

# Unreported Workers' Compensation Claims to the BLS Survey of Occupational Injuries and Illnesses: Establishment Factors

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**Background** *Studies suggest employers underreport injuries to the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses (SOII); less is known about reporting differences by establishment characteristics.*

**Methods** *We linked SOII data to Washington State workers' compensation claims data, using unemployment insurance data to improve linking accuracy. We used multivariable regression models to estimate incidence ratios (IR) of unreported workers' compensation claims for establishment characteristics.*

**Results** *An estimated 70% of workers' compensation claims were reported in SOII. Claims among state and local government establishments were most likely to be reported. Compared to large manufacturing establishments, unreported claims were most common among small educational services establishments (IR = 2.47, 95%CI: 1.52–4.01) and large construction establishments (IR = 2.05, 95%CI: 1.77–2.37).*

**Conclusions** *Underreporting of workers' compensation claims to SOII varies by establishment characteristics, obscuring true differences in work injury incidence. Findings may differ from previous research due to differences in study methods.* Am. J. Ind. Med. 59:274–289, 2016. © 2016 The Authors. American Journal of Industrial Medicine Published by Wiley Periodicals, Inc.

**KEY WORDS:** *occupational injury surveillance; under-reporting; workers' compensation data; BLS Survey of Occupational Injuries and Illnesses*

## INTRODUCTION

With the passage of the Occupational Safety and Health Act [1970], the Department of Labor (DOL) was charged with “[compiling] accurate statistics on work injuries and illnesses” (1970). The Bureau of Labor Statistics’ (BLS) annual Survey of Occupational Injuries and Illnesses (SOII) is central to the DOL’s approach to fulfilling that requirement, producing annual estimates of non-fatal work-related injuries and illnesses based on data submitted by employers. Studies have sought to assess the accuracy of the SOII data almost from its inception [Eisenberg and McDonald, 1988; Seligman et al., 1988], and nearly all have concluded that the survey underestimates the true burden of work-related injuries and illnesses [Leigh et al., 2004; Smith et al., 2005; Rosenman et al., 2006; Boden and Ozonoff, 2008].

While consensus grows regarding underreporting to SOII, there is less agreement on the magnitude of

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underreporting. To measure underreporting, SOII data has often been compared to workers' compensation claims data, a source of detailed case-level information on injuries and illnesses for a population that largely overlaps the workforce covered by SOII. In studies linking SOII cases to various states' workers' compensation claims data, SOII was found to miss 25–78% of injuries and illness reported in workers' compensation [Rosenman et al., 2006; Boden and Ozonoff, 2008]. SOII performs more favorably when the number of injuries estimated by SOII was compared to the number workers' compensation claims identified as SOII-eligible; using this approach, the underreporting of workers' compensation claims was estimated at 3–16% [Oleinick and Zaidman, 2004, 2010]. One challenge to comparing SOII and workers' compensation data is that the representation of business units often differs across data systems. SOII may sample an entire firm, consisting of one or more establishments, or a single establishment within a firm, whereas workers' compensation claim data are often organized by firm with no further delineation of establishments. The lack of establishment information in workers' compensation data makes it difficult to identify the workers' compensation claims attributable to the SOII sampled location, possibly over-estimating the number of claims considered reportable to SOII.

Underreporting has been found to vary by establishment characteristics. Several studies suggest that underreporting is greater for injuries among smaller establishments [Oleinick et al., 1995; Glazner et al., 1998; Morse et al., 2004; Dong et al., 2011], and varies by industry [Rosenman et al., 2006]. Research also suggests that injuries among multi-establishment firms are more likely to be missed than injuries among single-establishment firms [Nestoriak and Pierce, 2009; Boden, 2014]. What is currently unknown is the relationship between underreporting and these characteristics when examined in a multivariable analysis.

We attempted to address gaps in the existing SOII underreporting literature through two study objectives. First, we sought to estimate the magnitude of unreported workers' compensation claims from one state using an enhanced method to reconcile business structures across data sources. The method relies on inclusion of the state unemployment insurance (UI) data to recreate the BLS SOII establishment sample and identify workers employed at sampled establishments. Identifiers obtained from the UI data for both the sampled establishment and worker (e.g., social security number) enhance the accuracy of the matching between the SOII and workers' compensation data. Second, we evaluated differences in reporting by establishment characteristics using multivariable regression analysis to assess the association between unreported workers' compensation claims and several establishment characteristics simultaneously. Understanding more about the characteristics associated with underreporting may help identify approaches for improving the accuracy of occupational injury and illness surveillance data.

## METHODS

The purpose of this study was to identify workers' compensation claims eligible for inclusion within the BLS SOII and the degree to which the BLS SOII micro-data includes these claims. This is called the "SOII capture rate." Additionally, the study identifies BLS SOII day away from work (DAFW) cases eligible for inclusion into the Washington workers' compensation system and the degree to which the Washington workers' compensation data includes these cases. This is called the "WA workers' compensation capture rate." For survey years 2003–2011, we assessed variations in the BLS SOII capture rate and the Washington workers' compensation capture rate by establishment size, and industry, as well as by recordkeeping exemption status, workers' compensation insurer, and sampled workforce.

## Description of Data Sources Used

### *Washington workers' compensation data: Overview*

Washington State mandates workers' compensation insurance for all employers in Washington State except those covered by federal workers' compensation programs (e.g., Harbor and Longshore worker, Federal workers—Office of Workers Compensation Programs) or specifically exempt from requirements for mandatory insurance (e.g., self-employed, family member younger than 18 working on family farms, and other specific occupations or employment arrangements).<sup>1</sup>

Washington employers are required to purchase workers' compensation insurance from the Washington State Fund unless they are able to self-insure. Companies must meet specific requirements for self-insurance and the Self Insurance program has significant oversight and reporting requirements to the Washington State Department of Labor and Industries (L&I).<sup>2</sup> The Washington State Fund is administered by L&I.

Of the approximately 160,000 Washington State employer workers' compensation accounts, over 99.7% are insured through the State Fund covering approximately 70% of employed workers in WA. The remaining workers' compensation accounts (approximately 400) are self-insured and typically represent Washington's largest employers.

<sup>1</sup> See Revised Code of Washington, Title 51.12 'Employments and Occupations Covered' - <http://apps.leg.wa.gov/RCW/default.aspx?cite=51.12>

<sup>2</sup> See Revised Code of Washington, Title 51.14 'Self-Insurers' - <http://apps.leg.wa.gov/RCW/default.aspx?cite=51.14>

### **Washington workers' compensation data: Employer data**

Each employer in Washington State is required to have a workers' compensation policy. The workers' compensation policy may be composed of one or many accounts. Each account may have one or multiple business locations. A workers' compensation policy, account, and business location each has an assigned address within the workers' compensation system. Workers' compensation accounts are associated with the employer's Uniform Business Identifier (UBI). The UBI is a Washington State specific employer identifier that links an employer across Washington State government administrative databases (e.g., Washington Department of Labor and Industries and Washington State Employment Security Department). The UBI does not correlate to a specific level of the business hierarchy within the workers' compensation system. In general, a workers' compensation policy consists of one or more UBI, which consists of one or more workers' compensation accounts. In some cases, however, multiple UBI may relate to a single workers' compensation account. The most common organizational structure with the Washington workers' compensation system is a policy with a single account, a single business location, and a single UBI.

