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Millions of companies around the world have adopted management system standards to both convey superior operational performance and to improve their operations. Yet because these standards impose requirements on operational processes and procedures, it is largely unknown whether adopting these standards actually bears any relationship with operational performance. We examine this question in the context of the OHSAS 18001 Occupational Health and Safety Management system standard. Analyzing proprietary certification data from some of the world's largest certification companies and injury microdata from the U.S. Bureau of Labor Statistics, we find that U.S. establishments certified to the OHSAS 18001 standard indeed tend to be safer workplaces. The OHSAS 18001 standard attracts establishments with fewer injury and illness cases than comparable non-adopters (a selection effect), and certification leads to subsequent declines in such cases (a treatment effect). These results provide rare evidence the adoption of a management system standard serves both as a credible indicator of superior operational performance, as well as a means to improve performance.

Keywords: standards, occupational health and safety, program evaluation, quality, safety performance, injuries, OHSAS 18001, ISO 45001

1. Introduction

At companies across the United States, workers suffered 2.8 million workplace injuries and illnesses in 2018 (U.S. Bureau of Labor Statistics, 2019a). Workplace injuries in 2018 are estimated to have cost $171 billion, including wage and productivity losses ($53 billion), medical expenses ($35 billion), administrative expenses ($58 billion), and employers' uninsured costs ($13 billion) (National Safety Council, 2020).

Despite the persistence of workplace injuries and their substantial costs, occupational safety "has been virtually ignored in the operations literature" (Pagell et al. 2014: 1161). This inattention is surprising since a wide array of operational factors can affect occupational safety,

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including the design of production processes and equipment and the deployment of safety devices (Vincent et al. 2004), training and reinforcement (Komaki et al. 1980), and hazard reducing systems (de Koster, Stam and Balk, 2011). Indeed, firms and industries recognize that organizational practices are central to their safety performance. Some have developed sets of "best-practice" policies and procedures to improve occupational health and safety: as one example, the chemical manufacturing industry developed the Responsible Care program in the wake of an accident at a Union Carbine plant in Bhopal that led to thousands of deaths. Government agencies have also launched voluntary programs to encourage companies to adopt procedures to assure worker safety. For example, the U.S. Occupational Safety and Health Administration's (OSHA's) Voluntary Protection Programs offers incentives to encourage companies to implement "comprehensive safety and health management system[s]" (U.S. Department of Labor, 2020a).

Management system standards are an oft-touted organizational practice for companies to improve their health and safety performance. The OHSAS 18001 Occupational Health and Safety Management standard was developed by a consortium of national standard bodies, accreditation agencies, certification companies, and occupational safety and health organizations, and it became an official British Standard in 2007. OHSAS 18001 specifies a series of best practices for managing occupational health and safety, and it specifies processes and procedures that seek to enable organizations to control health and safety risks. While less popular than other management system standards such as those that govern quality management (ISO 9001) and environmental management (ISO 14001), adoption has been growing quickly over time. OHSAS 18001 has been adopted by more than 90,000 organizations across 127 countries (NQA, 2020). Adoption is expected to accelerate now that it has been transformed (in 2018) by the

International Organization for Standardization into a new ISO 45001 occupational health and safety management system standard (BSI, 2013b).[1]

Enthusiasts tout two benefits of OHSAS 18001, like many similar management system standards. The first claimed benefit is a *signaling* effect stemming from information asymmetry: companies know much more about their own safety culture, practices, and performance than their buyers, regulators, and potential employees. Because certification to OHSAS 18001 requires adoption of the standard's set of best practices in safety management, the standard will signal superior safety performance as long as implementing these processes and procedures is less costly for companies with better safety performance. One leading organization that certifies companies' adherence to various management system standards bolsters this impression in its marketing claim that "OHSAS 18001 helps you to publicly demonstrate you have a positive health and safety culture, differentiate your organization and put you in a strong position when competing for contracts" (BSI, 2018b).

The second potential benefit of adopting the OHSAS 18001 standard is that implementing its required processes and procedures could lead organizations to *improve* their safety performance. The BSI Group notes that most adopters report that OHSAS 18001 certification helped them remain in regulatory compliance, reduce business risk, and reduce the likelihood of mistakes (BSI, 2018b). Similarly, Certification Europe, another certification body, notes that "Effectively implementing the standard results in a safer working environment for your workforce" (Certification Europe, 2020).

It is unclear, however, whether these alleged benefits are realized in practice. While OHSAS 18001—like other management system standards—requires adopters to implement a set

[1] The ISO 45001 standard incorporates all elements of OHSAS 18001 (BSI, 2018a), and we address some implications of this transformation in the Discussion section below.

of processes and procedures, it does not require adopters to exhibit superior performance. Assessing the two touted performance benefits poses several empirical challenges given the absence of (1) publicly available listings of the identity of adopters and their adoption date, and (2) readily available data on occupational health and safety performance.

We overcame these challenges to examine whether there is empirical evidence of either or both of these potential benefits to workplace safety associated with OHSAS 18001. First, we signed data sharing agreements with 10 major certification bodies who provided data on all establishments in the United States that they certified to the OHSAS 18001 standard. Second, we obtained establishment-level safety data by accessing microdata on injury and illness incidents reported in the Survey of Occupational Injuries and Illnesses (SOII) conducted by the U.S. Bureau of Labor Statistics (BLS).

We found that OHSAS 18001 attracted safer establishments—those with fewer worker injuries and illnesses. Conditional on industry, size, and a host of other establishment characteristics, each additional injury and illness case was associated with a 21 percent decline in the odds that an establishment adopted OHSAS in the following two years; each of the most severe cases that resulted in days away from work were associated with an even larger 36 percent decline in the odds of adoption. In other words, OHSAS 18001 certification was indeed a *signal* of superior *ex ante* performance.

We then assess whether adopting the standard led to improvements in these performance indicators by estimating difference-in-differences models on matched samples constructed via propensity score matching. Those results indicate that establishments certified to the OHSAS 18001 standard subsequently experienced 20 % fewer injury and illness cases than the matched control group evaluated over the same period. In other words, our estimates imply that OHSAS 18001 certification also led to an *improvement* in safety performance.

This study contributes to the literature examining effects of other management standards. Prior studies have found that becoming certified to the ISO 9001 Quality Management System Standard has been rewarded by buyers and NGOs (Christmann and Taylor, 2002), has accelerated organizational growth (Terlaak and King, 2006), has led to superior financial performance and growth (Levine and Toffel, 2010; Terlaak and King, 2006; Corbett et al., 2005), and has led to improved compliance (Gray et al., 2015). Similarly, adopting the ISO 14001 Environmental Management System Standard has been shown to reduce toxic chemical emissions and to improve environmental regulatory compliance (Dasgupta, Hettige and Wheeler, 2000; Potoski and Prakash, 2005a; Potoski and Prakash, 2005b). We also complement prior studies investigating the OHSAS standard, including Lo et al. (2014) and Abad et al. (2013), which were limited in having to rely on employee surveys or regulatory compliance outcomes.

2. Related Literature

The BSI Group created the OHSAS 18001 management system standard in 1999 to encourage companies to adopt best practices of occupational health and safety in order to improve workplace safety. A few studies have sought to examine its effectiveness. One study found that employees who worked at the two chemical companies in India that were certified to OHSAS 18001 reported more safety training and safety procedures than six non-certified companies (Vinodkumar and Bhasi 2011), but this study did not discern whether those differences already existed before adoption or resulted from adoption. Two other studies found opposing selection effects. Abad et al. (2013) found a negative selection effect, whereby 124 firms in Spain that adopted the standards had a higher (worse) average accident rate than 25 non-adopters. Heras-Saizarbitoria et al. (2019) similarly found a negative selection effect at the sector level. In contrast, Lo et al. (2014) examined U.S. manufacturing firms' annual sum of compliance violations across their subsidiary establishments, and considered the entire firm to be an OHSAS 18001 adopter once any of its establishments became certified. They found that, compared to a matched control group of firms that lacked adopting establishments, "adopting firms" exhibited fewer violations in the years before their first subsidiary adopted, and that this gap persisted for several years after it adopted. This evidence suggests a selection effect. However, the firm-wide aggregation approach result is vulnerable to identification concerns and alternative explanations; furthermore, this study did not consider an actual measure of safety performance (e.g., injury rates), but instead focused on an intermediate metric: compliance with safety regulations.

