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Do safety management system standards indicate safer operations? Evidence from the OHSAS 18001 occupational health and safety standard

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A R T I C L E I N F O

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A B S T R A C T

Problem definition: Given the enormous disruptions and costs of occupational injuries, companies and buyers are increasingly looking to voluntary occupational health and safety standards to improve worker safety. Yet because these standards only require implementing certain processes and procedures, it is largely unknown whether certification actually conveys superior safety performance. We examine this relationship in the context of the OHSAS 18001 Occupational Health and Safety Management system standard.
Methodology/results: We analyze proprietary certification data over 1995 to 2016 from some of the world's largest certification bodies and establishment-level injury data from the U.S. Bureau of Labor Statistics, and find that U.S. establishments certified to OHSAS 18001 tend to be safer workplaces. OHSAS 18001 attracts establishments with fewer injury and illness cases than comparable establishments (a selection effect). Using propensity score matching and a difference-in-differences approach, we estimate that OHSAS 18001 certification reduces the total number of illness and injury cases by 20 percent and illness and injury cases associated with job transfers or restrictions by 24 percent.
Managerial implications: Our results indicate that becoming certified to a safety management standard can lead to meaningful improvements in workplace safety, and that OHSAS 18001 certification is a credible indicator of superior average safety performance, an important insight for buyers and suppliers. Given that OHSAS 18001 is the basis for the newer ISO 45001 standard that has quickly become the world's third-most popular management system standard, this study provides promising evidence that ISO 45001 will also prove effective in distinguishing safer workplaces.

1. Introduction

Workers in U.S. companies suffered 2.7 million workplace injuries and illnesses in 2020 (U.S. Bureau of Labor Statistics, 2021). Workplace injuries in 2020 are estimated to have cost $164 billion, including wage and productivity losses ($45 billion), medical expenses ($35 billion), administrative expenses ($61 billion), and employers' uninsured costs ($13 billion) (National Safety Council, 2022).

Despite the persistence and substantial costs of workplace injuries, occupational safety "has been virtually ignored in the operations literature" (Pagell et al., 2014: 1161), which is surprising given that many operational factors can affect occupational safety, including (a) the design of production processes and equipment and (b) the deployment of safety devices (Vincent et al., 2004), hazard-reducing systems (de Koster et al., 2011), and training and reinforcement (Komaki et al., 1980; Choudhary et al., 2022). Indeed, firms and industries recognize that organizational practices are central to safety performance. Some have developed "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 Carbide plant in Bhopal that killed thousands. Government agencies have also launched voluntary programs to encourage companies to implement procedures to assure worker safety. For example, the U.S. Occupational Safety and Health Administration's (OSHA) Voluntary Protection Programs offer incentives to encourage companies to implement "comprehensive safety and health management system[s]" (U.S. Department of Labor, 2020).

Management system standards—certification to which requires implementing a set of organizational procedures—are an oft-touted organizational practice that is *assumed* to signal or foster superior

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performance. Initially focused on quality management (ISO 9001) and subsequently on environmental management (ISO 14001) and other domains, this approach has more recently been applied to health and safety. Intended to encourage companies to adopt best practices for occupational health and safety, the OHSAS 18001 Occupational Health and Safety Management standard was developed by a consortium of national standard bodies, accreditation agencies, certification companies, and occupational health and safety (OH&S) organizations.

Initiated in 1999, it became an official British Standard in 2007. Facing no competing international standards, more than 90,000 organizations in 127 countries became certified to OHSAS 18001 within a decade (National Quality Assurance, 2020), making it "the benchmark for OH&S" (International Organization for Standardization, 2022a). Motives to adopt health and safety management standards like OHSAS 18001 (and now ISO 45001) also include the desire by buyers to encourage their suppliers to adopt best practices that can reduce the odds that health and safety concerns will arise—especially in countries that lack regulatory capacity to ensure workplaces are safe—that risk causing operational disruptions that lead to delivery delays or media stories that might harm the reputations of their buyers. Because buyers do not have the capacity to develop or monitor all of their suppliers, many turned to the OHSAS 18001 management system standard (and then to ISO 45001) to encourage or require their suppliers to adopt best practices in health and safety management.

Moreover, part of the popularity of safety management standards is attributable to the rising prominence of the ISO 14001 standard given companies manage environment, health, and safety activities in an integrated fashion. Indeed, one of the reasons the International Organization for Standardization launched the ISO 45001 standard in 2018 based on OHSAS 18001 was to make the health and safety management standard even more compatible with the ISO 14001 and ISO 9001 standards so that entities that had adopted one of them could more easily adopt the others. Both ISO and British Standards Institution (BSI) urged establishments that had adopted OHSAS 18001 to migrate to the new standard before 2021, when OHSAS 18001 would be phased out. According to certification industry experts, not only have the vast majority of OHSAS 18001 certified establishments migrated to ISO 45001, but many other establishments have become certified to ISO 45001 because it is an international standard (rather than just a British standard) and is organized like other leading ISO standards, which facilitates adoption.[1] Indeed, ISO 45001 has quickly become the world's third-most popular management system standard, trailing only ISO 9001 (launched in 1987) and ISO 14001 (launched in 1996). By 2020, just two years after ISO 45001 launched, 190,481 companies covering 251,191 establishments had already become certified, milestones that took the ISO 9001 and ISO 14001 standards at least a decade to achieve (International Organization for Standardization, 2022b).

OHSAS 18001—and, subsequently, ISO 45001—specify a series of best practices for managing occupational health and safety, including establishing processes and procedures to enable organizations to control health and safety risks. Like other management system standards, they do not require any threshold level of or improvement in safety *performance.* Instead, becoming certified (and recertified every three years) to these standards requires implementing their processes and procedures.

Enthusiasts suggest that adopting health and safety management system standards such as OHSAS 18001 and ISO 45001—and many other management system standards—bestows reputational and legitimacy benefits (Uhrenholdt Madsen et al., 2020). This is based on two *presumed* benefits. The first is that certification signals superior safety performance, predicated on the assumption that adoption will be less costly and thus more attractive to companies that had already been implementing some of the standard's best practices that correlate with superior safety performance. One leading certification body—an organization that certifies companies' adherence to various management system standards—bolsters this impression in its marketing claim that becoming certified to a safety management system standard "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" (British Standards Institution, 2018).

The second potential benefit of adopting a health and safety management system standard is that implementing its required processes and procedures could *improve* safety performance. For example, BSI notes that most establishments that became certified to OHSAS 18001 reported that implementing the standard's procedures helped them reduce business risk and the likelihood of mistakes (British Standards Institution, 2018). Similarly, Certification Europe, another certification body, notes that "[e]ffectively implementing the [OHSAS 18001] standard results in a safer working environment for your workforce" (Certification Europe, 2020). Others have observed that implementing safety management systems can have benefits that include "safer working conditions" and "reduced harm to workers" (Yiu et al., 2019: 23).