### **Washington workers' compensation data: Claim data**

A workers' compensation claim is initiated in Washington by an injured or ill worker seeking medical care from a health care provider. The injured worker and health care provider complete a report of accident form which is sent to either the state fund or the self-insured employer or the self-insured employer's third party administrator. The statute of limitations for filing a workers' compensation claim for an occupational injury is one year after the injury.<sup>3</sup> For an occupational disease the statute of limitations is two years after the written notification from a health care provider for eligibility to file a claim.<sup>4</sup> The employer is always notified by L&I of a workers' compensation claim.

**For state funded claims.** The claim is initiated on a Report of Industrial Injury and Occupational Disease (RIIOD) form which includes worker identifiers (name, Social Security number, date of birth, gender), employer name, and details about the incident (the injured worker's description of the occupational injury or illness, whether the injury occurred on the employer premises, and the injury

location and address). A unique claim identification number is assigned to each filed RIIOD.

Workers' compensation claims are accepted and rejected as work-related by trained claims managers in accordance with Washington State statutes, rules, and case law. Medical treatment, wage replacement benefits and all other billed services are linked to the claim identification number and recorded in L&I databases. In Washington, the waiting period for wage replacement eligibility is three calendar days after the date of injury. The date of injury is not counted towards any part of the waiting period for wage replacement eligibility. Each compensable state funded claim has a date of injury, a date of first medical treatment for the work injury or illness, an establishment date when L&I received the claim,<sup>5</sup> a disability date when the claimant was first unable to perform the job of injury, and the initial time loss payment date that indicates when the department made the determination that the claimant was disabled, issued the first payment for wage replacement, and notified the employer of the disability determination.

**For the self-insured claims.** Data for all claims are available within the L&I workers' compensation databases. The same worker identifiers recorded for state funded claims are available for self-insured claims, as are employer name and location data. Supplemental injury location data are not available for self-insured claims. Each self-insured claim has a date of injury and the date L&I received notification of the claim. Notification requirements differ by benefits paid. For medical-aid only claims, L&I must be notified by the end of the month following claim closure.<sup>6</sup> For wage replacement claims, the self-insurer must notify L&I within five business days of the first indemnity payment,<sup>7</sup> reflecting a date analogous to the initial time loss payment date for state funded claims. Among self-insured claims, reporting is not required and thus, less complete, for dates of first medical visit, disability, and initial time loss payment.

### **Unemployment insurance data**

UI data serves as the SOII sampling frame, in the form of the Quarterly Census of Employment and Wages

<sup>4</sup> See Revised Code of Washington, Title 51.28.055 - <http://apps.leg.wa.gov/RCW/default.aspx?cite=51.28.055>

<sup>5</sup> The claim establishment date documents the date that L&I entered the claim into the system. Establishment generally occurs soon after claim filing. A claim is filed by the worker and physician; a claim is established by L&I

<sup>6</sup> See Washington Administrative Code 296-15-450 <http://app.leg.wa.gov/WAC/default.aspx?cite=296-15-450>

<sup>7</sup> See Washington Administrative Code 296-15-420 <http://app.leg.wa.gov/WAC/default.aspx?cite=296-15-420>

<sup>3</sup> See Revised Code of Washington, Title 51.28.050 - <http://apps.leg.wa.gov/RCW/default.aspx?cite=51.28.050>

[Selby et al., 2008]. An employer is assigned a UI account, which may be divided into multiple individual locations, denoted by unique report unit numbers and described by an establishment address. The UI account identifies employees by SSN and worker name (employees are not linked directly to report units). In Washington, the UI data and L&I data are linked by UBI number. Additionally, workers can be linked across systems using SSN. UI data were made available through a data sharing agreement with the Washington State Employment Security Department, the state agency responsible for maintaining UI data.

### ***BLS SOII micro data***

The Bureau of Labor Statistics program provided three Washington State BLS datasets for each of the nine survey years from 2003 to 2011: final case file, unusable case file, final establishment file.<sup>8</sup> The final case files contain data on individual injuries and illnesses as well as demographic characteristics used for published estimates. The unusable case files consist of cases reported in the SOII but not included in final estimates.<sup>9</sup> Final establishment files contain establishment data that contribute to the final published estimates.

SOII establishment data include: the employer name, address, zip code, UI account number, and reporting unit number. Also included are the OSHA recordable injury and illness summary data submitted by the sampled employer. SOII case data are collected for OSHA DAFW cases and include the worker's name, gender, date of injury, date of birth or age at injury, and codes for nature of injury or illness, body part, source, and event. DAFW cases are those with at least one day away from work not including the day of injury and are counted based on the number of calendar days of missed work.

Sampled establishments were grouped into one of two categories based on the report unit number. Unit numbers of "00000" and a unit description of "All Washington State Employees", indicating an entire UI account, comprised one group (single site firms and multisite firms where all sites are sampled) while all other establishments were grouped into the second category: sampled establishments representing a "sub-account" within a UI account, that is, one location within a multisite firm.

<sup>8</sup> An unusable establishment file was also provided by BLS but was not used in the record linkage. Incident data reported by these establishments do not contribute to published estimates of occupational injuries and illnesses.

<sup>9</sup> Reasons for assigning a reported case to the unusable case file include: a duplicate case, an unusual case that was unable to be verified by survey staff, a case with no days away from work reported, or one that fell outside of the BLS sub-sampling timeframe.

### **Matching SOII Data to Washington Workers' Compensation Data**

BLS sampled establishments from the Washington UI data for participation in the SOII. We used the Washington UI data to recreate the BLS SOII sample and determine Washington workers' compensation coverage among the 44,634 Washington establishments that participated in SOII in 2003–2011.

### ***SOII establishment exclusion criteria***

The data were restricted to industries that report SOII data directly to BLS, and industries whose entire workforce is covered by the Washington State workers' compensation system. Injury and illness data for mining and railroads are not gathered through the annual survey of establishments but rather sent to BLS by the Mine Safety and Health and Federal Railroad Administrations. These 3,217 establishments (7%) are not sampled from UI and their UI account information is not recorded in SOII data. The maritime workforce is not covered by state workers' compensation systems and instead provided workers' compensation benefits through the Longshore and Harbor Workers' Compensation program or must make a legal claim through the Jones Act. Establishments operated by sovereign Native American tribes and located on tribal reservations are not required to participate in Washington's Industrial Insurance system. Industry classifications, available in UI as both SIC codes and NAICS codes were used to identify the water transportation, ship and boat building, seafood product preparation and packaging, and fishing establishments that have workers' compensation covered through the Longshore and Harbor Workers Compensation Act or where workers who must make a legal claim under the Jones Act. The ownership code in UI was used to identify establishments owned by tribes. These exclusions applied to 2% of establishments ( $n = 892$ ).

Additionally, 27 establishments were excluded from the linkage attempt because the SOII-provided UI account information could not be found within the Washington UI data.