Our paper improves upon these studies in four ways. First, our study is the first to estimate the impact of OHSAS 18001 certification on safety performance using injury and illness data that establishments are required by law to report. This goes beyond using occupational health and safety regulatory compliance as the sole proxy for safety performance (e.g., Lo et al. 2014). Second, our collection of proprietary lists and certification dates of the U.S. establishments that were certified by 10 major certification bodies enables us to avoid relying on firm-level inferences about establishment-level adoption effects (e.g., Lo et al., 2014; Yang et al., 2021). Third, we conduct our empirical analysis at the establishment level rather than the firm level, enabling us to align establishment-level outcomes and control variables with the fact that the OHSAS 18001 standard is typically adopted and certified at the establishment-level. It also avoids measurement concerns stemming from aggregating establishments-level data to firms. Fourth, our large dataset enables us to use extensive controls, matching methods, and difference-in-difference models to derive more accurate estimates of selection and treatment effects, in contrast to prior studies that have considered a relatively small group of companies in their samples (e.g., Abad et al. 2013, Ghahramania and Salminen. 2019).

3. Theory and Hypothesis

3.1 Will Safer Establishments Adopt OHSAS 18001?

Because stakeholders cannot directly observe establishments' safety performance, being certified to meeting the OHSAS 18001 standard might enable establishments to convey to stakeholders their superior safety performance. In his seminal paper, Spence (1973) described an information asymmetry problem whereby employers, who lacked information on job applicants' productivity, could rely on applicants' possession of a college degree as a credible signal of productivity. This held because the cost of earning a college degree was lower for more productive individuals, which led to a positive selection effect to pursue a college degree. As a result, even if college did not improve their productivity, college applicants' higher productivity would be signaled to the job market by their possessing a college degree.

This logic can be applied to management system standards. Terlaak and King (2006) argued that the ISO 9001 Quality Management System Standard could be a credible signal of superior performance. This signaling works only if the ISO 9001 standard disproportionately attracted companies with superior quality management practices because the adoption process would be less onerous for them "because they need to undertake fewer adjustments" (Terlaak and King, 2006: 582). Similarly, the former head of the chemical company DuPont's Quality Management & Technology Center argued that the cost of adopting the ISO 9001 standards requirements depends on "where you start…If you've just won a Baldrige Award, registration of a plant or business may take you a few days. But if your quality system needs to be improved or created from the ground up the process can take as long as a year" (Marquardt, 1992: 52). Such cost differentials "encourages high quality organizations to certify and that inhibits lower quality ones from following suit" (Terlaak and King, 2006: 582). Darnall and Edwards (2006) examined this in the context of environmental management, and found that companies that had already implemented more environmental programs incurred lower costs in making adjustments necessary to meet the requirements of the 14001 Environmental Management System Standard.

Applied to the domain of occupational safety, this logic implies that OHSAS 18001 certification would be a credible signal of superior workplace safety if organizations with above-average safety records faced lower costs of adopting the standard, and were thus disproportionately likely do so. Why might this be so? As with the ISO 9001 and ISO 14001 management system standards, the OHSAS 18001 standard requires establishing establishment-wide safety policies, evaluating risks and opportunities, setting improvement objectives and goals, establishing safety procedures, and designing employee training programs. It also requires conducting internal auditing to assess procedural adherence, implementing corrective actions when needed, monitoring progress against goals, and periodically engaging in a management review process to assess overall progress and set new goals. The "policies, procedures and controls" required by OHSAS 18001 were based on "internationally recognized best practice" to promote health and safety performance (BSI, 2020). Because establishments with better safety culture (which had potentially already implemented many of these practices) face a lower cost of meeting the OHSAS 18001's requirements to become certified, we anticipate that organizations that had already been operating with these practices—and plausibly exhibiting better health and safety performance—would be more likely to adopt the standards. Thus, we predict:

Hypothesis 1: Establishments with superior occupational health and safety performance are more likely to adopt the OHSAS 18001 Occupational Health and Safety Management System standard.

3.2 Will Adopting OHSAS 18001 Lead to Safer Establishments?

The OHSAS 18001 standard requires establishments to adopt a proactive, systematic approach to managing occupational health and safety, including risk identification, developing and deploying safety policies and procedures to manage those risks, training programs to promote their implementation, accident preparedness, and procedures to remedy nonconformities. Such training programs heighten employee and managerial attention to health and safety practices and safety hazards (Ghahramani, 2016). Moreover, the standard requires managers to ensure internal audits are conducted periodically, which entails evaluating the extent to which the organization's health and safety objectives are met. The OHSAS 18001 standard also requires certified establishments to engage in continuous improvement. The standard requires organizations to "implement, maintain and continually improve their organizational health and safety management system" (BSI, 1999). The standard uses the Plan-Do-Check-Act (PDCA) cycle to systematically improve performance, which encourages adopters to set goals and assess current risks (plan), implement plans with direction from management (do), monitor and audit performance (check) and take corrective action and improve (act) (BSI 2013a). The plan-do-check-act model was designed with the intent of directly improving outcomes (Coglianese and Nash, 2020). As one company's OHSAS 18001 coordinator explained, "Although we have now been awarded certification to BS OHSAS 18001, this is where the real hard work begins. As per the requirements of the standard, we are striving to constantly improve our safety record at both our sites and will continue to adapt our processes and procedures accordingly" (BSI, 2013a).

The OHSAS 18001 standard also features a robust monitoring and sanctions system. Certification determinations are made by accredited, independent third-party certification bodies, and re-certification is required periodically to confirm that all of the standard's elements continue to be met (King, Lenox and Terlaak, 2005). Failure to do so results in the loss of certification. This "substantive" management system standard stands in contrast to other "symbolic" self-regulatory programs such as the Responsible Care and Sustainable Slopes programs that lacked independent certification, attracted worse-than-average performers, and failed to stimulate improvement (King and Lenox, 2000; Rivera and De Leon, 2004; Christmann and Taylor, 2006).

Coglianese and Nash (2020) theorize that management systems lead organizations to improve compliance by reducing ignorance, aligning incentives, and increasing the legitimacy of rules. We believe these factors apply to how OHSAS 18001 adoption lead firms to improve safety performance. The OHSAS 18001 standard requires establishments to develop and implement safety training programs that focus on identifying and reporting workplace hazards that reduce employees' ignorance of safe and healthy work practices. The OHSAS 18001 standard requires top-management buy-in and requires documentation, risk assessment practices, and audits that create incentives for employees to exhibit health and safety work practices. Finally, the company's adoption of and certification to OHSAS 18001 signals to employees that management values health and safety best practices, which lends legitimacy to employees engaging in safe work practices, which might otherwise be sacrificed when they conflict with short-term production demands. As a result, we predict that certification to OHSAS 18001 will create a culture of workplace accountability that leads employees to engage in safer work practices, which will lead adopting establishments to improved safety performance.

Hypothesis 2: Adopting the OHSAS 18001 Occupational Health and Safety Management System standard leads to improved occupational health and safety performance.

