cancer and postinjury:

$$\begin{aligned} y_{it} = \quad & \alpha + \beta^C C_i + \beta^F F_i + \delta^C C_i \text{Post} - \text{Injury}_{it} + \psi F_i \text{Post} - \text{Injury}_{it} \\ & + \phi F_i C_i \text{Post} - \text{Injury}_{it} + X_i \beta_0^X + X_i \beta_1^X \text{Post} - \text{Injury}_{it} + \varepsilon_{it}. \end{aligned}$$

Now there are two coefficients of interest: δ^C captures the effect of cancer on labor market outcomes for men, while ϕ captures any incremental effect for women. We note that the gender indicator was included as a component of X_i in our main specification, and interactions between gender and the age indicators remain included in X_i in this model.

Event-Study Specifications and Evaluation of Parallel Trends Assumption

Figure 3.1 plots quarter-by-quarter estimates of the effects of cancer on earnings from two years before to two years after the injury. This figure was constructed by estimating an event-study regression model that allowed cancer claims to have a time-varying effect on labor market outcomes at the quarterly frequency. This model can be expressed as

$$y_{iqt} = \alpha + \beta^C C_i + \sum_{s=-8}^{-2} \mathbf{1}\{t - q = s\} \times C_i \gamma_s^C + \sum_{s=0}^{8} \delta_s^C C_i \mathbf{1}\{t - q = s\} + \sum_{s=-8}^{8} \mathbf{1}\{t - q = s\} \times X_i \beta_s^X + \varepsilon_{iqt},$$

where *q* indexes the quarter of injury and *s* is a summation index used to reference calendar time *t* in terms of the timing of each worker *i*'s date of injury. This model, which was estimated using the same sample of workers as our differences-in-differences model, uses a quarterly-frequency dataset ranging from eight quarters before to eight quarters after the date of injury. As in our main differences-in-differences specification, control variables are allowed to have time-varying effects on outcomes, so that each variable in X_i has its own trajectory of outcomes before and after injury. Effects of cancer are normalized to zero in the quarter before injury ($t = q - 1$), while β^C captures the difference in earnings between workers with cancer claims and those without cancer claims in the quarter before injury.

The effects of cancer on labor market outcomes at times $s = 1, 2, \ldots 8$ quarters after injury are captured by the coefficients δ_s^C. The counterfactual series in Figure 3.1 were constructed by subtracting these coefficients from the actual earnings of workers with cancer claims.

Our estimation strategy relies crucially on the assumption that outcomes for workers with cancer claims and workers in the medical-only control group would have evolved in parallel if the workers with cancer claims had not developed cancer and filed a claim. This assumption cannot be tested directly because we do not see what would have happened to these workers in the absence of the cancer claim, but it can be tested indirectly because we have eight quarterly observations prior to the date of injury. Specifically, we estimated the event-study model by ordinary least squares (i.e., without weights) and tested the hypothesis that one or more of the event-study coefficients from time periods before the date of injury was nonzero against the null

hypothesis that all coefficients were equal to zero ($H_0: \gamma_s^C = 0$ for all $s = -8, -7, \ldots -2$). We rejected the assumption of parallel trends at the 10-percent level for peace officers ($p = 0.0625$), and so we chose to construct weights for all models.

Weighting

In other studies, we have used sampling weights to produce estimates that are representative for the full population of workers' compensation claims. We chose not to pursue this sort of weighting strategy in the current study because we had concerns that we did not have a clear enough understanding of the target population of workers filing cancer claims. In particular, we cannot implement our preferred occupation definition without linking workers to industry codes from EDD, which prevents us from knowing the occupation distribution or distribution of characteristics within occupation for the target population. Sample averages and estimates of differences across occupation groups or genders are unweighted, which means that they are valid for the population of claims included in our analysis sample.

We use weights in our regression analysis for a different purpose, which is to ensure that the trajectory of earnings for the medical-only comparison group evolves in parallel to earnings for workers with cancer claims. This is an adaptation of the weighting methodology for differences-in-differences analyses proposed by Stuart et al. (2014). This method weights workers who made non-cancer claims, so that their weighted distribution resembles the distribution of workers who made cancer claims.

To estimate the weights used in our analysis, we first used all claims (cancer and non-cancer) to estimate a logistic regression model that describes the probability that a workers' compensation claim is filed for cancer as a function of age, gender, interactions between the age and gender, and quarter-on-quarter change in earnings at each point in time from eight quarters to one quarter before injury. The sample for each propensity score model was limited to observations included in the regression model, and separate models were estimated for each occupation group. Based on this logistic regression model, we estimated $\hat{p}_i$, the probability that given the age, sex, and earnings information the *i*th worker, they would have a cancer rather than non-cancer claim.

In the weighted regression analyses, we set the weight for each worker with a cancer claim to 1 and set the weight for each worker with a medical-only claim to $w_i = \hat{p}_i / 1 - \hat{p}_i$, the predicted odds of a cancer claim, which measures how much more likely it is that the worker was a cancer case relative to a non-cancer case. Workers who submitted a non-cancer claim would have a large weight when they were likely to have submitted a cancer claim (i.e., they were similar to workers with cancer claims) and would have a small weight when they were very unlikely to have submitted a cancer claim.