It is unclear whether these alleged benefits are systematically realized in practice, a question that similarly arose with the earlier introduction of management system standards governing quality (Sroufe and Curkovic, 2008; Levine and Toffel, 2010) and environmental management (Corbett and Kirsch, 2001). But assessing the two touted performance benefits poses several empirical challenges given the absence of publicly available data on (a) which establishments have been certified and when, and (b) establishment-level occupational health and safety performance over time. Several studies (discussed below) have begun examining these issues but have yielded mixed results and feature empirical challenges that our study overcomes.

While it is too early to evaluate the ISO 45001 standard, given the lack of data on post-certification performance, we overcame these challenges to investigate the potential benefits to workplace safety associated with OHSAS 18001. First, we obtained rare access to establishment-level safety panel data by gaining special approval to analyze 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). Second, we signed data-sharing agreements with 10 major certification bodies which provided data on all U.S. establishments that they had certified to OHSAS 18001. The availability of U.S.-establishment–level safety panel data—rare as it is—makes the U.S. an excellent empirical context despite being a relatively small market for such certifications. For example, comparing our data to that in the International Organization for Standardization (2022b), we found that in 2020, just 0.8 % of sites around that world that were certified to ISO 45001 were in the U.S., 1.4 % for ISO 14001, and 2.6 % for ISO 9001. One of the certification bodies in our dataset indicated that just 2 % of their overall OHSAS 18001 certifications in 2017 were for U.S. workplaces. Furthermore, because the U.S. has relatively robust government regulatory and liability regimes that incentivize managing workplace safety, the effects of adopting and becoming certified to safety management system standards might be lower in the U.S. than in countries with weaker regulatory regimes that tend to have worse occupational health and safety performance (International Labor Organization, 2003; Liu et al., 2019), and where safety management system standards are more popular, such as China (where 60 times more establishments have been certified to ISO 45001 than in the U.S.) and India (3 times).

Our analysis reveals that OHSAS 18001 attracted safer establishments—those with fewer worker injuries and illnesses. Conditional on industry, size, and other establishment characteristics, each additional injury and illness case was associated with a 21-percent decline in the odds that an establishment was certified to OHSAS 18001 in the following two years. Each of the most severe cases–those resulting in days away from work—was associated with an even larger 36-percent decline in the odds of certification. These results indicate that OHSAS

[1] Author conversations with managers of several leading certification bodies, June 2022.

18001 certification is indeed a signal of superior *ex ante* performance.

We then assess whether being certified to OHSAS 18001 was associated with subsequent safety improvement by estimating difference-in-differences models on matched samples. We use propensity score matching to identify a control group of non-certified establishments, and we confirm that these controls are balanced with the certified "treatment" establishments on a range of baseline characteristics; furthermore, our difference-in-differences model accounts for any unobserved time-invariant differences that may remain between treatment and control establishments. While there could in theory be time-varying unobserved differences between certified and matched non-certified establishments, we find no statistical difference in the treatment and matched control groups' pre-trends—that is, their injury rates prior to the match year—suggesting that this concern is unlikely to contaminate our estimated treatment effect of certification. Our regression results indicate that certified establishments subsequently had 20-percent fewer injury and illness cases than the matched control group over the next six years. These results indicate that OHSAS 18001 certification leads to improved safety performance.

As described below, our results build on earlier studies of OHSAS 18001 while overcoming some of their empirical challenges, and provide important managerial insights for those considering adopting or relying on health and safety management systems to signal superior safety performance or to prompt improved performance.

2. Related literature

A few studies examined the effectiveness of the OHSAS 18001 health and safety management system. A survey-based study by Vinodkumar and Bhasi (2011) found that employees of two chemical companies in India that were certified to OHSAS 18001 reported more safety training and procedures than those at six noncertified companies, but the study did not discern whether those differences already existed before certification.

Several other studies have investigated selection effects, with conflicting findings. Abad et al. (2013) compared 124 firms certified to OHSAS 18001 to 25 noncertified firms—all in Spain—and found that those with worse accident rates (accidents per employee) were more likely to become certified, but found no evidence that number of work days lost to injuries predicted certification.[2] Heras-Saizarbitoria et al.'s (2019) sector-level analysis of firms in Spain found that OHSAS 18001 certification was more prevalent in *sectors* with more accidents. In contrast, Lo et al. (2014) found that U.S. manufacturing firms with at least one OHSAS 18001 certified site had fewer firm-wide health and safety regulatory compliance violations than a matched set of firms with no OHSAS 18001 certified sites.

A few firm-level studies examined the treatment effects of becoming certified to OHSAS 18001. Abad et al. (2013) and Lafuente and Abad (2018) analyzed 149 firms in Spain and found that OHSAS 18001 adoption was associated with declines in accident rates. Yang et al. (2021) found subsequent improvement in financial performance (return on assets) and labor productivity for manufacturing companies in China that had been certified to OHSAS 18001 in 2002–2011, but not for those certified in 2012–2014. Ghahramania and Salminen (2019) compared three OHSAS 18001 certified manufacturing firms in Iran to three noncertified ones and found that certified firms had more health and safety policies and procedures, but found no evidence of reduced injury rates.[3]

Our paper improves upon these studies in several ways. It is the first to estimate the impact of OHSAS 18001 certification on establishment-level safety using longitudinal injury and illness data that establishments are legally required to report. Past efforts used proxies for safety performance such as OH&S regulatory compliance (e.g., Lo et al., 2014), or firm-level data on accident rates but over a short period (Abad et al., 2013; Lafuente and Abad, 2018).

Second, our collection of proprietary lists and certification dates of the U.S. establishments certified by 10 major certification bodies enables us to avoid relying on very small samples (e.g., Vinodkumar and Bhasi, 2011; Ghahramania and Salminen, 2019), firm-level inferences about establishment-level certification effects (e.g., Lo et al., 2014; Ghahramania and Salminen, 2019; Yang et al., 2021), or conducting sector-level analysis (Heras-Saizarbitoria et al., 2019). Conducting our empirical analysis at the establishment level enables 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. In contrast, classifying an entire firm based on a single site having been certified risks mismeasuring the deployment of the health and safety management practices that the standard requires.

Third, our data enables us to use extensive controls to estimate selection effects, and to also rely on matching methods to construct comparable treatment and control groups (to address endogeneity concerns) and difference-in-differences models to estimate treatment effects, in contrast to studies that analyzed a small group of companies (e.g., Vinodkumar and Bhasi, 2011; Lafuente and Abad, 2018[4]; Ghahramania and Salminen, 2019) or that provided little evidence that the two groups were reasonably similar (Abad et al., 2013).[5] Our larger sample size and rich set of controls enables us to both control for potentially confounding factors influencing the decision to become certified and identify a set of noncertified establishments sharing such characteristics to serve as our comparison group to estimate treatment effects.