4. Data and Measures

4.1 Data

We obtained annual establishment-level injury data from the U.S. Bureau of Labor Statistics' (BLS) Survey of Occupational Injuries and Illnesses (SOII). BLS sends the SOII survey to nearly 230,000 establishments each year, who were randomly selected according to location, industry and number of employees in order to provide a representative sample of all workplaces in the U.S. (U.S. Bureau of Labor Statistics, 2019b). All private sector establishments are required by law to respond if they receive a SOII survey.[2] We accessed SOII microdata by becoming authorized by BLS as temporary agents and visiting researchers, attaining Special Sworn Status by the Census Bureau, and working in a Federal Statistical Research Data Center. The SOII dataset contains 2,187,431 establishments, with 48,123,482 establishment-year observations from 1995 to 2016, the most recent year available.

After signing data sharing agreements with 10 major international certification bodies, we obtained from them the name, address, and certification date of every establishment in the United States that they had certified to OHSAS 18001 between 1995 and 2018, collecting 1,381 OHSAS certifications. We similarly obtained from these same bodies certification data to the ISO 9001 Quality Management System Standard and to the ISO 14001 Environmental Management System Standard.

We also obtained Dun and Bradstreet data from the 2014 National Establishment Time Series (NETS) Manufacturing Database, which includes all establishments that reported

[2] In contrast, government establishments are required to respond to the SOII only if mandated by state law (U.S. Department of Labor, 2020b).

manufacturing as their primary industry, as well as all other establishments associated with these manufacturers' headquarters. This database includes annual establishment-level data from 1995 to 2014 on employment and industry identifiers, as well as the following establishment characteristics: whether it was a headquarters, branch, or a standalone organization (meaning it had no parent company, subsidiaries, or branch/division locations), foreign owned, publicly owned (owned by a public company), a government contractor, and the year it was established. The NETS dataset contains 4,027,800 establishments, with 80,556,000 establishment-year observations, covering 1995 to 2014.[3]

Because the SOII, certification, and NETS datasets lack a common unique identifier, we linked establishments via their names and addresses using a combination of fuzzy matching via matchit software and Stata's *reclink2* function, geocode matching via ArcGIS, and manual assessment. Of the 1,381 OHSAS 18001 adopters in our certification data, we identified 1,309 adopters with records in NETS and 522 adopters with records in both SOII and NETS.

4.2 Measures

From SOII, we obtained establishment-year counts of *all injury and illness cases*, our primary measure of safety performance, and three severity levels: those cases associated with: (1) days away from work (*DAFW injury and illness cases*), (2) job transfers or restrictions (*DJTR injury and illness cases*), and (3) *other injury and illness cases* that triggered neither DAFW nor DJTR. We also obtained from SOII establishment-year counts of *all injury cases* and of *all illness cases,* each establishment's *total hours worked*, and each establishment's *average annual employment*, which we logged to reduce skew. To create a rate, we followed BLS's approach of dividing *all injury and illness cases* by *total hours worked*, multiplying the result by 200,000

[3] We used 2014 values for 2015-2016.

(which reflects 100 full-time employees working 40 hours per week, 50 weeks per year) (U.S. Bureau of Labor Statistics, 2021); we log the result to reduce skew and the impact of outliers to create *injury and illness incidence rate (log)*. We created *DAFW injury and illness incidence rate (log), DJTR injury and illness incidence rate (log) and other injury and illness incidence rate (log*) following this approach, using each subgroup of injury and illness cases.

From the lists of certified establishments we obtained from the 10 certification bodies, we created the dummy variables *OHSAS 18001 certified*, *ISO 9001 certified*, and *ISO 14001 certified,* coded 1 for every year during which an establishment was certified to that standard, and 0 otherwise.

From the Dun & Bradstreet data in the NETS dataset, we created dummies to denote whether each establishment was a *headquarters, branch,* or a *standalone* organization (meaning it had no parent company, subsidiaries, or branch/division locations), *foreign owned*, *publicly owned* (owned by a public company), and a *government contractor*. We created *establishment age* by subtracting the establishment's "year started" (from NETS) from the current year; because this was missing more often than the other NETS variables, in our models we use a version of this variable in which we recoded missing values to zero, and included a dummy indicating observations where we did this recoding.

5. Empirical Specifications and Results

5.1 Selection Model

To assess whether the safety performance of OHSAS 18001 adopters differed from non-adopters at the time the former became certified, we estimate several selection models that predict certification to OHSAS 18001. Once an establishment becomes certified, we omit it from the selection model sample in subsequent years because it was no longer at risk of certification.

We estimate the model depicted in Equation 1:

$$OHSAS_{i,j,t} = \beta \times \textit{injury and illness cases}_{i,t\text{-}2} + \boldsymbol{\gamma}'\mathbf{X}_{it} + \delta_t\, year_t + \delta_j\, industry_j + \varepsilon_{i,j,t} \qquad (1)$$

This model predicts that establishment i will become certified to the OHSAS 18001 standard in year t ($OHSAS_{i,t}$) as a function of its health and safety performance over the prior two years[4] (*all injury and illness cases*$_{i,t\text{-}2}$) and a vector of controls ($\mathbf{X}_{it}$), as described below. We also include three-digit NAICS[5] code industry dummies ($industry_j$) to account for potential differences in adoption propensity across industries, and year dummies ($year_t$) to flexibly allow for temporal-specific factors that might affect companies' propensity to seek certification.

$\mathbf{X}_{it}$ includes the following controls. We control for establishment size (employees) because larger firms might be more likely to adopt OHSAS 18001 given that they have more resources, and larger firms have been shown to adopt other management standards (Potoski and Prakash, 2005a; Levine and Toffel, 2010). We also control for whether an establishment was a standalone firm, headquarters, or branch of a multi-establishment firm, as the type of establishment might affect how easily it can get buy-in from top management to adopt OHSAS 18001. We also control for whether each establishment was foreign owned because those establishments might face more internal pressure to adopt the standard to bridge intra-organizational information asymmetries, owned by a public company because public and private companies might face different incentives to adopt, or a government contractor which might face government customers prone to require suppliers be certified to standards.

[4] We find similar results (not reported) when we use the average of the prior five years instead of two years (to account for sparsity of our data due to variable SOII sampling across years).

[5] We use 3-digit NAICS codes because the SOII survey reported NAICS codes from 2003 to 2016. For our selection models that include data before 2003, when the SOII survey instead reported SIC codes, we used a U.S. Census concordance file to convert SIC codes to NAICS codes. When several NAICS codes corresponded to a SIC code, we used the maximum NAICS code; using the minimum NAICS code yielded similar results.

We then substitute *all injury and illness cases* with (a) both of its components *injury cases* and *illness cases,* and then, in another model, (b) three subtotals based on different severity levels: *DAFW injury and illness cases, DJTR injury and illness cases,* and *other injury and illness cases*. We also estimate versions of these models that control for whether each establishment has previously been certified to the ISO 9001 quality and/or ISO 14001 environmental management standards, as adopting them might make it easier to adopt OHSAS 18001 given some overlapping management practice requirements, such as the recordkeeping requirements for training and internal auditing. Moreover, adopting ISO 9001 and OHSAS 18001 might unleash complementary routines that bolster the effectiveness of these standards in improving quality and safety (Pagell et al., 2015).

Estimating this model restricts our sample to establishments found in both the SOII and NETS datasets and that had reported injury data to the SOII in the prior two years, and excludes adopters' observations during the years after it was certified. This results in an estimation sample of 107,513 establishments including 279 OHSAS 18001 adopters, for a total of 461,478 establishment-years. We report industry distribution in Table 1, summary statistics in Table 2, and correlations in Table 3.