### ***Identification of SOII sample in Washington workers' compensation via unemployment insurance data***

***Identification of SOII data in unemployment insurance data.*** Using the UI account and reporting unit numbers provided in the SOII establishment file, BLS sampled establishments were identified within Washington's UI data from the quarter when the sample was drawn, specifically, seven quarters

prior to the beginning of the survey year. The sampled establishments were mapped through successive quarters within the UI data to identify changes in ownership, physical location, or a break in liability (e.g., a quarter in which there was no employment reported) that might impact the identification in workers' compensation of the employer during the survey period.

Next, we identified workers employed by SOII respondents during the survey year using the UI account information current at the time of the survey. Worker identifiers, including SSN, for individuals reported in at least one of the four quarters of the survey year among SOII-participating UI accounts were extracted from the Washington UI database. When a SOII establishment represented a report unit rather than the entire UI account, the workforce identified from the UI account data was greater than the workforce sampled since worker identifiers are reported at the UI account level. Establishment characteristics were used later in the record linkage process to limit workers to those likely employed at the sampled reporting unit. A discussion of this process occurs below; see "Identification of workers' compensation claims eligible for SOII."

**Identification of unemployment insurance data in workers' compensation data.** Using the UI-reported SSNs for employees among SOII-participating UI accounts, we extracted as potentially eligible for SOII 631,148 workers' compensation claims among the sampled workforce with an injury date in the survey year in which the establishment participated. To allow for differences between SOII and workers' compensation in the characterization of missed work, no restrictions were made to the workers' compensation claim population prior to linking; all workers' compensation claims associated with sampled establishments were extracted regardless of claim liability status and included rejected claims, claims for medical-treatment only, and indemnity claims. This approach identified more claims than are likely eligible for reporting in SOII (similar to extracting all claims for an entire UI account when SOII participation was limited to a reporting unit). Record level exclusions were applied after the linkage process was complete (described below in "Identification of workers' compensation claims eligible for SOII)."

### **Record linkage**

Research staff developed SAS code to deterministically link records through an iterative process, altering the linking criteria of one or more variables in each successive attempt. SOII cases linked to workers' compensation claims based on the following data elements: worker first name, last name, date of birth or age at injury, and date of injury. Extracting only claims among workers reported in UI by sampled

employers established the claimant's relationship to the employer. First and last names were allowed to match identically or phonetically; on later attempts, first name was also allowed to match on first initial or not at all. Over the course of the multiple record linkage attempts, the matching requirement for date of birth was broadened iteratively from exact match between SOII and workers' compensation to within 7, 31, 65, 365, 3,660, and finally 7,220 days. For cases where date of birth was not provided, the age at injury was allowed to vary from exact, to within 1 year, then within 10 years. After each iteration, potential links were manually reviewed by research staff to confirm that the new criteria identified true matches.

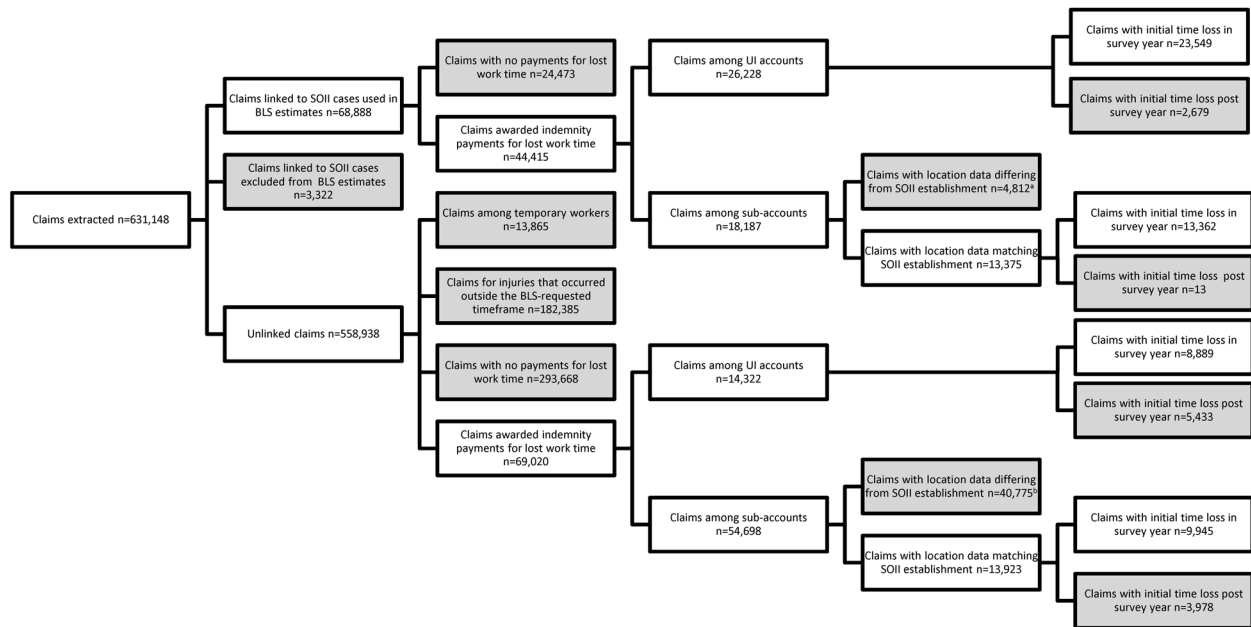
Linking iterations followed a hierarchy so that links to the more relevant claims preceded other attempts. Links to claims with wage replacement were attempted prior to links among medical only claims, with all other variables being equal. Linkages were first attempted among the SOII cases in the "final cases" file and then followed by an attempt to link cases in the "unusable case" file. Once linked, both cases and claims were removed from the group of records available for subsequent linkage attempts. Seventy-five percent of linked records matched identically or phonetically on first and last names, and identical injury dates and birthdates or ages. Ninety-three percent matched phonetically on last name, first name or first initial, and had injury dates differed across data sources by no more than 7 days. Cases linked by linking criteria are presented in a supplementary table available online as Supporting Information.

### **Identification of SOII cases eligible for Washington workers' compensation**

To evaluate workers' compensation capture of SOII cases, all SOII cases (among establishments eligible for Washington workers' compensation coverage), linked and unlinked, were retained since a DAFW injury is likely eligible for workers' compensation—for medical-aid benefits if not wage replacement.

### **Identification of workers' compensation claims eligible for SOII**

As noted above, more workers' compensation claims were extracted than were expected to meet the SOII case reporting criteria because they were: (i) filed for an injury that did not result in missed work (e.g., rejected claims, claims limited to medical-aid); (ii) employed by the sampled employer at some location other than the sampled reporting unit; or (iii) filed for an injury that did not miss work until after the survey year. These, plus three additional scenarios described below necessitated reducing claims to those identifiable as eligible for SOII as a DAFW case during the survey year. Exclusion criteria were applied to both



**FIGURE 1.** Flowchart depicting determination of SOII-eligibility among workers' compensation claims. <sup>a</sup>Excluded based on differences of: Washington Unified Business ID (49 claims), worksite city (3,588 claims), and street (1,175 claims). <sup>b</sup>Excluded based on differences of: Washington Unified Business ID (108 claims), worksite city (32,515 claims), and street (8,078 claims). An additional 74 claims were excluded because all linked claims among the sampled establishment were assigned to another workers' compensation business location.

linked and unlinked claims. Figure 1 charts claims from extraction through SOII-eligibility determination. A description of the process follows.