3. Theory and hypotheses

As argued by King, Lenox and Terlaak (2005), management standards like OHSAS 18001 include two fundamental elements: they codify a set of standard practices, and they enable organizations to communicate the use of these practices via the certification system. These two theoretical elements suggest two ways that becoming certified to the OHSAS 18001 standard can relate to an organization's safety performance: (1) a selection effect, in which eventually-certified establishments may have differential initial (pre-certification) safety performance compared to those that do not eventually get certified, and (2) a treatment effect, where becoming certified may cause an

[2] Lafuente and Abad (2018) use a nearly identical sample as Abad et al. (2013) and find similar selection effects: 117 OHSAS adopters had higher injury rates than 32 non-adopting firms in their sample.

[3] While Lo et al. (2014) find that OHSAS 18001 is associated with improved "safety performance," they measure performance via compliance with safety regulations, not via injury rates.

[4] Our paper also differs from Lafuente and Abad (2018) regarding how we account for endogenous selection into OHSAS adoption. Whereas Lafuente and Abad (2018) use a Heckman selection model to account for endogenous selection into OHSAS adoption among 117 adopting firms compared to 32 non-adopting firms in Spain, we use a propensity-score matching method to construct a matched sample whose control group of non-adopting firms draws from a pool of tens of thousands of establishments. This large pool enables us to identify a set of matched controls that are balanced on baseline characteristics (as described below), increasing confidence that our control group represents a valid counterfactual for adopting establishments.

[5] Lo et al. (2014) also construct a matched sample to estimate the effect of firm-level OHSAS certification on OSHA compliance violations, a different outcome from the injuries that we examine. However, for logistical reasons they do not include safety measures in their set of variables used to create the matched sample. Since those establishments that get OHSAS certified likely already have different safety performance than average (which we show in this paper is indeed the case), this omission makes it difficult to know if the control establishments in their paper serve as an appropriate counterfactual for certified establishments.

improvement in establishments' safety performance.

3.1. Will safer establishments adopt safety management system standards?

Stakeholders can seldom perfectly observe whether establishments have adopted certain safety practices and procedures—a type of "information asymmetry" that can be harmful to all parties of a transaction (Akerlof, 1970). Because stakeholders cannot directly observe establishments' safety performance, being certified to the OHSAS 18001 standard might enable establishments to convey to stakeholders their superior safety performance. Spence's (1973) seminal paper described an information asymmetry problem whereby employers, lacking information on job applicants' productivity, could rely on a college degree as a credible signal of productivity. This held because the cost of earning a degree was lower for more-productive individuals, which led to a positive selection effect to attend and graduate college. As a result, even if college did not improve their productivity, college applicants' higher productivity would be signaled to the job market by their college degree.

How might this model help understand differences in *ex ante* safety performance among adopters of the OHSAS 18001 standard? First, extensive evidence suggests there is widespread information asymmetry between firms and their stakeholders regarding occupational safety performance. There is little to no publicly available information about firms' safety performance: whereas firms are required to publicly disclose some aspects of their environmental performance, such as releases of toxic chemicals through the U.S. Toxic Release Inventory (Doshi et al., 2013), there is no requirement that firms disclose their rates of injuries or other measures of safety performance. Workers have imperfect information about the hazards associated with particular jobs or workplaces (Viscusi and O'Connor, 1984). Firms' compliance with U. S. occupational health and safety regulations rose substantially when OSHA begin publicizing firms' noncompliance (Johnson, 2020), suggesting that stakeholders were initially uninformed about firms' safety performance, and that firms recognized there were large costs to having their poor safety records publicly exposed. Given this environment, firms with relatively high safety performance would have a strong incentive to credibly signal their superior performance, if such a signal were available.

One factor that likely distinguishes firms with superior safety performances is the adoption of particular policies, procedures and controls. The presence of safety rules and procedures is highly predictive of workers' safety behavior (Vinodkumar and Bhasi, 2011) and accident rates (Mearns et al., 2003). Safety professionals overwhelmingly report that procedures like "reporting, cataloging, and investigating (near) accidents" and policies like safety training were the most effective types of interventions to improve safety performance (van Kampen et al., 2023).

Safety management systems like OHSAS 18001 codify and formalize these procedures, processes, and controls (Álvarez-Santos et al., 2018) that are associated with better safety performance. The OHSAS 18001 standard requires creating 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 (British Standards Institution 2020). Furthermore, since becoming certified to the OHSAS 18001 standard requires the adoption of the policies, procedures, and controls that are themselves associated with better safety performance, becoming certified offers a credible signal that a workplace has relatively high safety performance.

Collectively, this logic suggests that OHSAS 18001 certification would be a credible signal of superior workplace safety. Establishments that have already implemented some of the practices required for certification to the OHSAS 18001 standard will face lower costs to meeting the requirements for becoming certified. Because adoption of these policies and procedures itself is associated with superior safety performance, it follows that establishments that become certified will on average have relatively better initial safety performance.[6] Thus, we predict:

> Hypothesis 1 (H1): Establishments with superior occupational health and safety performance are more likely to become certified to the OHSAS 18001 Occupational Health and Safety Management System standard.

3.2. Will adopting safety management system standards lead to safer establishments?

Certification to the OHSAS 18001 standard requires establishments to adopt a set of practices very likely to lead to safety performance improvements. To be certified, establishments must implement a proactive, systematic approach to managing occupational health and safety, including identifying risks and developing and deploying safety policies and procedures to manage those risks, training programs to promote implementation of those policies and procedures, accident preparedness, and procedures to remedy nonconformities. Such training programs seek to heighten employee and managerial attention to health and safety practices and hazards (Ghahramani, 2016). The OHSAS 18001 standard also requires certified establishments to "implement, maintain and continually improve their organizational health and safety management system" (British Standards Institution, 1999). The standard uses the Plan-Do-Check-Act cycle to systematically improve performance, which encourages establishments 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) (British Standards Institution, 2013).[7]

The OHSAS 18001 standard's robust monitoring and sanctions system also likely ensures performance improvements. Certification determinations are made by accredited, independent third-party certification bodies and periodic recertification is required to confirm that all of the standard's elements continue to be met. If noncompliances, whether major or minor, are found, they must be fixed; failure to do so results in the loss of certification. This "substantive" management system standard—demanding specific health and safety practices with independent recertification—stands in contrast to "symbolic" self-regulatory programs such as the Responsible Care and Sustainable Slopes programs, which lack independent certification and have been shown to fail to stimulate improvement (King and Lenox, 2000; Rivera and De Leon, 2004; Christmann and Taylor, 2006).