5.2 Selection Analysis Results

We estimate our selection models using logistic regressions and report results in Table 4. These results provide evidence of a positive selection effect: establishments with fewer total injury and illness cases were more likely to pursue certification. The results of Model 1a indicate that each additional injury and illness case in the prior two years before certification was associated with a 21 percent decline in the odds that an establishment adopted OHSAS 18001 (β

= -0. 21, $p < 0.01$).[6] We plot the predictive margins with 95% confidence intervals in Figure A-1, which further illustrates that less injurious establishments are more likely to adopt OHSAS 18001. Model 2a reveals that this relationship is driven entirely by injury cases (β = -0.27, $p < 0.01$), whereas illness cases have no predictive power for OHSAS adoption (β = 0.04, p = 0.67).

Model 3a results indicate that more severe injuries, DAFW injury and illness cases, drive the overall relationship between OHSAS certification and *ex ante* safety performance. Specifically, each injury and illness case with days away from work (DAFW injury and illness case) decreased the odds by 36% that establishments pursued OHSAS certification (β = -0.36, $p < 0.01$). On the other hand, we found no evidence that the decision to pursue certification was affected by the less-serious number of cases with job transfer or restriction (DJTR injury and illness cases) (β = 0. 02, p = 0.79) or other injury or illness cases (β = 0.03, p = 0.96).[7] Models 1b-3b, which also control for ISO 9001 and ISO 14001 adoption, yield nearly identical results.

Turning to controls, we find evidence that larger establishments (more employees) were more likely to adopt OHSAS 18001, as were establishments that were publicly owned, owned by a foreign entity, and had already adopted ISO 9001 or ISO 14001.

Overall, these results provide evidence that supports Hypothesis H1: adoption of the OHSAS 18001 standard was indeed an indicator of superior safety performance. In the sections that follow, we evaluate H2: whether adoption of the standard led to changes in establishments' subsequent safety performance.

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[6] Here since our independent variables are logged injury and illness cases to reduce skew, these coefficients can be interpreted as odds ratios.

[7] One possible reason why less serious injuries do not predict OHSAS 18001 adoption is that these injuries are more vulnerable to under-reporting (Boden et al. 2010). If adopting firms have better reporting practices than non-adopting firms, then they might report a larger share of their less-serious injuries to BLS, even if they experience fewer *actual* injuries.

5.3 Treatment Effect Analysis

We next develop a matched sample and then estimate a differences-in-differences model to evaluate the extent to which adopting the OHSAS 18001 standard had a causal effect on annual injury and illness cases.

5.3.1 Developing a Matched Sample. To yield causal inferences, the difference-in-differences approach relies on an identifying assumption that the treatment group (adopters) would exhibit performance trends in the post-adoption that would be indistinguishable from the control group's trends if treatment (being certified to OHSAS 18001) had not occurred. To bolster credibility that this assumption holds, we use propensity score matching to develop a matched sample that is balanced on observable adoption determinants, an approach used by others (e.g., Fisher, Gallino, and Netessine, 2021, Akturk and Ketzenberg, forthcoming) that assumes that assignment to treatment is based on the observable variables in our model, and that other unobservable factors represent random noise (that is, are uncorrelated with adoption and safety performance). Our approach goes one step further by ensuring balance on levels of the outcome variable during the pre-adoption period.

We use propensity score matching to develop our matched control group. We start with the SOII dataset, and estimate a model that predicts OHSAS 18001 certification based on all variables in our selection model, similar to the models reported in Table 4 but with several differences. First, because the SOII survey targets many establishments only once every few years, we use values averaged over the prior five years (instead of the two-year-averages used in the selection model). Second, we increase the richness of our specification by including five SOII sub-tallies as predictors: *DAFW injury and illness cases*, *DJTR injury and illness cases*, *other injury and illness cases*, *all injury cases*, and *all illness cases*. Third, we include even those

SOII establishments that we were unable to link to NETS data in order to avoid losing statistical power. We therefore use NETS variables in which missing values are recoded to zero (and include dummies denoting when we do this). We estimate this model using logistic regression on observations starting in 2005 (because very few certifications in our dataset occurred before then), and use predicted values as propensity scores. As described in Table 5, restricting to establishments with non-missing propensity scores reduces our sample from 578 (row 2) OHSAS 18001 adopters found in both SOII and NETS to 393 adopters (row 3).[8]

To develop our matched sample, we focus only adopters that additionally have at least one SOII record subsequent to their certification year—a restriction required to enable us to assess changes in safety associated with adoption. This restriction reduces our set of adopters from 393 to 274 (Table 5, row 4). For adopters that are certified in a given year, we similarly further restrict non-adopters as potential matching candidates to those that have at least one SOII record after this year. We use propensity scores to conduct single nearest neighbor matching without replacement, conditional on exact matching on each adopter's OHSAS 18001 certification year. This led us to identify 274 pairs of adopters (treatments) and non-adopters (controls) for the difference-in-differences model.

Adopters and non-adopters were balanced respect to their distribution of 3-digit NAICS industry codes (chi-square = 25.28; p-value = 0.79). We also assessed the quality of our matched samples by conducting a series of t-tests to compare the matched adopters and non-adopters along a wide array of covariates. Table 6 indicates that none of the 26 covariates in the injury and illness matched sample exhibit statistically significant or economically meaningful differences between adopters and non-adopters, a dramatic improvement over the imbalance

[8] We report the result of this model in Appendix Table A-1.

exhibited in the full sample, where there were statistically significant and qualitatively large differences for all of the variables (Columns 1-4). Table 7 reports the summary statistics of the matched sample used in the difference-in-difference analysis.

5.3.2 Evaluation Model. We use a difference in differences model to estimate the effect of OHSAS adoption on establishments' injury and illness cases. We estimate the following difference-in-difference model:

$$Y_{i,t} = \beta_1 \; OHSAS_{i,t} + \beta_2 \; total\ hours\ worked\ (log) + \gamma_t + \tau_{i,t} + \alpha_i + \varepsilon_{i,t}, \quad (2)$$

$Y_{i,t}$ refers to establishment *i*'s annual number of *injury and illness cases* in year *t* (or *DAFW injury and illness cases*, *DJTR injury and illness cases*, and *other injury and illness cases*), or *to* establishment *i*'s *injury and illness incident rate (log)* in year *t*. Our primary independent variable of interest is $OHSAS_{it}$, coded 1 to denote all years beginning with the year the establishment *i* became certified to OHSAS 18001, and 0 before—and is coded 0 in all years for non-adopters.

We control for *total hours worked (log)* to account for the possibility that adopters might grow in size at a different rate in the post period. We include year fixed effects (γ_t) to account for unobservable shocks that might be correlated with time-varying trends in injuries across calendar years. We create *post-period dummy* ($\tau_{I,t}$) to denote an establishment's match year (which is the OHSAS 18001 certification year for adopters) and all years thereafter. This acknowledges that other factors besides adoption might affect both treatments and controls after the match year. Finally, we include establishment fixed effects (α_i) to control for establishments' time-invariant attributes.

5.4 Treatment Effect Results

We estimate our difference-in-difference models using fixed effects Poisson regression and report standard errors clustered by establishment. We use all available observations ranging from six years before to six years after the match (adoption) year, recalling that the SOII data is unbalanced due to its sample varying every year. Model 1 in Table 8 reports our main estimates of the treatment effect of OHSAS adoption on *all injury and illness cases*, which indicates that OHSAS certification reduces all illness and injury cases by 20 percent (β = -0.22, $p < 0.01$; incident rate ratio = 0.80).