**Exclusion of claims based on benefit eligibility.** We used workers' compensation indemnity payment information to identify claims for injuries that resulted in one or more days of missed work (thus meeting the DAFW case criteria). Claims that received payments for missed work (i.e., temporary total disability) were considered to have met the missed work criterion to be recordable as a DAFW case. Of the 631,148 claims extracted, 318,141 were excluded because they lacked evidence of missed work.

**Exclusion of claims based on location data.** For sampled establishments that represented the entirety of a UI account, all missed work claims identified through an employee's SSN were retained since these workers were reported in UI data as employed within the sampled UI account. When the sampled establishment represented one of many reporting units within a UI account, we ascertained the claim's association with the sampled establishments through the UBI and address data: when the UBI or address of the workers' compensation business location associated with the unlinked workers'

compensation claim differed from the UBI or address of the sampled reporting unit or from the reporting unit associated with the majority of linked SOII-workers' compensation cases, the unlinked claim was considered to be associated with a reporting unit other than the sampled unit. In total, 45,587 claims were excluded based on location data.

Linkage procedures allowed for an unlinked workers' compensation claim to be associated with more than one sampled establishment. This occurred when a claimant worked for an employer with a UI account with multiple sampled reporting units and few differences among the units' physical location data. Unlinked self-insured claims were more likely to be associated with multiple reporting units than state funded claims (18% of unlinked self-insured claims compared to 1% of unlinked state funded claims). Claims with multiple associations were randomly assigned to one of the associated reporting units. Random assignment did not alter the distribution of unlinked claims by industry or establishment size.

**Exclusion of claims based on timing of claim events.** Next, we used claim event dates to indicate whether the missed work occurred within the survey year. When the workers' compensation date for first medical treatment, claim establishment, disability, initial time loss

**TABLE I.** Time Loss Claims Among SOII-Sampled Establishments by Timing of Key Claim Events Used to Estimate SOII DAFW Case Eligibility and Percent of Claims by Claim Events Linked to SOII Case, Washington State, 2003–2011

	Key claim events	Claims n (%)	% linked to SOII case
Washington State funded claims (n = 29,894)			
Claims included in final estimate of underreporting	No key claim events post survey year	23,575 (78.9)	72
Claims excluded from final estimate of underreporting	Disability post survey year	4,128 (13.8)	13
	Disability in survey year, first wage replacement payment post survey year	2,176 (7.3)	45
	Medical visit date post survey year	15 (0.1)	53
Self-insured claims (n = 37,954)			
Claims included in final estimate of underreporting	No key claim events post survey year	32,170 (84.8)	62
Claims excluded from final estimate of underreporting	Claim reported to L&I post survey year	5,739 (15.1)	20
	Claim reported to L&I in survey year, first wage replacement payment, disability, or medical visit post survey year	45 (0.1)	7

payment, or for self-insured claims, L&I notification date occurred after the survey year, records (both linked and unlinked workers' compensation claims) were excluded from further analyses. Although these injuries occurred during the survey year and eventually resulted in missed work, the claim data suggested the missed work did not occur until after the survey year concluded and thus, would not have been recordable as a DAFW case during the survey year. In the case where the disability occurred during the survey year but the initial time loss payment was not made until after the survey year, the data suggest that the missed work was not recognized as work injury-related by L&I until after the close of the survey. Using the claim establishment, notification and time loss payment dates ensured that the employer was notified of the injury and resulting disability.

Among the remaining 29,894 state funded wage replacement claims for injuries during the survey period, a total of 6,319 claims (21.1%) were excluded based on the following: 4,128 claims (13.8%) of claims were excluded because the disability did not occur until after the survey year; 2,176 (7.3%) were excluded because, although workers' compensation determined that the claimant was disabled during the survey year, the determination and accompanying employer notification of disability did not occur until after the survey year.<sup>10</sup> The remaining 15 claims were excluded because the first medical visit occurred after the survey year. Among the remaining 37,954 self-insured time loss claims, 5,739 (15.1%) were excluded because L&I was notified of the claim after the survey year.<sup>11</sup> An additional 45 claims were excluded because one of the other key claim events occurred after the survey year. Table I presents the numbers of claims excluded based on claim events post survey year, and the percent of excluded claims that linked to a SOII case.

**Additional claim exclusion criteria.** Three additional exclusions were applied to limit workers' compensation claims to those eligible for SOII reporting. First, all records in the BLS "unusable" case file—both linked and unlinked—were excluded. Linking claims to cases reported in the "unusable" file identified claims that may otherwise have been considered unlinked or unreported in SOII in previous research. Of the 3,322 claims that linked to an unusable case, 1,214 involved claims with payments for missed work. Second, for establishments asked to report on a subsample of cases based on the injury date (e.g., injuries that occurred in the first 3 months of the year, or injuries that occurred on the 15th day of the month), any unlinked claim with an injury date outside the subsample timeframe was removed from the group of unlinked claims. Third, claims among temporary workers, identified through the Washington workers' compensation risk classification, were removed. The temporary staffing agency is assigned workers' compensation claims among temp workers while the host or client employer is responsible for reporting the injury in SOII. Available data are insufficient for determining whether the temporary worker was injured while under the supervision of a host employer participating in SOII.

## Data Analysis

Reporting was assessed by workers' compensation insurer (state fund vs. self-insured), sampled workforce (UI account vs. sub-account), DAFW cases requested by BLS

<sup>10</sup> This includes 1,788 claims (6.0%) that were established during the survey year and 388 claims (1.3%) established after the survey year.

<sup>11</sup> Notification to L&I is required within five days of indemnity payment for self-insured claims.

(all vs. subset based on injury date), workplace injury recordkeeping exemption status, establishment size and industry. The SOII size grouping was used to classify establishment size. The SOII NAICS codes combined with the ownership code (private industry, state government, local government) were used to classify industry. UI-based SIC codes and BLS size data were used to identify establishments exempt from annual recordkeeping based on Washington State regulations.<sup>12</sup>

SOII and workers' compensation capture rates by individual establishment characteristics are presented for observed case totals and weighted estimates to account for disproportionate sampling and non-response in SOII. Linked claims were assigned the weight of the corresponding SOII case and unlinked claims were assigned the weight associated with the establishment determined to be responsible for reporting the claim.

Unreported workers' compensation claims, defined as unlinked claims, were a common occurrence (approximately 30%) and binomial log-link regression models were used to estimate the incidence ratios of unreported claims [Spiegelman and Hertzmark, 2005]. The five BLS size classes were collapsed into three (<50 employees, 50–249 employees, and 250 or more employees) to create strata of sufficient size for regression analysis. Manufacturing with 250 or more employees was selected as the reference group because it had both a large sample size and high percent of claims reported in SOII. All establishment characteristics were included in the multivariable regression model which was adjusted for survey year and nature of injury or illness. The joint effect of size and industry on unreported claims was assessed as described by Knol and VanderWeele [2012]. Regression models were limited to state funded claims because of the detailed workers' compensation data available compared to self-insured claims. Because the regression analysis focused on a subset of the population, the regression models did not include survey weights but did include variables related to the SOII sampling design including ownership, establishment size, and industry [Korn and Graubard, 1991]. Analyses were conducted using SAS 9.3. The Washington State Institutional Review Board reviewed and approved the study.