While establishments that become certified may already have some

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[6] Terlaak and King (2006) make a similar argument that the adoption of the ISO 9001 Quality Management System Standard could be a credible signal of superior performance. This signaling works only if ISO 9001 disproportionately attracts companies with superior quality management practices in the first place because the implementation process would be less onerous for them "because they need to undertake fewer adjustments" (Terlaak and King, 2006: 582). Darnall and Edwards (2006) examined this effect in the context of environmental management and found that companies that had already implemented more environmental programs incurred lower costs in meeting the requirements of the ISO 14001 Environmental Management System Standard.

[7] 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" (British Standards Institution, 2013).

of these policies in place beforehand, it is plausible that certification to the standard leads to even greater improvement in performance. First, it is unlikely that an establishment had adopted every single one of these practices prior to becoming certified.

Second, and more generally, certification to the OHSAS standard could improve safety performance by reducing ignorance, enhancing incentives, and increasing the legitimacy of rules (Coglianese and Nash, 2020). OHSAS 18001 reduces employees' ignorance of safe and healthy work practices through the requirement that establishments develop and implement safety training programs, which safety professionals deem to be one of the most effective interventions to improve safety performance (van Kampen et al., 2023). The standard can bind organizations to focus on safety in the face of production rushes and earnings pressures that otherwise create incentives to shift resources away from safety performance (Caskey and Ozel, 2017; Charles et al., 2022). Finally, the company's certification to OHSAS 18001 lends legitimacy to actions that can improve safety performance by signaling to employees that management values health and safety best practices.

In short, we predict that OHSAS 18001 certification will create a culture of workplace accountability that leads employees to engage in safer work practices, which will in turn lead to improved safety performance. We therefore hypothesize:

> Hypothesis 2 (H2): Being certified to the OHSAS 18001 Occupational Health and Safety Management System standard will lead establishments to improve their occupational health and safety performance.

4. Data and measures

4.1. Data

We obtained annual establishment-level injury data spanning 1995 to 2016, the most recent year available, from the U.S. Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses (SOII). Each year, BLS sends the SOII to nearly 230,000 establishments, randomly selected according to location, industry, and number of employees in order to provide a representative sample of U.S. establishments (U.S. Bureau of Labor Statistics, 2019). All private sector establishments that receive the survey are legally required to respond.[8] The final dataset comprises an unbalanced establishment-year panel, with the number of observations for any given establishment depending on the number of years it was surveyed. We accessed SOII data 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.

We signed data-sharing agreements with 10 major international certification bodies, all accredited by the ANSI National Accreditation Board (ANAB), which provides independent validation to ensure that they "demonstrate competence to audit and certify organizations conforming to management systems standards" (ANSI National Accreditation Board, 2022). We obtained from these certification bodies the name, address, and certification date of all 1,381 U.S. establishments that they had certified to OHSAS 18001 between 1995 and 2018, as well as data on certification to the ISO 9001 and ISO 14001 standards. Annual tallies of OHSAS 18001 certifications were never collected or published,[9] but assuming that these 10 certification bodies had the same 20-percent market share of OHSAS 18001 certifications in the U.S. as they did for the ISO 9001 and ISO 14001 certifications conducted in the U.S. during 2010–2016 (from comparing our data to the ISO Survey annual reports during that period), we estimate that roughly 6,900 OHSAS 18001 certifications occurred in the U.S. between 1995 and 2018. Furthermore, U.S. workplaces constituted 2.6 % of the world's ISO 9001 certifications and 1.4 % of the world's ISO 14001 certifications in 2020 (International Organization for Standardization., 2022b), and one of the certification bodies that provided us data indicated that U.S. workplaces constituted 2 % of their global OHSAS 18001 certifications in 2017. Thus, assuming that the U.S. market similarly represented just two percent of the world's OHSAS 18001 certifications, we estimate that as many as 345,000 OHSAS 18001 certifications would have occurred worldwide between 1995 and 2018. (By 2021, three years after ISO 45001 was launched to replace OHSAS 18001, 294,420 organizations had been certified, affecting 374,293 establishments (International Organization for Standardization., 2022c).)

We also obtained Dun and Bradstreet data from the 2014 National Establishment Time Series (NETS) Manufacturing Database, which includes all establishments that reported manufacturing as their primary industry and 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 standalone organization ("standalone" meaning it had no parent company, subsidiaries, or branch/division locations); whether it was foreign-owned, publicly owned (owned by a public company), and/or a government contractor; and the year it was established. (We used 2014 values for 2015–2016.)

Because the SOII, certification, and NETS datasets lack a common unique identifier, we linked establishments via their names and addresses using a combination of (a) fuzzy matching via matchit software and Stata's *reclink2* function, (b) geocode matching via ArcGIS, and (c) manual assessment. Of the 1,381 establishments certified to OHSAS 18001 in our certification data, we identified 578 that had records in SOII and 522 that had records in both SOII and NETS. Our final dataset spans 1995 to 2016, which represents the years for which we have data from SOII, the certification bodies, 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—namely, cases associated with (a) days away from work (*DAFW injury and illness cases*), (b) days of job transfers or restrictions (*DJTR injury and illness cases*), and (c) *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.

From the lists of certified establishments 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 *standalone* organization; *foreign owned*; *publicly owned*; and a *government contractor*. We created *establishment age* by subtracting the establishment's "first year" (from NETS) from the current year.[10]

[8] Below, we discuss how unlawful underreporting of SOII data might affect our results.

[9] Author conversation with BSI Group, May 2022.

[10] For 5.0% of the selection regression estimation sample, this measure of *establishment age* was a negative number, which might be due to measurement error in NETS (miscoding "first year") and/or our imperfectly matching SOII and NETS records. We recoded negative and missing values to zero. Our regression models use a version of this variable in which we recoded negative and missing values to 0 and included a dummy indicating when we had done so.

5. Empirical specifications and results

5.1. Selection model

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

We estimate the model depicted in Equation 1:

$$OHSAS_{i,j,t} = \alpha + \beta \times i\&i\ cases_{i,t\text{-}1\&2} + \gamma'\mathbf{X}_{it} + \delta_j + \delta_t + \varepsilon_{i,j,t}. \quad (1)$$

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 (*i&i cases* referring to *injury and illness cases*$_{i,t\text{-}1\&2}$) and a vector of controls ($\mathbf{X}_{it}$), as described below. We find similar results (not reported) when we use the average of the prior five years instead of two years in order to account for sparsity of our data due to variable SOII sampling across years. We also include fixed effects for three-digit NAICS code industry dummies (δ_j) to account for potential differences in certification propensity across industries, and year dummies (δ_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 become certified to OHSAS 18001 given that they have more resources and have been found more likely to become certified to other management standards (Potoski and Prakash, 2005a; Levine and Toffel, 2010). We 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 and become certified to OHSAS 18001. We control for whether an establishment was (a) foreign owned because they might face more internal pressure to become certified in order to bridge intra-organizational information asymmetries, (b) owned by a public company because they might face different incentives than private companies to become certified, and/or (c) a government contractor which might face government customers prone to require suppliers be certified to standards.

