

**Do Safety Management System Standards Indicate Safer Operations?
Evidence from the OHSAS 18001 Occupational Health and Safety Standard**

Online Appendix

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Table A-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	

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

Table A-2. Correlations of Selection Analysis Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) OHSAS 18001 certified	1.00														
(2) All injury and illness cases [†]	0.01	1.00													
(3) DAFW injury and illness cases [†]	0.01	0.83	1.00												
(4) DJTR injury and illness cases [†]	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	-0.10	-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

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. Missing values of establishment age were recoded to 0. N = 461,478 establishment-year observations from 107,513 establishments.

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

Table A-3. Selection Model Robustness Tests Results

Dependent variable: OHSAS 18001 certified

	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)	(1c)	(2c)	(3c)
		Include state fixed effects		Include year × industry fixed effects			Include year × state fixed effects		
All injury and illness cases†	-0.222** [0.072]			-0.218** [0.071]			-0.214** [0.073]		
All injury cases†		-0.279** [0.079]			-0.269** [0.078]			-0.271** [0.079]	
All illness cases†		0.031 [0.085]			0.015 [0.087]			0.034 [0.085]	
DAFW injury and illness cases†			-0.325** [0.099]			-0.361** [0.096]			-0.332** [0.100]
DJTR injury and illness cases†			0.008 [0.075]			0.029 [0.075]			0.015 [0.075]
Other injury and illness cases†			-0.031 [0.080]			-0.015 [0.080]			-0.02 [0.082]
Annual employment†	0.561** [0.074]	0.582** [0.074]	0.554** [0.073]	0.564** [0.072]	0.586** [0.071]	0.554** [0.069]	0.563** [0.075]	0.583** [0.075]	0.555** [0.073]
Establishment age	-0.006 [0.009]	-0.006 [0.009]	-0.005 [0.009]	-0.004 [0.009]	-0.005 [0.009]	-0.004 [0.009]	-0.005 [0.010]	-0.006 [0.010]	-0.005 [0.010]
Standalone	-0.384+ [0.210]	-0.387+ [0.211]	-0.384+ [0.210]	-0.339 [0.210]	-0.341 [0.211]	-0.339 [0.209]	-0.392+ [0.211]	-0.394+ [0.211]	-0.391+ [0.211]
Branch	0.295+ [0.163]	0.285+ [0.163]	0.283+ [0.163]	0.327* [0.160]	0.318* [0.161]	0.307+ [0.161]	0.296+ [0.163]	0.286+ [0.163]	0.282+ [0.164]
Publicly owned	0.684** [0.153]	0.671** [0.154]	0.682** [0.153]	0.685** [0.155]	0.675** [0.156]	0.681** [0.155]	0.694** [0.155]	0.682** [0.156]	0.692** [0.154]
Foreign owned	1.840** [0.152]	1.830** [0.152]	1.826** [0.152]	1.837** [0.152]	1.827** [0.152]	1.820** [0.153]	1.860** [0.153]	1.848** [0.153]	1.849** [0.154]
Government contractor	-0.077 [0.218]	-0.082 [0.219]	-0.077 [0.218]	-0.089 [0.215]	-0.093 [0.215]	-0.078 [0.215]	-0.089 [0.219]	-0.095 [0.220]	-0.088 [0.219]
Industry dummies (3-digit NAICS codes)	Yes	Yes	Yes				Yes	Yes	Yes
Year dummies (1997–2016)	Yes	Yes	Yes						
Year × industry dummies				Yes	Yes	Yes			
State dummies	Yes	Yes	Yes						
Year × state dummies							Yes	Yes	Yes

Notes. Logistic 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 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. Missing values of *establishment age* were recoded to 0 and all models include a dummy variable indicating observations when this recoding occurred. Since logit drops observations corresponding to fixed effects that perfectly predict failure and as the fixed effects get more granular, there are more observations that get dropped. Models 1A-3A: $N = 437,081$ establishment-year observations of 102,107 establishments, including 279 OHSAS 18001 certified establishments. Models 1B-3B: $N = 172,504$ establishment-year observations of 65,352 establishments, including 279 OHSAS 18001 certified establishments. Models 1c-3c: $N = 154,108$ establishment-year observations of 69,594 establishments, including 279 OHSAS 18001 certified establishments.