<sup>12</sup> For the survey years included in the study, the recordkeeping requirements in Washington, an OSHA state plan state, were identical to the federal OSHA regulations except that in Washington, offices and clinics of health care providers and dentists and public educational services (except elementary and secondary schools and public libraries) are required to maintain annual injury and illness records. These establishments were partially exempt from federal recordkeeping requirements. All establishments selected for SOII participation are required to maintain OSHA injury and illness records for the duration of the survey year, including establishments partially exempt from OSHA recordkeeping requirements.

## RESULTS

### Workers' compensation capture of reported SOII cases

There were 72,087 DAFW cases among the 40,498 SOII establishments included in the record linkage procedures. Ninety-six percent of SOII cases linked to a workers' compensation claim (i.e., workers' compensation captured 96% of SOII cases). Table II shows SOII case totals and the percent reported in workers' compensation by establishment characteristics. There were few differences in the workers' compensation capture of SOII cases by establishment characteristic; for most characteristics, workers' compensation captured 96% of SOII cases after weighting. Workers' compensation capture increased slightly with establishment size. The largest differences were observed within industry, where, after weighting, workers' compensation capture ranged from 93% of SOII cases in Information and Financial Activities and Professional and Business Services to 97% in Retail Trade.

### SOII capture of workers' compensation claims

After restricting workers' compensation claims to those with documented time loss payments in the survey year, there were 55,745 claims eligible for SOII reporting among sampled establishments. Sixty-six percent of claims linked to a SOII case. After weighting, SOII captured an estimated 70% of workers' compensation time loss claims. SOII capture of workers' compensation claims was greater for state funded claims (73%) compared to self-insured claims (67%), and among UI accounts sampled in their entirety compared to a sub-account (i.e., a sampled reporting unit within a UI account). Table III shows the unweighted and weighted percent of claims reported in SOII by establishment characteristics for all wage replacement claims and for state funded claims alone. After weighting, SOII capture was greater among establishments required to maintain annual injury and illness records and lower for establishments usually exempt from recordkeeping requirements. SOII capture of workers' compensation claims differed by the instructions provided to establishments regarding which DAFW cases to report. Among establishments instructed to report a subset of DAFW cases based on injury date (to reduce response burden), SOII captured 89% of workers' compensation claims after weighting, whereas among establishments instructed to report all DAFW cases that occurred during the survey year, SOII captured 66% of estimated claims.

Based on the weighted estimates, SOII capture increased with establishment size, from 63% of claims among



**TABLE II.** Total SOII Cases\* and The Percent Reported in Workers' Compensation (WC) by Establishment Characteristics, Washington State, 2003–2011

	Unweighted case counts		Weighted estimate	
	Total SOII cases	Percent of SOII cases reported in WC (%)	Total SOII cases	Percent of SOII cases reported in WC (%)
All	72,087	96	372,311	96
Sampled workforce				
UI account	45,146	96	252,848	95
Sub-account	26,941	97	252,849	96
Establishment size				
1–10 employees	793	95	41,814	96
11–49 employees	6,185	95	89,757	95
50–249 employees	26,654	96	123,175	95
250–999 employees	21,857	96	57,117	96
1000 or more employees	16,598	97	60,448	98
Industry				
Private sector				
Agriculture, forestry, fishing, hunting	3,680	96	16,743	96
Transportation, warehousing, utilities	5,118	96	25,329	96
Construction	5,244	95	42,398	96
Manufacturing	13,033	96	46,112	96
Wholesale trade	3,238	95	19,057	94
Retail trade	9,262	98	43,662	97
Information and financial activities	2,060	93	12,087	93
Professional and business services	2,378	94	25,798	93
Educational services	575	94	1,092	95
Health care and social assistance	9,263	96	40,275	96
Leisure and hospitality	2,553	91	23,867	94
Other services	1,067	95	8,370	94
Public sector				
State government	3,530	96	17,855	97
Local government	11,086	98	49,665	97

\*SOII cases with one or more DAFW among establishments eligible for WA workers' compensation coverage.

establishments with fewer than 50 employees to 86% of establishments with 1,000 or more establishments. Less than half of the estimated claims among Information and Financial Activities were captured by SOII. The highest SOII capture rate (84%) was observed for claims among State Government establishments.

### Multivariable analysis of underreporting

Table IV presents the incidence ratios (IR) for unreported state funded claims by industry within each of the three size groupings. Within the size stratum of establishments with fewer the 50 employees, three industry classes differed significantly from small manufacturing establishments: educational services, professional and

business services, and leisure and hospitality. There was more difference within the large employers, where compared to manufacturing establishments with 250 or more employees, seven industry classes had more unreported claims and one (Local Government) had fewer.

Within the industry strata, the incidence of unreported claims was greater among the largest establishments compared to the smallest for: agriculture, forestry, fishing, hunting, construction, transportation, warehousing and utilities, and retail trade. Unreported claims were more common among the smaller establishments than larger establishments in Educational Services and State Government (Table V).

Table VI presents IR for unreported state funded claims for the joint effect of size and industry, adjusted for survey year, nature of injury, sampled workforce, and DAFW cases requested by BLS. Compared to manufacturing

**TABLE III.** Total Workers' Compensation Claims\* and the Percent Reported in SOII by Establishment Characteristics, Washington State, 2003–2011

	All claims				State Fund claims			
	Unweighted claim		Weighted estimate		Unweighted claim		Weighted estimate	
	counts		Percent of claims		counts		Percent of claims	
	Total claims	Percent of claims reported in SOII (%)	Total claims	Percent of claims reported in SOII (%)	Total claims	Percent of claims reported in SOII (%)	Total claims	Percent of claims reported in SOII (%)
All	55,745	66	263,078	70	23,575	72	156,059	73
Workers' compensation insurer								
Washington State Fund	23,575	72	156,059	73	23,575	72	156,059	73
Self-insured	32,170	62	107,019	67	—	—	—	—
Sampled workforce								
UI account	32,438	73	163,127	78	17,995	73	120,200	75
Sub-account	23,307	57	99,950	57	5,580	68	35,859	63
Recordkeeping exemption status**								
Not exempt	51,193	66	205,385	72	20,141	73	106,934	74
Partially exempt	4,552	67	57,693	65	3,434	68	49,125	69
Injuries requested by BLS								
All DAFW in survey year	43,213	67	213,076	66	21,392	72	145,553	71
Subset of DAFW based in injury date	12,532	64	50,002	89	2,183	70	10,506	91
Establishment size								
1–10 employees	609	63	28,767	69	538	69	26,621	73
11–49 employees	4,539	61	65,318	61	3,450	73	51,840	70
50–249 employees	17,616	69	82,928	68	10,947	73	54,421	71
250–999 employees	16,846	65	40,721	73	5,999	71	15,860	79
1000 or more employees	16,135	66	45,344	86	2,641	69	7,317	87
Industry								
Private sector								
Agriculture, forestry, fishing, hunting	2,043	69	9,031	72	1,575	70	7,888	73
Transportation, warehousing, utilities	3,812	71	19,485	74	1,339	73	9,292	76
Construction	2,991	66	25,917	72	2,529	69	24,828	73
Manufacturing	8,975	71	28,648	77	4,587	77	15,584	77
Wholesale trade	2,198	68	13,207	68	1,296	72	9,926	71
Retail trade	7,106	66	33,175	64	1,982	70	14,669	68
Information and financial activities	1,404	62	9,064	48	680	73	4,432	66
Professional and business services	2,143	51	19,720	59	1,196	60	15,484	64
Educational services	259	80	461	74	194	80	376	76
Health care and social assistance	7,758	65	28,653	73	2,454	71	14,573	74
Leisure and hospitality	1,821	66	18,841	59	1,420	69	14,291	66
Other services	710	70	5,521	69	552	73	5,027	71
Public sector								
Local government	11,894	62	39,073	77	1,143	80	7,412	81
State government	2,631	74	12,282	84	2,628	74	12,277	84

\*Claims among SOII sampled establishments with wage replacement for time loss paid in survey year.