We also required that each control worker included in weighted regression models have the same age at injury, gender, and occupation group as at least one worker with a cancer claim.

Because of this, some workers with non-cancer claims were excluded from weighted regression models.

Table A.6 presents the event-study estimates used to construct Figure 3.1. We did not include controls for region, industry, or firm size in these models due to computational burden. Age-gender and quarter of injury controls were included, however, and the small and insignificant coefficients on all preinjury cancer effects indicate that our weighting strategy was successful in achieving balance with respect to preinjury trends, even without the full set of control variables used in our main estimates. X^2 and *p*-values for the parallel trends tests are reported at the end of the table. The X^2 statistics are very small, and *p*-values for the hypothesis that trends were not parallel are all 0.94 or higher.

Table A.6. Weighted Least Squares Event-Study Regression Coefficients for Effects of Cancer on Quarterly Labor Earnings, by Occupation

Coefficients on Cancer Indicator Interacted with Event-Time Indicator	Peace Officer	Firefighter	Lifeguard	Other Occupations
Quarters before injury				
8	75.98 (203.2)	26.88 (321.6)	94.21 (499.3)	–152.3 (312.8)
7	74.81 (212.2)	202.8 (341.9)	190.3 (532.7)	–155.2 (307.9)
6	52.76 (209.1)	–88.31 (343.7)	79.63 (405.5)	–31.54 (302.6)
5	62.03 (187.8)	23.28 (302.1)	67.14 (331.0)	–87.93 (326.8)
4	44.33 (203.7)	–16.10 (327.3)	–271.4 (446.9)	–91.65 (315.2)
3	74.29 (180.7)	156.1 (313.6)	–148.3 (500.8)	23.45 (211.4)
2	–2.066 (163.6)	–17.89 (286.6)	–183.3 (387.9)	72.21 (235.1)
1	0 –	0 –	0 –	0 –
Quarters after injury				
0	–330.1 (211.2)	–165.6 (327.0)	67.50 (416.8)	–1,285*** (340.4)
1	–1,894*** (288.9)	–1,300*** (448.5)	–35.09 (444.2)	–4,794*** (436.4)
2	–2,490*** (326.1)	–1,614*** (460.0)	628.8 (431.0)	–5,490*** (420.4)
3	–2,337*** (339.5)	–1,376*** (465.8)	565.6 (355.8)	–5,464*** (435.8)
4	–1,535*** (381.7)	–932.6* (488.9)	549.1 (491.0)	–5,950*** (479.0)
5	-1,774*** (387.4)	–1,092** (521.9)	19.23 (517.3)	–5,796*** (475.6)

Coefficients on Cancer Indicator Interacted with Event-Time Indicator	Peace Officer	Firefighter	Lifeguard	Other Occupations
6	–2,184***	–1,517***	–78.86	–5,949***
	(414.5)	(575.0)	(531.0)	(498.0)
7	–2,393***	–1,120**	–42.98	–5,503***
	(416.5)	(570.0)	(509.4)	(651.1)
8	–2,283***	–1,134*	1,093*	–6,489***
	(442.2)	(607.9)	(564.4)	(521.2)
Number of observations	1,460,079	493,748	16,745	28,813,572
R^2	0.153	0.195	0.501	0.223
X^2 statistic	0.0482	0.188	0.331	0.0762
p-value for parallel trends	1	0.988	0.940	0.999

NOTES: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors appear in parentheses.

Additional Estimates and Sensitivity Analyses

Table A.7 presents unweighted (ordinary least squares) regression estimates and unweighted Poisson regression estimates of the differences-in-differences models underlying Table 3.2 in the text. OLS estimates are very close to weighted least squares estimates for public safety workers, and are slightly more negative but qualitatively similar (–$46,513 vs. –$43,058) for workers in other occupations. The Poisson regressions, which are more robust to outliers and which model the effect of cancer on earnings as a multiplicative (or proportional) change in earnings, are also qualitatively similar to the weighted least squares estimates reported in Chapter 3. As we discuss in the report, the Poisson regressions indicate that cancer reduces earnings by 8.6 percent for peace officers, 4.5 percent for firefighters, and 66 percent for workers in other occupations, while there is no evidence of an adverse effect on the earnings of lifeguards.

Table A.7. Effects of Cancer on Earnings Using Alternative Estimators, by Occupation

	Peace Officers	Active Firefighters	Lifeguards	Other
Unweighted OLS with all covariates				
Change in earnings over two postinjury years ($)	–18,108***	–10,875***	3,734	–46,513***
	(2,385)	(3,052)	(3,423)	(4,086)
Number of observations	186,028	61,466	3,062	4,193,682
Poisson regression				
Percentage change in earnings over two postinjury years (%/100)	–0.0857***	–0.0451***	0.0337	–0.662***
	(0.0118)	(0.0120)	(0.0278)	(0.0750)
Number of observations	186,028	61,466	3,062	4,193,682

NOTES: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors appear in parentheses.