We then substitute *all injury and illness cases* with (a) both of its components—*injury cases* and *illness cases*—and then, in another model, with (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 system standard, either of which might make it easier to become certified to OHSAS 18001 given some overlapping requirements, such as training recordkeeping and internal auditing. Moreover, implementing the requirements of ISO 9001 and OHSAS 18001 might result in complementary routines that make these standards more effective in improving quality and safety (Pagell et al., 2015) akin to complementarities found among ISO 9001 and ISO 14001 (Corbett and Kirsch, 2001).

Estimating this selection model (a) restricts our sample to establishments found in both the SOII and NETS datasets that had reported injury data in at least one of the prior two years and (b) excludes OHSAS 18001 certified establishments' annual observations after the certification year. The resulting estimation sample for our selection model is 107,513 establishments, including 279 certified to OHSAS 18001, for a total of 461,478 establishment-years. (To the extent that any of the establishment-year observations in our sample that we classified as noncertified were in fact certified by certification bodies other than those 10 that provided our certification data, that would represent a bias against a result.) Table 1 reports the selection model's summary statistics. The industry distribution and correlations are reported in Tables A-1 and A-2 in the Appendix.

Table 1
Summary Statistics of Selection Analysis Sample.

	Mean	Std. dev.
OHSAS 18,001 certified	0.0006	0.0246
All injury and illness cases †	1.42	1.30
DAFW 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

Notes. 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 DAFW 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 0. N = 461,478 establishment-years from 107,513 establishments.

† Averaged over the two years before the SOII survey year, then logged after adding 1.

5.2. Selection analysis results

We estimate our selection models using logistic regressions and report results in Table 2. We find a positive selection effect: establishments with fewer total injury and illness cases were more likely to pursue certification. The results of Model 1 indicate that each additional injury and illness case in the two years before certification was associated with a 21-percent decline in the odds that an establishment was certified to OHSAS 18001 (β = -0. 21, $p < 0.01$). We plot the predictive margins with 95-percent confidence intervals in Figure A-1, further illustrating that less-injurious establishments are more likely to become certified. Model 2 reveals that this relationship is driven entirely by injury cases (β = -0.27, $p < 0.01$); illness cases have no predictive power for OHSAS 18001 certification (β = 0.04, p = 0.67).

Model 3 results indicate that the 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 decreased the establishment's odds of pursuing OHSAS certification by 36 percent (β = -0.36, $p < 0.01$). We found, however, no evidence that the decision to pursue certification was affected by the less-serious cases with days of job transfer or restriction (DJTR) (β = 0. 02, p = 0.79) or by other injury or illness cases (β = 0.03, p = 0.96).[11] Models 4–6, which also control for ISO 9001 and ISO 14001 certification, yield nearly identical results.

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

[11] One possible reason why less-serious injuries do not predict OHSAS 18001 adoption is that they are more vulnerable to underreporting (Boden et al., 2010). If eventually-certified establishments have better reporting practices than noncertified ones, then they might *report* a larger share of their less-serious injuries to BLS than never-certified establishments, even if they *experience* fewer actual injuries.

Table 2
Selection Model Results Dependent variable: OHSAS 18001 certified.

	(1)	(2)	(3)	(4)	(5)	(6)
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)	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies (1997–2016)	Yes	Yes	Yes	Yes	Yes	Yes

Notes. Logistic coefficients, with standard errors clustered by establishment in brackets. *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. Missing values of *establishment age* were recoded to 0 and all models include a dummy variable indicating observations when this recoding occurred. N = 461,478 establishment-year observations of 107,513 establishments, including 279 OHSAS 18001 certified establishments.

† Averaged over the two years before the SOII survey year, then logged after adding 1.

** $p < 0.01$, * $p < 0.05$, + $p < 0.10$.

5.2.1. Robustness tests

Our selection results are robust to several plausible alternative specifications, including (a) a series of year × industry interaction terms to allow for the possibility that certification propensity varied over time differently across industries, (b) state dummies to account for regional differences that could affect certification propensity, and (c) a series of year × state interaction terms to allow for these state-level factors to vary differentially over time. These alternative specifications, reported in Table A-3 in the Appendix, yield results similar to our main results, alleviating this concern.

One potential concern of our selection model is that if, in the two years before certification, establishments preparing for certification make substantial safety improvements that yield fewer injuries and illnesses in those pre-certification years, we might be misinterpreting those improvements as a selection effect rather than a treatment effect. We therefore estimate a variation of Equation (1) using averages of an establishment's four- and three-year lagged values of injuries and illnesses rather than of their two- and one-year lagged values. (That is, we replace *injury and illness cases*$_{i,t\text{-}1\&2}$ with *injury and illness cases*$_{i,t\text{-}3\&4}$.) These models yield results, reported in Table A-4 in the Appendix, similar to our main results, alleviating this concern.

Overall, these results support Hypothesis H1: becoming certified to the OHSAS 18001 standard was indeed an indicator of superior safety performance. We next evaluate H2: whether being certified to the standard led to subsequent safety performance improvement.

5.3. Treatment effect analysis

Our identification strategy entails developing a matched sample to address potential endogenous selection into OHSAS certification and then estimating a difference-in-differences model to evaluate the extent to which being certified to the OHSAS 18001 standard had a causal effect on annual injury and illness cases.

5.3.1. Developing a matched sample

To yield a causal estimate of the effect of OHSAS certification, the difference-in-differences approach relies on an identifying assumption that the control group's post-certification average trend is a plausible proxy for the treatment group's if it had not become certified. To identify a set of non-certified establishments that plausibly satisfy this assumption, we use propensity-score matching to develop a matched sample that is balanced on observable baseline determinants of certification. This approach, used by others (e.g., Levine and Toffel, 2010, Fisher et al., 2021, Akturk and Ketzenberg, 2022), 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 certification and safety performance). While certified and non-certified establishments might differ in unobserved time-invariant ways (such as worker-management relations), our analysis accounts for such differences with establishment fixed effects in the difference-in-differences model. Certified and non-certified establishments might also differ in *time-varying* attributes, such as if the timing of OHSAS certification coincides with the commencement of exporting. We assume such attributes are not independently correlated with changes in injury rates. Furthermore, we show below that certified establishments do not exhibit differential pre-trends in injury rates relative to matched controls in the years leading up to certification, indicating that such time-varying unobservables are not a practical concern in our setting.