The remaining columns of this table report how OSHAS 18001 adoption affects injury and illness cases of different severities. Model 2 provides a point estimate that indicates that OHSAS certification reduces *DAFW injury and illness cases* by 19 percent (ß = -0.21, p = 0.13; incident rate ratio = 0.81), but is (barely) not statistically significant at the 10 percent level. Model 3 indicates that OHSAS 18001 certification reduces (less severe) *DJTR injury and illness cases* by 24 percent (ß = -0.28, $p < 0.01$; incident rate ratio = 0.76). Model 4 indicates that OHSAS 18001 certification reduces *other injury and illness cases* by 15 percent (ß = -0.16, p = 0.06; incident rate ratio = 0.85). These results show a detailed picture of how OHSAS 18001 certification impacts different types of injury and illness cases, indicating that adoption leads to a decline in a range of injuries of varying severity.

As a robustness check, we assess whether our results vary depending on the time window. Our primary approach is based on a window that spans six years prior to the match year to six years after. We re-estimated the models reported in Table 8 on a narrower window that spans three years prior to the match year to three years after and report results in Appendix Table A-2. These results tend to find similar but in some cases slightly smaller effect sizes of OHSAS adoption. We find that OHSAS 18001 adoption prompts a 16 percent decline in *all injury and illness cases* (β = -0.18, $p < 0.01$; incident rate ratio [IRR] = 0.84) over the three years subsequent to adoption compared to the three years before, a 15 percent decline in *DAFW injury and illness cases* (ß = -0.17, p = 0.14; IRR = 0.85), a 20 percent decline in *DJTR injury and illness cases* (ß = -0.23, p = 0.01; IRR = 0.80), and a 14 percent decline in *other injury and illness cases* (ß = -0.15, p = 0.05; IRR = 0.86).

While our matched sample is balanced in terms of the number of establishments having previously been certified to ISO 9001 quality and/or ISO 14001 environmental management system standards, it is possible that addition such certifications—or the loss of those certifications—might occur at different rates in the post-match period between our matched OHSAS 18001 adopters and non-adopters. As such, the models in Table 9 add controls for ISO 9001 and ISO 14001 to the models in Table 8. Accounting for these factors yields estimates very similar in magnitude and statistical significance to our primary models except that we find that OHSAS 18001 has a larger, and now statistically significant, effect on *DAFW injury and illness cases*. Specifically, the results in Table 9 indicate that, controlling for ISO 9001 and ISO 14001 adoption, OHSAS 18001 adoption prompts a 21 percent decline in *all illness and injury cases* (Model 1: β = -0.23, $p < 0.01$; IRR = 0.79), a 26 percent decline in *DAFW illness and injury cases* (Model 2: β = -0.30, p = 0.03; IRR = 0.74), a 24 percent decline in *DJTR illness and injury cases* (Model 3: β = -0.27,$p < 0.01$; IRR = 0.76), and a 14 percent decline in *other illness and injury cases* (Model 4: β = -0.15, p = 0.10; IRR = 0.86).

6. Discussion

Our study finds that workplaces in the U.S. that adopted OHSAS 18001 tended to already be safer workplaces than comparable non-adopters. Each additional injury and illness case was associated with a 21 percent decline in the odds that an establishment adopted OHSAS, and each additional case of the most severe type of injury and illness we studied—cases that resulted in days away from work (DAFW)—is associated with a 36 percent decline in the odds of adoption. This positive selection effect indicates that OHSAS 18001 certification is a credible signal of *ex ante* superior safety performance.

We also find that OHSAS 18001 adopters subsequently reduce injuries to a greater extent than a matched set of non-adopters, revealing a treatment effect. OHSAS 18001 certification reduces the total number of illness and injury by 20 percent, and the number of illness and injury cases associated with job transfers or restrictions by 24 percent. We find some evidence that OHSAS 18001 also reduces the most severe injuries and illnesses—those that lead to days away from work—by a similar magnitude, though this estimate was somewhat imprecise.

Finding that OHSAS 18001 adopters have superior safety performance at the time of adoption and that adopters continue to improve after certification has the potential to inform buyers and regulators that OHSAS 18001 is a credible indicator of superior average safety performance. Cost-constrained regulatory agencies like U.S. OSHA and its state-level counterparts should consider whether to reduce scrutiny over OHSAS 18001 certified establishments and divert their monitoring resources to other establishments. That said, heterogeneous effects likely underlie the average effects we found, and more research is needed to ascertain which types of adopters are especially likely to exhibit superior safety performance, and which types might not exhibit superior safety performance at all.

Our study is the first to directly examine the effects of the OHSAS 18001 standard on establishment-level safety performance using injury and illness data, supplementing other studies that examined the effect of adopting the OHSAS 18001 standard on regulatory compliance (Lo et al. 2014), and that examined the standard's effect using only a relatively small set of comparison establishments (Abad et al. 2013). Our findings complement those of other studies that found safety to be a spillover benefit of adopting an ISO 9000 quality management system standard. Specifically, Naveh and Marcus (2007) found that certification to the ISO 9002 quality standard reduced accident rates among trucking companies, and Levine and Toffel (2010) found limited evidence that adopting the ISO 9001 quality standard increased California manufacturers' propensity to be injury free.

Our paper also contributes to the safety performance literature, which has focused on the importance of safety leadership, safety routines, and high reliability, and the challenge of accidents being viewed as "normal" (e.g., Komaki et al. 1980; Roberts, 1990; Perrow 1999; Vincent et. al, 2004; de Koster et. al., 2011). We add to this literature by showing that an occupational health and safety management system can also be an effective approach to improving safety performance.

Our study has several limitations. Qualitative studies can complement our work by revealing the mechanisms through which the adoption of the practices required by management system standards actually change how work is conducted, which our quantitative approach cannot do. Also, our analysis is limited to establishments within the United States, and results might differ in other contexts such as Europe and Asia, where management system standard adoption is especially prevalent. Future studies that focus on management system standards with many more adopters can use their greater statistical power to go beyond estimating average effects by exploring heterogeneous effects across industries, organizational size, and other institutional and organizational factors.

Future work should examine the effects of the ISO 45001 Occupational Health and Safety Management Systems standard that built on, and has largely replaced, the OHSAS 18001 standard. The ISO 45001 standard is structured to be more aligned with other management system standards such as ISO 9001 (quality) and ISO 14001 (environment) in order to make it easier for establishments to adopt and integrate several of these standards—and thus accelerate their adoption. This could lead more companies to adopt the management processes and procedures that OHSAS 18001 has required, which our study has demonstrated to lead to safer workplaces. ISO 45001 adds some requirements beyond what OHSAS 18001 had stipulated, such as greater engagement of senior management leadership in health and safety, and a broader set of health and safety activities to promote a safety culture such as more transparent accident investigations and incorporating safety in employee performance appraisal systems and in recruiting messaging (Pavlovic, 2020). The greater emphases on senior leadership engagement and safety culture might mean that our results underestimate the safety benefits this new standard might yield, but research is needed to evaluate the effects of ISO 45001 once sufficient adoption occurs and post-adoption safety performance data become available.

7. Conclusion

Management system standards have been implemented by hundreds of thousands of companies around the world, yet many managers and regulators remain unclear whether organizations that adopted these standards exhibit better performance than others, and whether adopting these standards actually improves performance. Companies considering adopting an occupational health and safety management system standard have a clear interest in knowing whether doing so would lead them to improve their safety performance. And companies who purchase from certified establishments ask whether certification is a credible signal of safer workplaces, which could help the buyers avoid risk of disruption and reputation spillovers consequences of purchasing from unsafe suppliers.

Our study examines the first health and safety management system standard that requires companies to implement a set of best practices in safety management. Our results confirm that, when establishments become certified to OHSAS 18001, they are already safer workplaces—they report fewer injuries and illnesses—than comparable establishments that do not adopt the standard. Moreover, we find that certification leads to subsequent improvements in safety performance, in that adopters experience significant declines in injury and illness cases, compared to a matched set of non-adopters.