\*\*Washington State recordkeeping exemption status.

**TABLE IV.** Nine Year Average Incidence Ratios (IR) for Unreported Washington State Fund Workers' Compensation Time Loss Claims in S0II by Industry Within the Stratum of Establishment Size

	< 50 employees IR (95%CI)	50–249 employees IR (95%CI)	250+ employees IR (95%CI)
Agriculture, forestry, fishing, hunting	1.29 (0.99, 1.68)	1.10 (0.97, 1.26)	1.55 (1.34, 1.80)**
Construction	1.17 (0.98, 1.39)	1.32 (1.18, 1.47)**	2.02 (1.74, 2.34)**
Manufacturing (referent)	1.00	1.00	1.00
Transportation, warehouse, utilities	0.99 (0.77, 1.26)	0.97 (0.83, 1.13)	1.42 (1.20, 1.68)**
Wholesale trade	1.17 (0.92, 1.48)	0.99 (0.85, 1.15)	1.44 (1.21, 1.70)**
Retail trade	1.18 (0.97, 1.43)	1.19 (1.06, 1.34)*	1.31 (1.10, 1.55)*
Information and financial activities	1.35 (0.97, 1.86)	1.08 (0.88, 1.34)	1.09 (0.88, 1.34)
Professional and business services	1.73 (1.39, 2.15)**	1.54 (1.36, 1.75)**	1.59 (1.36, 1.85)**
Educational services	2.86 (1.73, 4.71)**	1.59 (0.92, 2.74)	0.60 (0.41, 0.88)*
Health care and social assistance	1.24 (0.97, 1.59)	1.14 (1.02, 1.28)*	1.11 (0.96, 1.29)
Leisure and hospitality	1.35 (1.08, 1.70)*	1.26 (1.10, 1.44)*	1.23 (1.04, 1.45)*
Other services	1.23 (0.93, 1.63)	1.19 (0.99, 1.42)	0.56 (0.27, 1.19)
Local government	1.27 (0.87, 1.86)	0.98 (0.79, 1.23)	0.67 (0.56, 0.81)**
State government	1.56 (0.95, 2.55)	0.83 (0.65, 1.05)	0.98 (0.86, 1.12)

IRs adjusted for survey year, nature of injury, sampled workforce, and injuries requested by BLS.

\* $P < 0.05$ .

\*\* $P < 0.0001$ .

establishments with 250 or more employees, unreported claims were more than twice as prevalent in Educational Services establishments with fewer than 50 employees (IR = 2.47, 95%CI: 1.52–4.01) and Construction establishments with 250 or more employees (IR = 2.05, 95%CI: 1.77–2.37). The only establishments with more complete reporting of claims than manufacturing establishments with 250 or

more employees were Local Government establishments with 250 or more employees and State Government establishments with 50–249 employees.

After controlling for survey year, nature of injury, and the joint effect of size and industry, increased underreporting was found both for claims among sampled sub-accounts (compared to sampled UI accounts), and for

**TABLE V.** Nine Year Average Incidence Ratios (IR) for Unreported Washington State Fund workers' Compensation Time Loss Claims in S0II by Establishment Size Within the Stratum of Industry

	< 50 employees IR (95%CI)	50–249 employees IR (95%CI)	250+ employees (referent)
Agriculture, forestry, fishing, hunting	0.72 (0.56, 0.93)*	0.63 (0.54, 0.74)**	1.00
Construction	0.49 (0.43, 0.57)**	0.62 (0.54, 0.70)**	1.00
Manufacturing	0.95 (0.80, 1.14)	1.00 (0.88, 1.14)	1.00
Transportation, warehouse, utilities	0.61 (0.48, 0.78)**	0.60 (0.49, 0.73)**	1.00
Wholesale trade	0.85 (0.66, 1.09)	0.72 (0.58, 0.89)*	1.00
Retail trade	0.82 (0.67, 1.00)*	0.80 (0.67, 0.96)*	1.00
Information and financial activities	1.28 (0.91, 1.79)	0.95 (0.72, 1.24)	1.00
Professional and business services	1.07 (0.87, 1.31)	0.91 (0.77, 1.07)	1.00
Educational services	4.73 (2.35, 9.50)**	2.67 (1.30, 5.49)*	1.00
Health care and social assistance	1.16 (0.93, 1.45)	0.97 (0.85, 1.12)	1.00
Leisure and hospitality	1.18 (0.95, 1.47)	0.97 (0.82, 1.16)	1.00
Other Services	1.81 (0.83, 3.96)	1.82 (0.85, 3.91)	1.00
Local government	1.31 (0.86, 2.01)	1.13 (0.84, 1.52)	1.00
State government	2.01 (1.24, 3.26)*	0.81 (0.63, 1.04)	1.00

IRs adjusted for survey year, nature of injury, sampled workforce, and injuries requested by BLS.

\* $P < 0.05$ .

\*\* $P < 0.0001$ .

**TABLE VI.** Nine Year Average Incidence Ratios (IR) for Unreported Washington State Fund Workers' Compensation Time Loss Claims in SOII by Establishment Size and Industry

	<50 employees IR (95%CI)	50–249 employees IR (95%CI)	250+ employees IR (95%CI)
Agriculture, forestry, fishing, hunting	1.23 (0.96, 1.58)	1.06 (0.91, 1.24)	1.58 (1.36, 1.83)**
Construction	1.03 (0.89, 1.20)	1.26 (1.10, 1.45)*	2.05 (1.77, 2.37)**
Manufacturing	0.91 (0.77, 1.09)	0.96 (0.85, 1.09)	Referent
Transportation, warehouse, utilities	0.96 (0.77, 1.20)	0.93 (0.79, 1.11)	1.41 (1.19, 1.67)**
Wholesale trade	1.14 (0.92, 1.41)	0.95 (0.81, 1.13)	1.43 (1.21, 1.69)**
Retail trade	1.23 (1.04, 1.45)*	1.16 (1.01, 1.33)*	1.34 (1.13, 1.59)*
Information and financial activities	1.39 (1.02, 1.89)*	1.06 (0.84, 1.32)	1.04 (0.84, 1.28)
Professional and business services	1.75 (1.44, 2.13)**	1.50 (1.29, 1.73)**	1.58 (1.35, 1.83)**
Educational services	2.47 (1.52, 4.01)*	1.54 (0.89, 2.66)	0.61 (0.42, 0.90)*
Health care and social assistance	1.31 (1.05, 1.64)*	1.10 (0.96, 1.26)	1.09 (0.95, 1.26)
Leisure and hospitality	1.42 (1.16, 1.74)*	1.22 (1.04, 1.42)*	1.20 (1.02, 1.42)*
Other Services	1.14 (0.88, 1.48)	1.15 (0.95, 1.40)	0.57 (0.27, 1.21)
Local government	1.34 (0.93, 1.94)	0.95 (0.75, 1.20)	0.71 (0.59, 0.85)*
State government	1.77 (1.09, 2.87)*	0.76 (0.60, 0.98)*	0.98 (0.86, 1.12)

IRs adjusted for survey year, nature of injury, sampled workforce, and injuries requested by BLS.