Many cancer claims are reported later (relative to the date of injury) than is the norm for injury claims (which must typically be reported within 30 days of injury) or even for other

occupational illnesses (which must typically be reported within one year of the date of diagnosis or attribution to occupational exposures). In our linked WCIS-EDD analysis sample, 65 percent of cancer claims were reported within 30 days of the date of injury, compared with 93 percent of all other workers' compensation claims. Even when we consider the more generous one-year timeline for occupational disease reporting, 91 percent of cancer claims versus 99 percent of non-cancer claims were reported within one year. In part, this reflects the more generous time limits provided by the LC for reporting of cancers. However, the higher proportion of claims that are reported with a substantial delay after the date of injury raises the possibility that some of these claims are filed, at least in part, in response to workers' labor market outcomes. In this case, our estimates of earnings losses could be biased due to reverse causation.

To evaluate the robustness of our estimates to reverse causation associated with claims that are filed with a substantial delay, we estimated our main regression models on a sample that excluded all claims (both cancer claims and medical-only claims) filed more than 90 days (approximately three months) after the date of injury. Results are presented in Table A.8, with our main estimates reproduced for comparison. Earnings losses are smaller for firefighters and workers in other occupations when we exclude claims filed more than 90 days after the date of injury, but the significance and relative magnitude of earnings losses across occupations remain broadly similar to those estimated on the full sample of claims.

Table A.8. Effects of Cancer on Earnings over Two Years After Date of Injury, by Duration Between Date of Injury and Date of Claim Reported

	Peace Officers	Active Firefighters	Lifeguards	Other
Claims filed within 90 days of injury date				
Change in earnings over two postinjury years ($)	–16,732***	–6,208**	3,518	–33,980***
	(2,746)	(2,983)	(2,995)	(2,819)
Number of observations	164,794	56,108	1,924	3,091,828
Number of cancer cases included	691	538	146	112
Number of cancer cases excluded	168	109	6	95
Total number of cancer cases	859	647	152	207
Main estimates				
Change in earnings over two postinjury years ($)	–18,159***	–10,499***	3,194	–43,058***
	(2,574)	(2,947)	(3,045)	(3,082)
Number of observations	171,774	58,088	1,970	3,249,586

NOTE: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors appear in parentheses. "Date of claim reported" is defined as the earlier of the date reported to employer and the date reported to claim administrator.

Finally, Table A.9 shows differences-in-differences regression estimates for the alternative definitions of cancer cases that we constructed using the medical claims data. We had an insufficient sample of lifeguards to estimate these models, but results are presented for peace officers, firefighters, and other occupations.

Table A.9. Effects of Cancer on Earnings over Two Years After Date of Injury Under Alternative Case Definitions, by Occupation

	Peace Officers	Firefighters	Lifeguards	Other Occupations
FROI nature of injury	–18,159***	–10,499***	3,194	–43,058***
	(2,574)	(2,947)	(3,045)	(3,082)
Number of observations	171,774	58,088	1,970	3,249,586
Medical claims (loose)	–22,784***	–14,794***	–	–51,276***
	(4,816)	(5,468)	–	(7,248)
Number of observations	63,828	20,210		1,777,552
	Peace Officers	**Firefighters**	**Lifeguards**	**Other Occupations**
Medical claims (strict)	–24,498***	–52,089***	–	–11,417***
	(4,017)	(5673)	–	(1,512)
Number of observations	37,340	10,624		635,450

NOTE: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors appear in parentheses. "Nature of injury" definition includes claims for which nature of injury on FROI is 74 (Cancer). "Medical claims (loose)" definition includes claims with 1+ bill line reported to WCIS medical with primary diagnosis of neoplasm (ICD-9 codes 140–239), excluding benign neoplasms. Sample limited to claims from 2007–2014 injury dates with medical claims available. "Medical claims (strict)" definition includes claims with 3+ consecutive calendar quarters with 1+ bill line reported to WCIS medical with primary diagnosis of neoplasm (ICD-9 codes 140–239), excluding benign neoplasms. Sample limited to claims from 2007–2014 injury dates with medical claims available.

Using our loose case definition, which required only that one medical bill with cancer as the primary diagnosis be submitted to the WCIS, we obtain slightly larger estimates of earnings losses ($23,784 vs. $18,159 for peace officers, $14,794 vs. $10,499 for firefighters, and $51,276 vs. $43,058 for other occupations). These estimates are less precisely estimated than our main estimates, however, and the confidence intervals for all of these new estimates cover the original estimates.

In the third panel of Table A.9, we show results using our strict definition of cancer claims, which required evidence of medical treatment for cancer in three consecutive calendar quarters. The estimate for peace officers is similar to the estimates obtained under our loose definition ($24,498 vs. $22,784), but estimated losses for firefighters and workers in other occupations look very different. Losses for firefighters meeting this strict definition are very large ($52,089) while losses for workers in other occupations are modest ($11,417). The implications of these estimates for our main analysis are unclear, however: the vast majority of workers with cancer claims (based on the nature of injury code) do not receive enough sustained medical treatment in the workers' compensation system to meet our strict definition, and the extent of agreement (or disagreement) between case definitions varied widely across occupations.

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