These results has wide implications for thousands of companies around the world, including those who already adopted OHSAS 18001 and the companies considering adopting its successor standard ISO 45001. Our results also have ramifications for both buyers and regulators who now have credible evidence that indicates that OHSAS 18001 is a signal of superior *ex ante* health and safety performance, and that it typically leads to further safety performance improvement over time.

Our study is also one of few that directly examines the effects of management system standards on their domain's performance, such as the few studies that examined the impact of ISO 14001 on environmental performance measured by toxic chemical emissions (Potoski and Prakash, 2005a) and environmental compliance (Potoski and Prakash, 2005b). In the case of organizational health and safety, we find that the management system standard was effective: adopters of OHSAS 18001 were directly related to both superior *ex ante* performance and improved performance after certification by measuring workplace injury and illness cases. This gives credence to the effectiveness of management system standards as a tool to improve performance and encourages the creation and adoption of similar management system standards across other performance dimensions.

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Table 1. Industry Distribution of Selection Analysis Sample

Industry (3-digit NAICS code)		Establishment-Years	
		Number	Percent
236	Construction of Buildings	3,399	<1%
238	Specialty Trade Contractors	14,376	3%
311	Food Manufacturing	29,802	6%
312	Beverage and Tobacco Product Manufacturing	5,041	1%
313	Textile Mills	6,272	1%
322	Paper Manufacturing	13,906	3%
323	Printing and Related Support Activities	20,914	5%
324	Petroleum and Coal Products Manufacturing	2,767	<1%
325	Chemical Manufacturing	20,091	4%
326	Plastics and Rubber Products Manufacturing	20,341	4%
327	Nonmetallic Mineral Product Manufacturing	14,950	3%
331	Primary Metal Manufacturing	14,799	3%
332	Fabricated Metal Product Manufacturing	53,386	12%
333	Machinery Manufacturing	37,059	8%
334	Computer and Electronic Product Manufacturing	22,279	5%
335	Electrical Equipment, Appliance, and Component Manufacturing	11,786	3%
336	Transportation Equipment Manufacturing	30,316	7%
339	Miscellaneous Manufacturing	17,607	4%
423	Merchant Wholesalers, Durable Goods	27,719	6%
424	Merchant Wholesalers, Nondurable Goods	17,369	4%
425	Wholesale Electronic Markets and Agents and Brokers	6,867	1%
488	Support Activities for Transportation	4,001	<1%
493	Warehousing and Storage	6,557	1%
517	Telecommunications	5,880	1%
541	Professional, Scientific, and Technical Services	19,105	4%
551	Management of Companies and Enterprises	9,730	2%
561	Administrative and Support Services	13,222	3%
562	Waste Management and Remediation Services	3,785	<1%
811	Repair and Maintenance	8,152	2%
Total:		**461,478**	

N = 461,478 establishment-years from 107,513 establishments.

Table 2. Summary Statistics of Selection Analysis Sample

	Mean	SD
OHSAS 18001 certified	0.0006	0.0246
All injury and illness cases †	1.42	1.30
DAWF injury and illness cases †	0.69	0.87
DJRT injury and illness cases †	0.65	0.99
Other injury and illness cases †	0.94	1.07
All injury cases †	1.37	1.26
All illness cases †	0.27	0.67
Average annual employment †	4.19	1.52
Establishment age (years)	14.35	7.26
Standalone (dummy)	0.44	0.50
Branch (dummy)	0.37	0.48
Publicly owned (dummy)	0.22	0.42
Foreign owned (dummy)	0.10	0.31
Government contractor (dummy)	0.10	0.31
ISO 9001 certified, prior year (dummy)	0.05	0.22
ISO 14001 certified, prior year (dummy)	0.01	0.11

N = 461,478 establishment-years from 107,513 establishments.

† Averaged over prior two years prior to SOII survey year, then logged after adding one.

DAFW injury and illness cases are those causing at least one day away from work. *DJTR injury and illness cases* refers to those causing a job transfer or restriction. *Other injury and illness cases* refers to those that did not cause DAWF or DJTR. U.S. Bureau of Labor Statistics confidentiality concerns prevent us from reporting minimum and maximum values of the variables based on SOII microdata (all injury and illness variables and *average annual employment*). *Establishment age* ranges from 0 to 25 years; all other control variables are dummies. Missing values of *establishment age* were recoded to zero.

Table 3. Correlations of Selection Analysis Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) OHSAS 18001 certified	1.00															
(2) All injury and illness cases†	0.01	1.00														
(3) DAFW†	0.01	0.83	1.00													
(4) DJTR†	0.01	0.79	0.60	1.00												
(5) Other injury and illness cases†	0.01	0.90	0.68	0.63	1.00											
(6) All injury cases†	0.01	0.99	0.83	0.79	0.89	1.00										
(7) All illness cases†	0.01	0.61	0.54	0.58	0.63	0.55	1.00									
(8) Average annual employment†	0.02	0.74	0.60	0.59	0.66	0.73	0.47	1.00								
(9) Establishment age	0.00	-0.10	-0.01	-0.07	-0.11	-0.09	-0.09	-0.05	1.00							
(10) Standalone	-0.01	-0.24	-0.19	-0.21	-0.20	-0.23	-0.16	-0.36	0.06	1.00						
(11) Branch	0.01	0.16	0.12	0.16	0.13	0.16	0.14	0.26	-0.21	-0.68	1.00					
(12) Publicly owned	0.01	0.15	0.12	0.15	0.13	0.14	0.15	0.29	-0.07	-0.34	0.36	1.00				
(13) Foreign owned	0.03	0.08	0.06	0.08	0.07	0.08	0.07	0.14	-0.03	-0.17	0.14	-0.16	1.00			
(14) Government contractor	0.00	0.02	0.02	-0.01	0.02	0.02	0.00	0.07	0.12	-0.03	-0.14	0.02	0.00	1.00		
(15) ISO9k certified, prior year	0.04	0.09	0.05	0.07	0.08	0.08	0.06	0.14	0.06	-0.06	0.04	0.06	0.06	0.05	1.00	
(16) ISO14k certified, prior year	0.08	0.08	0.05	0.08	0.07	0.07	0.07	0.10	0.04	-0.05	0.04	0.02	0.10	-0.01	0.18	1.00

N = 461,478 establishment-year observations from 107,513 establishments.

† Averaged over prior two years prior to SOII survey year, then logged after adding one.

Missing values of *establishment age* were recoded to zero.

Table 4. Injury Analysis Selection Model Results

Dependent variable: OHSAS 18001 certified

	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)
All injury and illness cases†	-0.209**			-0.202**		
	[0.071]			[0.075]		
All injury cases†		-0.267**			-0.246**	
		[0.077]			[0.084]	
All illness cases†		0.036			-0.006	
		[0.085]			[0.090]	
DAFW injury and illness cases†			-0.358**			-0.339**
			[0.096]			[0.099]
DJTR injury and illness cases†			0.019			0.038
			[0.074]			[0.079]
Other injury and illness cases†			0.003			-0.024
			[0.079]			[0.082]
Annual employment†	0.550**	0.570**	0.541**	0.441**	0.467**	0.438**
	[0.072]	[0.071]	[0.070]	[0.077]	[0.076]	[0.074]
Establishment age	-0.005	-0.005	-0.005	-0.014	-0.014	-0.014
	[0.009]	[0.009]	[0.009]	[0.010]	[0.010]	[0.010]
Standalone	-0.347+	-0.351+	-0.351+	-0.243	-0.242	-0.250
	[0.210]	[0.211]	[0.209]	[0.212]	[0.213]	[0.212]
Branch	0.327*	0.316*	0.306+	0.242	0.237	0.226
	[0.160]	[0.161]	[0.161]	[0.164]	[0.164]	[0.164]
Publicly owned	0.677**	0.665**	0.675**	0.637**	0.628**	0.631**
	[0.153]	[0.154]	[0.153]	[0.162]	[0.162]	[0.160]
Foreign owned	1.830**	1.821**	1.812**	1.597**	1.589**	1.576**
	[0.151]	[0.151]	[0.152]	[0.161]	[0.161]	[0.161]
Government contractor	-0.098	-0.103	-0.091	-0.066	-0.072	-0.066
	[0.215]	[0.215]	[0.215]	[0.218]	[0.218]	[0.217]
ISO 9001 certified, prior year				1.332**	1.333**	1.340**
				[0.160]	[0.160]	[0.160]
ISO 14001 certified, prior year				2.068**	2.066**	2.063**
				[0.185]	[0.185]	[0.183]
Industry dummies (3-digit NAICS Codes)	Included	Included	Included	Included	Included	Included
Year dummies (1997-2016)	Included	Included	Included	Included	Included	Included

N = 461,478 establishment-year observations of 107,513 establishments including 279 OHSAS 18001 adopters.