\* $P < 0.05$ .

\*\* $P < 0.0001$ .

claims among establishments instructed to report a subset of cases based on injury dates (compared to claims among establishments instructed to report all cases in the survey year) (Table VII).

## DISCUSSION

In a novel approach for linking SOII and workers' compensation injury data that utilizes UI data to identify the SOII-sampled workforce among workers' compensation claims data, this study estimated that SOII captures 70% of SOII-eligible Washington workers' compensation claims. Our overall estimate of SOII reporting is greater than previous studies linking SOII data to workers' compensation data. Rosenman et al. [2006] reported that SOII captured 22% of Michigan workers' compensation claims [Rosenman et al., 2006]. Boden and Ozonoff [2008] found reporting of workers' compensation claims in SOII varied by state; their

estimate of SOII capture of Washington workers' compensation claims was 57% [Boden and Ozonoff, 2008]. The higher percentage of workers' compensation claims reported in SOII found in this study likely reflects three differences in methodology: (i) the availability and use of unemployment insurance data to link SOII and workers' compensation; (ii) utilization of workers' compensation worksite location data for multi-site firms which enhances identification of the surveyed workforce within workers' compensation among sampled reporting units; and (iii) the restriction of claims to those involving missed work during the survey (as opposed to initial missed work sometime after the close of the survey). Also, both studies involved data collected prior to the implementation of the current OSHA recordkeeping regulations, which may further impact comparability of the estimates. Our estimate of SOII capture is lower than that of Oleinick and Zaidman [2010], who found SOII to estimate 86–90% of Minnesota workers' compensation claims [Oleinick and Zaidman, 2010]. Their analysis is based not on record linkage but on a comparison of total injuries and does not address the overlap of cases reported in each data source. Data from the National Health Interview Survey suggested that 70% of injuries with work absence were reflected in SOII [Smith et al., 2005], an estimate similar to the SOII capture reported here.

Underreporting by workers' compensation insurer in Washington is analogous to underreporting by industry in other linkage studies. In many other states, the workers' compensation employer data more closely resemble the Washington self-insured data, with minimal data on worksite locations. In contrast, the Washington State Fund workers

**TABLE VII.** Nine Year Average Incidence Ratios (IR) for Unreported Washington State Fund Workers' Compensation Time Loss Claims in SOII by SOII Survey Characteristics

	PR (95%CI)
Sampled workforce	
Sub-account versus UI account	1.13 (1.08, 1.18)
Cases requested by BLS	
Subset based on injury date versus all in in survey year	1.16 (1.07, 1.26)

IRs adjusted for survey year, nature of injury, and joint effect of industry and size.

compensation data delineates business locations within a firm, allowing for better alignment with the SOII establishment data compared to workers compensation data. The appearance of poorer reporting among self-insured employers was likely due to overestimating the number of SOII-sampled workers' compensation claims among reporting units, and not from true differences in case reporting between state funded and self-insured employers. In other linkage studies, industry underreporting variations may be more a reflection of the difficulties in identifying the SOII-sampled workforce within workers' compensation data—a task more complex for some industries—than true industry-based reporting patterns.

Underreporting was evident within each industry division, but the magnitude of underreporting varied. After controlling for survey, injury, and establishment factors, large Construction establishments had among the highest incidence of unreported claims. The Construction industry has been the focus of several underreporting studies, and the frequently cited reason for employer underreporting specific to the industry is a reliance on a bidding process that includes injury and illness rates in the competition for work among firms, creating an incentive to not report injuries [Glazner et al., 1998; Dong et al., 2011]. But reporting disincentives hypothesized for the construction industry seem unsuitable for explaining underreporting across all industries and establishment factors. Compared to large manufacturing establishments, increased underreporting was also found among large establishments in agriculture, forestry, fishing, and hunting and transportation and warehousing, as well as small establishments in Information and financial activities, educational services, and health care and social assistance, and among establishments of all sizes in retail trade, professional and business services, and leisure and hospitality. The range of industries and establishment sizes with unreported claims suggest that the reasons for underreporting likely differ by industry, possibly even by establishment. Some employers may underreport because they receive bonuses for low injury rates, while other underreport because they misinterpret the reporting requirements, or they lack an adequate system to report and track workplace injuries [Phipps and Moore, 2010; Wuellner and Bonauto, 2014]. Establishments that maintain records sporadically, such as those usually exempt from recordkeeping requirements, may be less familiar with the OSHA recordkeeping regulations than those who routinely maintain records, and poor recordkeeping knowledge likely results in underreporting cases on the OSHA log [Eisenberg and McDonald, 1988; US Government Accountability Office, 2009].

Our findings suggest that claims among State and Local Government workers are more likely to be reported than claims among the private sector. This may be due to the increased emphasis on transparency within government relative to the private sector, or it may reflect other factors that improve reporting such as unionization, the rate for

which is five times higher among public-sector workers than among private sector workers [Bureau of Labor Statistics, 2015]. Unionization may improve reporting by offering increased protection for reporting injuries to employers [Azaroff et al., 2002], or by reviewing posted injury logs to ensure that they are complete and accurate. Additional research is needed to understand the reasons for reporting differences between the public and private sectors.

Two factors related to the implementation of the survey were associated with unreported workers' compensation claims. First, our findings suggest that SOII reporting is less complete when the sampled establishment is one of many within a UI account, a pattern found in a previous SOII-workers' compensation record linkage study [Nestoriak and Pierce, 2009; Boden, 2014]. For an injury to be recorded on a company's OSHA log, details of the incident must be transferred across one or more individuals within the company, for example, from the injured worker to the supervisor, and from the supervisor to the establishment recordkeeper. When the recordkeeper is located offsite, the transfer of information across multiple locations presents an additional barrier to maintaining accurate and current injury records. Alternatively, it is possible that the increased risk of underreporting in SOII among sampled sub-accounts may be due to irreconcilable differences in the sampled employer's business structure across administrative data systems. The relationship between reporting and the second survey factor, injuries requested by BLS (all DAFW vs. those occurring on specified dates), was more complex. More complete reporting among establishments instructed to report cases based on injury dates compared to establishments instructed to report all DAFW cases in the survey year likely reflected differences in size and industry distributions between the two groups; larger establishments were more likely to be instructed to report a subset of cases and also had high estimates of SOII capture. Multivariable analysis suggested greater underreporting among sub-sampled establishments compared to establishments of similar size and industry, perhaps because the respondents failed to follow the BLS instructions regarding which cases to report, or because of differences in injury dates between the employer's injury records and workers' compensation (the injury appeared to be within the sub-sampled based on the workers' compensation date of injury but outside of the sub-sample based on the employer's date of injury). BLS may be able to improve reporting accuracy through increased outreach to these establishments to ensure they report the intended cases.