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 2 but with several key differences. First, because the SOII 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 subtallies 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, in order to avoid losing statistical power, we include even those SOII establishments that we could not link to NETS data. We therefore use NETS variables in which missing values are recoded to 0 (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 (see results in Table A-5 in the Appendix) and use predicted values as propensity scores. Restricting establishments found in SOII to those with non-missing propensity scores reduces the number of OHSAS 18001 certified establishments in our sample from 578 (Table A-6, Row 2) to 393 (Row 3).

To develop our matched sample, among certified establishments we focus only on those that also have at least one SOII record after their certification year—a restriction required to assess changes in safety associated with being certified. This restriction reduces our set of certified establishments from 393 to 274 (Table A-6, Row 4). When identifying potential matching candidates among noncertified establishments, we similarly restrict attention to those with at least one SOII record after the treatment establishment's certification year. We use propensity scores to conduct single-nearest-neighbor matching without replacement, conditional on exact matching on each treatment establishment's OHSAS 18001 certification year. This led us to identify 274 pairs of certified (treatment) and noncertified (control) establishments for the difference-in-differences model. Our results are robust to two alternative matching approaches, described below as robustness tests.[12]

These treatment and control establishments were from comparable industries: the two groups were balanced with 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 matching process by conducting t-tests to compare the matched treatments and controls along a wide array of covariates. None of the 26 covariates in the injury and illness matched sample exhibit statistically significant or economically meaningful differences between the treatments and controls (see Table A-7), a dramatic improvement over the imbalance of the full sample, for which there were statistically significant and qualitatively large differences for all variables (Columns 1–4). Table A-8 reports summary statistics for the matched sample used in the difference-in-difference analysis.

5.3.2. Evaluation model

We use the following difference-in-differences model to estimate the effect of being certified to OHSAS 18001 on establishments' injury and illness cases:

$Y_{i,t} = \beta_1\, OHSAS_{i,t} + \beta_2\, hours\ (\log)_{i,t} + \gamma_t + \tau_{i,t} + \alpha_i + \varepsilon_{i,t}$ (2).

$Y_{i,t}$ refers to establishment *i*'s 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*). Our primary independent variable of interest is $OHSAS_{it}$. For treatment establishment *i*, it is coded 1 for all years beginning with the year of certification to OHSAS 18001, and 0 before. For control establishments, it is always 0.

*Hours (*log) refers to *total hours worked* (log), which we control for in order to account for the possibility that treatment and control establishments might grow at different rates 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—the OHSAS 18001 certification year for each treatment establishment and its matched control—and all years thereafter. This acknowledges that other factors besides OHSAS 18001 certification 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.

We estimate our difference-in-differences models using fixed-effects Poisson regression and report standard errors clustered by establishment. We use Poisson regression instead of negative binomial regression because the former can include establishment fixed effects and is robust to overdispersion (Wooldridge, 2010), and it is well-suited to handle count variables with a mass of zeroes (Silva and Tenreyro, 2006). We use all available observations ranging from six years before to six years after the match year, recalling that the SOII data is unbalanced due to its sample varying every year.

5.4. Treatment effect results

5.4.1. Effects on all injury and illness cases

Model 1 in Table 3 reports our main estimates of the treatment effect of OHSAS 18001 certification on *all injury and illness cases*. We find that OHSAS certification reduces all illness and injury cases by 20 percent (β = -0.22, p < 0.01; incident rate ratio = 0.80).

Table 3
Difference-in-Differences Treatment Effects Analysis of OHSAS 18001 on Injuries and Illness Cases: Main Results.

	(1)	(2)	(3)	(4)
	All injury and illness cases	DAFW injury and illness cases	DJTR injury and illness cases	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]
Total hours worked (log)	1.005**	1.013**	1.099**	0.921**
	[0.068]	[0.149]	[0.089]	[0.076]
Establishment-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 (certified/ noncertified)	263 / 261	240 / 234	235/231	256/247
Mean dependent variable	20.7	4.7	8.5	8.7

Notes. Poisson regression coefficients, with standard errors clustered by establishment in brackets. *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. Sample includes all available observations ranging from 6 years before to 6 years after the match year.
** p < 0.01, * p < 0.05, + p < 0.10.

[12] In theory, our set of eligible controls could include some establishments certified to OHSAS 18001 by certification bodies not included in our certification dataset. However, in practice the risk of such contamination is low, as there are at most a few thousand establishments in the U.S. certified to OHSAS and we draw from over 1 million establishments in the SOII to identify our set of matched controls. Furthermore, even if such contamination occurs, it would only lead us to *underestimate* effects of certification.

5.4.2. Dynamic effects

The estimate in Column 1 of Table 3 could be difficult to interpret for two reasons. First, the estimate of β_1 from Equation (2) could be contaminated by pre-trends; that is, establishments that achieve OHSAS 18001 certification might already have had greater injury improvement trends than their matched controls, even before being certified. We view this risk as minimal in our setting, since our matching process ensured that the *level* of prior injury rates for our certified and matched noncertified establishments was balanced. Still, it is possible that the *trends* are imbalanced, even if the *levels* are not. Second, the estimate of β_1 from Equation (2) estimates a single average treatment effect over time, but these effects could be dynamic; that is, the safety benefits of OHSAS 18001 certification might take time to materialize or they might be short-lived if certification does not result in permanent changes.

We therefore create Equation (3) that amends Equation (2) to formulate an event-study specification that estimates the difference in injury rates between certified establishments and their matched counterparts for each year τ relative to the "focal year" (the certified establishment's year of certification):

$$Y_{i,t} = \sum\nolimits_{\tau\in\{-6,6\}} \beta_\tau OHSAS_i {}^* 1(t=\tau) + \beta_2 hours(log)_{i,t} + \gamma_t + \alpha_i + \varepsilon_{i,t} \quad (3)$$

where all comparable terms are defined in Equation (2), but here $1()$ is an indicator function and we let τ range from −6 to 6. Thus $1(t=\tau)$ is a series of 13 dummy variables indicating that an observation in year t is τ years relative to the focal year. If there is indeed a causal treatment effect of OHSAS certification on injuries, we expect β_τ to hover around 0 for $\tau < 0$. The magnitudes of the β_τ coefficients for $\tau \geq 0$ indicate the dynamic effects of certification over time.

Fig. 1 shows the estimates of the β_τ coefficients when estimating *all illness and injury cases.* To avoid collinearity, we drop two pre-period variables (τ = -1 and τ = -6) so that the coefficients are normalized relative to these years (Borusyak et al., 2023).[13] The pre-period coefficients all hover around 0, indicating that injury rates of certified establishments and their matched counterparts were not already on different trends, providing reassurance that our control group serves as a reasonable counterfactual for the treatment group. The coefficients in the post-period are all negative, grow in magnitude over time, and are mostly individually statistically significant.