† Averaged over prior two years prior to SOII survey year, then logged after adding one.

Logistic coefficients, with standard errors clustered by establishment in brackets. ** p<0.01, * p<0.05, + p<0.10. Missing values of *establishment age* were recoded to zero, and all models include a dummy variable indicating observations when this recoding occurred.

Table 5: Pipeline Table: Constructing the Matched Sample

	Establishment-Level Statistics			
	Adopters		Non adopters	
		% of prev row		*% of prev row*
1. All OHSAS 18001 adopters in certification data	1,381			
2. In SOII	578		2,187,431	
3. Restrict to establishments with predicted propensity scores (uses values averaged over the prior five years)	393	*68.0*	602,653	*27.6*
4. Restrict to establishments that have SOII data in both pre- and post-periods	274	*69.7*	602,527	*99.9*
5. Establishments that successfully matched one treatment to one control	274	*100.0*	274	*0.1*

Table 6. Balancing Tests for Matched Sample

	Sample Eligible for Matching (establishment-years in the sample to generate propensity scores)				Matched Sample (establishment-year in the matched year)			
	Adopters (mean)	Non-adopters (mean)	Diff in Means ♠	t-test p-value	Adopters (mean)	Non-adopters (mean)	Diff in Means ♠	t-test p-value
All injury and illness cases (log) ♦	2.11	0.71	197%	0.00 *	2.18	2.14	2%	0.68
All injury and illness cases ♦	17.40	3.80	358%	0.00 *	16.03	18.27	-12%	0.47
DAFW injury and illness cases (log) ♦	0.99	0.35	183%	0.00 *	1.00	1.02	-2%	0.82
DAFW injury and illness cases♦	3.47	1.15	202%	0.00 *	3.34	3.33	0%	0.98
DJTR injury and illness cases (log) ♦	1.25	0.26	381%	0.00 *	1.30	1.23	6%	0.45
DJTR injury and illness cases ♦	6.81	1.02	568%	0.00 *	6.16	7.08	-13%	0.58
Other cases ♦	1.45	0.44	230%	0.00 *	1.49	1.45	3%	0.66
Other cases (log) ♦	7.12	1.63	337%	0.00 *	6.53	7.86	-17%	0.28
All injury cases (log) ♦	2.03	0.69	194%	0.00 *	2.07	2.05	1%	0.86
All injury cases ♦	15.17	3.46	338%	0.00 *	13.67	14.79	-8%	0.58
All illness cases (log) ♦	0.51	0.09	467%	0.00 *	0.60	0.58	4%	0.79
All illness cases ♦	2.23	0.34	556%	0.00 *	2.35	3.49	-32%	0.41
Average annual employment (log) ♦	5.33	3.16	69%	0.00 *	5.58	5.42	3%	0.08
Average annual employment ♦	381.42	85.98	344%	0.00 *	442.29	434.50	2%	0.89
Standalone	0.14	0.09	56%	0.00 *	0.15	0.15	3%	0.90
Standalone missing	0.07	0.80	-91%	0.00 *	0.06	0.04	33%	0.44
Branch	0.58	0.07	729%	0.00 *	0.59	0.61	-2%	0.73
Branch missing	0.07	0.80	-91%	0.00 *	0.06	0.04	33%	0.44
Publicly owned	0.32	0.04	700%	0.00 *	0.35	0.39	-10%	0.33
Publicly owned missing	0.07	0.80	-91%	0.00 *	0.06	0.04	33%	0.44
Foreign owned	0.41	0.02	1950%	0.00 *	0.42	0.42	0%	1.00
Foreign owned missing	0.07	0.80	-91%	0.00 *	0.06	0.04	33%	0.44
Government contractor	0.09	0.02	350%	0.00 *	0.12	0.09	31%	0.27
Government contractor missing	0.07	0.80	-91%	0.00 *	0.06	0.04	33%	0.44
ISO9001 certified, prior year	0.31	0.01	3000%	0.00 *	0.41	0.46	-13%	0.17
ISO14001 certified, prior year	0.19	0.00	n/a	0.00 *	0.32	0.30	10%	0.46

This table reports means and p-values from two-sample t-tests. * $p < 0.05$.

♦ Averaged over prior five years, then logged after adding one.

♠ Difference in means is calculated as difference between the adopters' mean and non-adopters' means, divided by the non-adopters' mean.

The sample eligible for matching is the sample used to generate propensity scores. This includes all adopters' establishment-years between 2005 and their adoption year (N = 2,474) and all non-adopters' establishment-years starting in 2005 (N=3,274,943).

The matched sample columns report averages of the 274 adopter observations and 274 non-adopter observations pertaining to their match year. The match year for each adopter is its OHSAS 18001 certification year. The match year for each non-adopter is the certification year of the adopter to which it was matched.

Table 7. Matched Sample Summary Statistics

	Mean	SD
All injury and illness cases	20.39	43.12
DAFW injury and illness cases	4.40	11.40
DJTR injury and illness cases	7.67	21.59
Other injury and illness cases	8.33	16.49
Total hours worked (log)	13.42	1.10
OHSAS 18001 certified, prior year	0.19	0.39

N = 3,295 establishment-years from 548 establishments (274 adopters and 274 non-adopters).

U.S. Bureau of Labor Statistics confidentiality concerns prevent us from reporting minimum and maximum values of the injury and illness variables, which are based on SOII microdata.

Table 8. **Poisson Regression Results of Difference-in-Differences Analysis: Main Results**

	(1) All injury and illness cases	(2) DAFW injury and illness cases	(3) DJTR injury and illness cases	(4) Other injury and illness cases
OHSAS 18001 certified, prior year	-0.220**	-0.214	-0.277**	-0.159+
	[0.070]	[0.139]	[0.089]	[0.083]
Log total hours worked	1.005**	1.013**	1.099**	0.921**
	[0.068]	[0.149]	[0.089]	[0.076]
Facility-level conditional fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Post-period dummy	Yes	Yes	Yes	Yes
Observations (establishment-years)	3,239	3,067	3,024	3,161
Establishments (Adopters/Non adopters)	263 / 261	240 / 234	235/231	256/247
Mean Dependent Variable	0.73	4.72	8.35	8.67

Poisson regression coefficients, with standard errors clustered by establishment in brackets. ** p<0.01, * p<0.05, + p<0.10. DAFW injury and illness cases are associated with days away from work. DJTR injury and illness cases are cases associated with job transfer or restriction. Other injury and illness cases are cases that are not associated with DAWF or DJTR.