The reporting mechanism for Washington workers' compensation injury data differs from the process typical in other states. Whereas in most states, it is the employer who usually files the initial report of injury with the insurance provider, in Washington, the worker (with the health care provider) files the injury report directly with the workers' compensation agency, somewhat lessening a barrier to claim

filing. By comparing claims initiated directly by injured workers to employer reported SOII cases, we measured SOII reporting against a group of injuries not filtered directly through an employer reporting mechanism, a potentially greater population of injuries than would be captured by other workers' compensation systems. While we view this as a strength of the study, injuries captured in the Washington workers' compensation system may differ both quantitatively and qualitatively from injuries captured by other workers' compensation systems, presenting a challenge to generalizing our findings beyond similar workers' compensation systems. Evidence from Boden and Ozonoff [2008] and Mendeloff and Burns [2013] suggest that the magnitude of underreporting varies by state. Beyond differences in claim filing procedures, state level factors that potentially impact reporting include: rates of unionization; rates of unemployment; and workers' compensation benefits. It is unknown whether patterns of underreporting by establishment characteristics are similar across states.

There are several limitations of this study. In order to limit the analysis to claims most likely to have met SOII reporting criteria and construct populations of linked and unlinked claims that were comparable, we chose to exclude both linked and unlinked claims that failed to meet specified location and indemnity criteria. The location parameters were sometimes insufficient for reconciling sampled SOII establishments within the workers' compensation data, as illustrated by the exclusion of over four thousand linked claims on the basis of discordant worksite data. The problem was particularly acute for self-insured claims which comprised 77% of the linked claims excluded based on location data. A more sensitive method of reconciling sampled worksites may produce different estimates of relative rates of reporting.

Exclusion criteria based on indemnity benefits limits claims to the most severe acute injuries, removing less severe injuries not eligible for time loss benefits and also injuries that progress over time, becoming eligible for time loss benefits months or years after the initial injury. Additionally, the exclusion of claims with disability during the survey year but initial time loss payments after the survey year likely underestimated the number of SOII-eligible claims; indeed, 45% of claims with such events were reported in SOII. However, were we to estimate SOII eligibility using only the disability date, the final estimate of underreporting changes little: including claims with disability during the survey year, regardless of the timing of claim establishment or time loss payments reduced the percent of state funded claims linked to a SOII case from 72% to 70%. Given the limited disability date data for self-insured claims, a similar assessment cannot be completed for self-insured claims. These issues can be examined in depth in future research where data are available.

The study evaluates only SOII cases and workers' compensation claims and does not consider underreporting

of injuries and illnesses not captured by either SOII or workers' compensation, often estimated through capture-recapture methods [Morse et al., 2001; Rosenman et al., 2006; Boden and Ozonoff, 2008]. We have chosen not to apply capture-recapture methods here because of the possible biases introduced when the two data sources are dependent [Boden, 2014; Jones et al., 2014], specifically, cases reported in SOII are likely reported in workers' compensation and vice versa. Indeed, SOII cases appear to be a subset of workers' compensation claims in Washington, with workers' compensation capturing 96% of SOII cases. A third data source independent of workers' compensation and SOII would greatly enhance capture-recapture estimates. This study's assessment of unreported claims can be considered a lower bound of underreporting; estimates would increase if eligible injuries not captured in either data source were included. Furthermore, with evidence that "underclaiming" varies by industry, occupation, and worker characteristics [Fan et al., 2006], an evaluation of underreporting that includes injuries not reported in either workers' compensation or SOII may alter the relative rates of SOII underreporting. This may explain, in part, our finding of more unreported workers' compensation claims among the largest Construction establishments compared to smaller Construction establishments where others have found the opposite [Dong et al., 2011]. Workers in smaller establishments are less likely to file workers' compensation claims than workers in larger establishments [Biddle et al., 1998]; claims that are reported may be relatively severe [Shannon and Lowe, 2002] and thus, more likely to be reported in SOII. Additional research into worker and injury characteristics of unreported claims would further enhance our understanding of SOII underreporting.

SOII data accuracy may be improved through modifications to the survey and increased education of employers on the recordkeeping requirements. To help standardize and improve injury recordkeeping across employers, both BLS and OSHA can increase education and outreach efforts with employers regarding recordkeeping requirements. Interactive recordkeeping software that reminds users of the recordkeeping regulations and performs data quality checks in real time may help reduce recordkeeping errors. Collecting data quarterly rather than once at the end of the year may improve employers' familiarity with the recordkeeping requirements by requiring periodic data submission during the course of the survey year. Finally, BLS could revisit conducting audits among a sample of respondents. Although the audit process has been considered too labor intensive to be useful in validating submitted SOII data [Eisenberg and McDonald, 1988], the mere threat of an audit may improve recordkeeping among all participating establishments.

The advantages of SOII include the consistent collection of case-level injury and illness data by detailed industry and

the ability to generate national and state level estimates through the utilization of a federally regulated system of incident tracking uniform across the nation, but the system is hampered by incomplete case ascertainment [Ruser, 2008]. Moreover, any occupational injury surveillance system dependent on employer reported data will face allegations of underreporting so long as the business environment continues to incentivize workplace injury data. Barring a shift in business incentive programs from injury data to hazard identification and mitigation, BLS may never alleviate concerns about underreporting. Other sources of occupational injury and illness data have their own limitations: workers' compensation data are not comparable across states and face similar concerns about underreporting, and hospital discharge or emergency department data provide little if any information on industry or occupation and are often related back to workers' compensation data through the identification of work-related incidents using payer data. Development of an enhanced surveillance system that links establishment reported data with worker reported data would be an improvement over either individual data collection system, but the cost to implement such a system that tracks workers within each participating establishment likely would be substantial.

SOII underestimates of the true incidence of work-related injuries and illnesses, and the magnitude of the underestimate appears to vary across employers. The variation in reporting across establishment characteristics impedes the ability to identify and prioritize groups at increased risk of work injury and illness. Absent changes to the current system, other data sources, despite their limitations, may be more appropriate for gauging injury risk across establishment or injury characteristics.

## AUTHORS' CONTRIBUTIONS

All authors contributed to the study design and interpretation of the data. S. Wuellner drafted the manuscript and performed statistical analysis. D. Adams conducted the record linkage, contributed to data analysis and interpretation, and provided critical review of the manuscript. D. Bonauto led the design of the study, provided oversight of the record linkage and data analysis, and provided critical review of the manuscript. All authors agree to be accountable for all aspects of the work.

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## DISCLOSURE (AUTHORS)

The authors report no conflict of interest.

## DISCLOSURE BY AJIM EDITOR OF RECORD

Steven Markowitz declares that he has no competing or conflicts of interest in the review and publication decision regarding this article.

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