5.4.3. Effects on various types of injury and illness cases

The remaining columns of Table 2 report how OHSAS 18001 certification affects injury and illness cases of different severity. Model 2 provides a point estimate indicating that OHSAS 18001 certification leads to a 19 percent decline in *DAFW injury and illness cases* (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 leads to a 24 percent decline in the less severe *DJTR injury and illness cases* (ß = −0.28, p < 0.01; incident rate ratio = 0.76). Model 4 indicates that certification leads to a 15 percent decline in *other injury and illness cases* (ß = −0.16, p = 0.06; incident rate ratio = 0.85). Thus, OHSAS 18001 certification reduces a range of injuries.

As a robustness check, we assess whether our results vary depending on the time window. Our primary approach is based on a window spanning six years before and six years after the match year. We reestimated the models reported in Table 3 on a narrower window (three years before and after the match year). The results, reported in Table A-9 in the Appendix, tend to show similar but sometimes slightly smaller effect sizes.[14] We find that OHSAS 18001 certification 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 after certification 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 the post-match addition or loss of such certifications might occur at different rates for our matched treatments and controls. The models in Table A-10 therefore add controls for ISO 9001 and ISO 14001 to the models in Table 3, yielding estimates very similar in magnitude and statistical significance to those of our primary models except that OHSAS 18001 certification has a larger and now statistically significant effect on *DAFW injury and illness cases*. Specifically, the results in Table A-10 indicate that, controlling for ISO 9001 and ISO 14001 certification, OHSAS 18001 certification leads to 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).

5.4.4. Robustness to alternative matching

Our treatment analysis is based on difference-in-differences regressions estimated on a matched sample of certified and noncertified establishments that was constructed using nearest-neighbor propensity score matching. To ensure our results were not driven by the particular matching strategy we employed, we constructed an alternative matching approach. In our main analysis, our logistic model that generated propensity scores (Table A-5) included variables from the SOII, certification, and NETS databases. For those establishments in the SOII database which we could not link to corresponding NETS records, we recoded those NETS variables from missing to 0; we did this to maximize the number of establishments eligible for matching, but it might have inadvertently created poor matches among those establishments missing NETS data. We therefore developed an alternative model to generate propensity scores that omitted all NETS variables. Doing so entails a tradeoff: while it ensures that all establishments' propensity scores are generated using the same set of fully-populated variables (the SOII and ISO certification variables), omitting NETS variables—some of which were statistically significant predictors of OHSAS 18001 adoption—-creates the risk that the resulting propensity scores are noisier estimates of the probability that an establishment adopts OHSAS 18001. This yielded a matched sample that is balanced on the SOII and certification variables (Table A-11, Panel A, part 1) but only partially balanced for the NETS variables (part 2), which is unsurprising given the former but not the latter were included in this alternative model that generated the propensity scores used to construct this alternative matched sample. That several of the NETS variables were balanced despite our excluding NETS from the propensity score model might be due to ISO 9001 and ISO 14001 certification being correlated with several NETS variables, as indicated in Table A-2 and in Levine and Toffel (2010). Estimating our difference-in-differences model on this alternative matched sample yields results (Table A-11, Panel B) that are very similar to our primary results (Table 3), indicating that our treatment results are robust to this

[13] While it is common to only drop one pre-period coefficient, Borusyak et al. (2023) show that normalizing by two baseline coefficients is necessary to avoid multi-collinearity.

[14] This smaller estimated effect using the shorter 3-year window is not necessarily surprising since, as we showed above in Section 5.4.1, the improvements in safety following OHSAS certification appear to grow in magnitude over time.

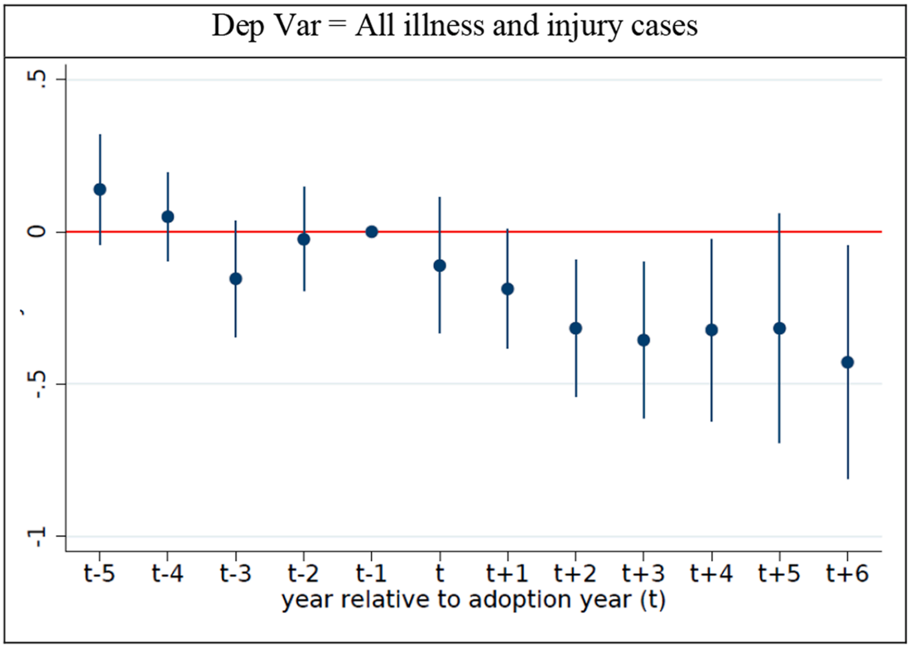

Fig. 1. Dynamic Effects of OHSAS 18001 Certification on Establishments' Injury and Illness Rates *Notes:* This figure shows coefficients and 95% confidence intervals from Equation (3). Each coefficient estimates the difference in total illness and injury cases between treatments (OHSAS-certified establishments) and their matched controls for each year relative to the match year (the treatment's certification year). The coefficients are normalized by years/t and *t-6.* See text for details.

alternative matching approach.

6. Discussion

We find that U.S. establishments that became certified to OHSAS 18001 tended to already be safer than comparable workplaces. Each additional injury and illness case was associated with a 21-percent decline in the odds that an establishment became certified to OHSAS 18001, and each additional case of the most severe type of injury and illness we studied—those resulting in days away from work—is associated with a 36-percent decline in the odds of becoming certified. This positive selection effect indicates that OHSAS 18001 certification is a credible signal of *ex ante* superior safety performance.

We also find that establishments certified to OHSAS 18001 subsequently became safer workplaces by reducing injuries to a greater extent than a matched set of noncertified establishments, revealing a treatment effect. OHSAS 18001 certification reduces the total number of illness and injury cases 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 the precision of this estimate was somewhat sensitive to specification.