Table 9: Poisson Regression Results of Difference-in-Differences Analysis Controlling for ISO Certifications

	(1) All injury and illness cases	(2) DAFW injury and illness cases	(3) DJRT injury and illness cases	(4) Other injury and illness cases
OHSAS 18001 certified, prior year	-0.232**	-0.304*	-0.271**	-0.151+
	[0.072]	[0.136]	[0.095]	[0.091]
Log total hours worked	1.007**	1.015**	1.095**	0.919**
	[0.068]	[0.148]	[0.090]	[0.077]
ISO9k certified by prior year	0.029	-0.106	0.116	-0.037
	[0.084]	[0.109]	[0.121]	[0.102]
ISO14k certified by prior year	0.02	0.229*	-0.038	-0.017
	[0.059]	[0.089]	[0.082]	[0.081]
Facility-level conditional fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Post-period dummy	Yes	Yes	Yes	Yes
Observations (establishment-years)	3,239	3,067	3,024	3,161
Establishments (Adopters/Non adopters)	263 / 261	240 / 234	235/231	256/247
Mean Dependent Variable	20.73	4.72	8.35	8.67

Poisson regression coefficients, with standard errors clustered by establishment in brackets** p<0.01, * p<0.05, + p<0.10.

Appendix

Table A-1. Logistic Regression Results of Model Generating Propensity Scores

Dependent variable: OHSAS 18001 certified

	(1)
Injury and illness cases♦	0.121*
	[0.058]
Injury and illness cases♦	-0.269**
	[0.078]
Injury cases in survey year♦	-0.132*
	[0.057]
Illness cases in survey year♦	-0.133*
	[0.056]
Injury and illness cases with job transfer or restriction (DJTR) ♦	0.012
	[0.012]
Other injury and illness cases♦	0.007
	[0.010]
Annual employment♦	0.000**
	[0.000]
Establishment age	-0.020
	[0.009]
Standalone	-0.559**
	[0.189]
Branch	0.158*
	[0.147]
Publicly owned	0.975**
	[0.143]
Foreign owned	1.790**
	[0.145]
Government contractor	0.151
	[0.186]
ISO 9001 certified in prior year	1.673**
	[0.150]
ISO 14001 certified in prior year	2.241**
	[0.163]
Industry dummies (3-digit NAICS Codes)	Included
Year dummies (1997-2016)	Included

Logistic coefficients, with standard errors clustered by establishment in brackets. ** p<0.01, * p<0.05, + p<0.10.

N = 3,277,417 establishment-year observations of 602,687 establishments including 429 OHSAS 18001 adopters.

We recoded missing values of establishment age, standalone, branch, publicly owned, foreign owned and government contractor to zero, and included corresponding dummy variables to indicate these observations.

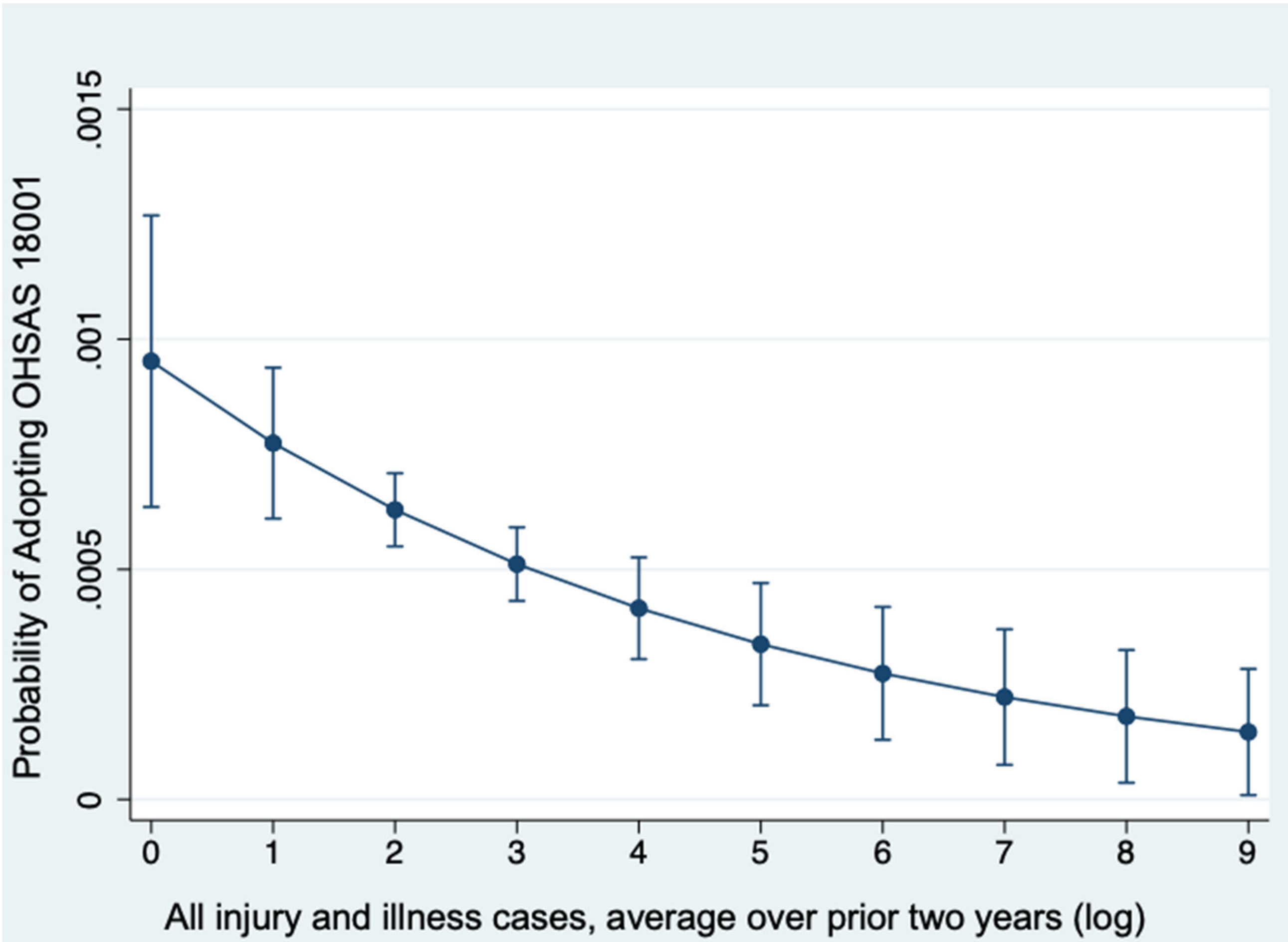
♦ Averaged over five years prior to SOII survey year, then logged after adding one.

Table A-2. Poisson Regression Results of Injury Treatment Analysis on Narrower Sample Window

	(1)	(2)	(3)	(4)
	All injury and illness cases	DAFW injury and illness cases	DJRT injury and illness cases	Other injury and illness cases
OHSAS 18001 certified by prior year	-0.179**	-0.167	-0.229**	-0.146+
	[0.059]	[0.112]	[0.085]	[0.075]
Log total hours worked	1.023**	1.115**	1.023**	0.953**
	[0.097]	[0.145]	[0.134]	[0.098]
Facility-level conditional fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Post-period dummy	Yes	Yes	Yes	Yes
Observations (establishment-years)	2,028	1,840	1,834	1,979
Establishments (Adopters/Non adopters)	239/235	208/200	209/197	232/223
Mean Dependent Variable	18.98	4.65	7.90	7.81

Poisson regression coefficients, with standard errors clustered by establishment in brackets** $p<0.01$, * $p<0.05$, + $p<0.10$. Analyzed on the injury matched sample, using observations 3 years before through 3 years after the match year.

Figure A-1. Less Injurious Establishments are More Likely to Adopt OHSAS 18001



This graph depicts predictive margins (with 95% confidence intervals) associated with our primary selection model (Table 4 Model 1).