6.1. Contributions

Our study is the first to directly examine the effects of the OHSAS 18001 standard on establishment-level safety performance using longitudinal injury and illness data and leveraging a sample large enough to let us identify appropriate comparison groups. Our results supplement other studies of the effect of OHSAS 18001 certification on regulatory compliance (Lo et al., 2014), accident rates (Abad et al., 2013), and financial performance (Yang et al., 2021). Our findings complement studies that found safety to be a spillover benefit of becoming certified to ISO quality management system standards. 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 some evidence that ISO 9001 quality standard certification increased California manufacturers' propensity to be injury free.

We also contribute 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 improve safety performance.

Our study also contributes to the literature on the effects of other management standards. Studies have found that becoming certified to ISO 9001 has (a) been rewarded by buyers and NGOs (Christmann and Taylor, 2002), (b) accelerated organizational growth (Terlaak and King, 2006), (c) led to improved financial performance and growth (Corbett et al., 2005; Terlaak and King, 2006; Levine and Toffel, 2010), and (d) led to improved regulatory compliance (Gray et al., 2015). Similarly, research has shown that becoming certified to ISO 14001 has reduced toxic chemical emissions and improved environmental regulatory compliance (Dasgupta et al., 2000; Potoski and Prakash, 2005a, 2005b), and that its pollution reduction effects can come at the expense of energy efficiency (Jeong and Lee, 2022). Our work complements studies analyzing OHSAS 18001, including Abad et al. (2013) and Lo et al. (2014), which relied on employee surveys or explored regulatory compliance (described below).

6.2. Managerial implications

Our finding that adopters of the OHSAS 18001 standard exhibit superior safety performance and that being certified to the standard further improves safety has important implications for four sets of managers: (1) corporate managers concerned about the safety of their subsidiaries, (2) managers of procurement and sustainable supply chain teams concerned about the safety of their suppliers, (3) managers of certification bodies, and (4) leaders of safety regulatory agencies. Managers in corporate headquarters who are responsible for ensuring their subsidiary operations are safe workplaces can rely on this knowledge that OHSAS 18001 certification is a credible indicator of superior average safety performance and that its adoption predicts above-average safety improvement. Managers in procurement and sustainable supply chain departments are responsible for ensuring that suppliers provide safe workplaces to reduce risks of business interruption and reputational harm from injuries, protests, and strikes. These managers can benefit by knowing that OHSAS 18001 certified suppliers are more likely to have superior—and improving—safety records. Our findings bolster the attractiveness of adopting safety management systems like OHSAS 18001 and its successor ISO 45001, and provide evidence to justify companies' efforts to encourage their suppliers to adopt these standards.

Our results also provide large-scale empirical evidence to bolster certification bodies' efforts to promote the effectiveness of safety management systems, efforts that to date have largely relied on anecdotal evidence. Finally, our results provide leaders of regulatory agencies like U.S. OSHA and its state-level counterparts with evidence they can use to more seriously consider whether to reduce scrutiny over OHSAS 18001 certified establishments and divert their scarce monitoring resources elsewhere.

6.3. Limitations and future research

Our study has several limitations. First, we were unable to test for mechanisms through which OHSAS certification led to fewer injuries. Qualitative studies can complement our work by revealing how implementing the practices required by management system standards actually changes how work is conducted, which our quantitative approach cannot do. Also, our analysis is limited to U.S. establishments; results might differ in Europe and Asia, where management system standard certification is especially prevalent. Future studies that focus on management system standards with many more certified establishments 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. Finally, our study relied on injury data that establishments self-report to BLS. While the establishments that BLS contacts are legally required to provide SOII data, there is some evidence that less-serious injuries are underreported (Boden et al., 2010). If OHSAS 18001 results in more managerial attention to reporting accuracy and thus less underreporting of less-serious injuries, our treatment effect results might *underestimate* the true impact of OHSAS 18001 on less-serious injuries (including *DJTR* and *Other* injuries).

Given that OHSAS 18001 is the basis for the new ISO 45001 Occupational Health and Safety Management Systems standard that was launched in 2018 and already adopted by more than 250,000 establishments—quickly becoming the world's third-most popular management system standard worldwide—our study provides promising evidence that this new standard will also prove effective in distinguishing safer workplaces. This new standard is structured to be more aligned and thus easier to integrate with other management system standards, such as ISO 9001 (quality) and ISO 14001 (environment), which could prompt many more companies to implement the management processes and procedures that OHSAS 18001 has specified—which our study has demonstrated led to improved workplace safety. ISO 45001 adds some requirements beyond what OHSAS 18001 stipulated, such as greater senior management engagement in health and safety, and a broader set of health and safety activities to promote a safety culture, such as conducting more-transparent accident investigations and incorporating safety into performance appraisal systems and recruiting efforts (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 time passes and sufficient post-certification safety performance data becomes available. Such data will also enable investigations of heterogeneous effects, akin to work on other management system standards (e.g., Lo et al., 2013).

7. Conclusion

Safety management system standards have been implemented by hundreds of thousands of companies around the world, yet it has remained unclear whether certified organizations exhibit better safety performance than others and whether being certified actually improves an establishment's own safety performance. Companies considering certification to an occupational health and safety management system standard have a clear interest in knowing whether it tends to improve safety. And companies that preferentially procure from certified establishments might do so based on the presumption that certification is a credible signal of safer workplaces that, in turn, might reduce the risk of disruption and reputation spillover due to sourcing from unsafe suppliers.

Our study examines the first health and safety management system standard that calls for implementing a set of best practices. Our results confirm that, when establishments became certified to OHSAS 18001, they were already safer workplaces—reporting fewer injuries and illnesses—than comparable establishments. Moreover, we find that certification led to subsequent safety improvement—significant declines in injury and illness—compared to a matched set of noncertified establishments. This finding is particularly important for managers given the enormous costs that occupational injuries impose on companies. Together, our finding both a selection effect and a treatment effect reveals that OHSAS 18001 certification is a credible indicator of superior average safety performance, an important insight for buyers interested in procuring from safer workplaces and regulators determining where to allocate scarce inspection resources.

These results have wide implications for thousands of companies around the world, including those certified to OHSAS 18001 and to its successor ISO 45001 and those considering seeking certification to the latter. Our results also have ramifications for both buyers and regulators, who now have credible evidence that OHSAS 18001 certification both signals superior *ex ante* health and safety performance and typically leads to further safety improvement.

Our study is also one of few that directly examine 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). Our results lend credence to those advocating management system standards as a tool to improve performance and provides encouragement to those that are creating and become certified to management system standards in other domains.

CRediT authorship contribution statement

Kala Viswanathan: Methodology, Data curation, Conceptualization, Formal analysis, Software, Writing – original draft, Writing – review & editing. **Matthew S. Johnson:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Michael W. Toffel:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Writing – original draft; Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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