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

Table A-4. Selection Model Results Using Earlier Injury and Illness Cases

Dependent variable: OHSAS 18001 certified

	(1)	(2)	(3)
All injury and illness cases ♦	-0.178*		
	[0.073]		
All injury cases ♦		-0.169*	
		[0.079]	
All illness cases ♦		-0.065	
		[0.079]	
DAFW injury and illness cases ♦			-0.336**
			[0.094]
DJTR injury and illness cases ♦			0.101
			[0.078]
Other injury and illness cases ♦			-0.074
			[0.084]
Annual employment ♦	0.554**	0.567**	0.567**
	[0.079]	[0.079]	[0.078]
Establishment age	0.006	0.006	0.007
	[0.010]	[0.010]	[0.010]
Standalone	-0.608**	-0.603**	-0.606**
	[0.229]	[0.230]	[0.229]
Branch	0.25	0.252	0.228
	[0.162]	[0.163]	[0.162]
Publicly owned	0.808**	0.806**	0.792**
	[0.157]	[0.157]	[0.158]
Foreign owned	1.903**	1.899**	1.875**
	[0.154]	[0.154]	[0.155]
Government contractor	0.079	0.078	0.095
	[0.210]	[0.210]	[0.209]
Industry dummies (3-digit NAICS codes)	Yes	Yes	Yes
Year dummies (1997–2016)	Yes	Yes	Yes

Notes. Logistic 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 DAFW 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 = 409,820 establishment-year observations of 100,162 establishments, including 259 OHSAS 18001 certified establishments.

♦ Averaged over the third and fourth years before the SOII survey year, then logged after adding 1.

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

Table A-5. Logistic Regression Results of Model Generating Propensity Scores

Dependent variable: OHSAS 18001 certified

	(1)
Total injury and illness cases ♦	0.121* [0.058]
Total injury cases ♦	-0.132* [0.057]
Total illness cases ♦	-0.133* [0.056]
DJTR injury and illness cases	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)	Yes
Year dummies (1997–2016)	Yes

Notes. Logistic regression coefficients, with standard errors clustered by establishment in brackets. *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. Missing values were recoded to 0 for *establishment age*, *standalone*, *branch*, *publicly owned*, *foreign owned* and *government contractor* and the model includes corresponding dummy variables indicating observations when this recoding occurred. N = 3,277,417 establishment-year observations of 602,687 establishments, including 429 that became certified to OHSAS 18001.

♦ Averaged over five years before SOII survey year, then logged after adding 1.

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

Table A-6. Pipeline Table: Constructing the Primary Matched Sample

	OHSAS 18001 certified establishments		Noncertified establishments	
	N	<i>% of row above</i>	N	<i>% of row above</i>
1. Establishments certified to OHSAS 18001 in certification data	1,381			
2. And have any SOII data	578		2,187,431	
3. And with predicted propensity scores (uses values averaged over the prior five years)	393	68.0	602,653	27.6
4. And have SOII data in both pre- and post-periods	274	69.7	602,527	99.9
5. And that matched to one treatment or control establishment	274	100.0	274	0.05

Table A-7. Balancing Tests

	Sample eligible for matching (establishment-years in the sample to generate propensity scores)				Primary matched sample (establishment-year in the matched year)			
	Certified (mean)	Non- certified (mean)	Diff in means ♠	t-test p-value	Matched certified (mean)	Matched non- certified (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 (log) ♦	1.45	0.44	230%	0.00 *	1.49	1.45	3%	0.66
Other cases ♦	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
Establishment age	13.90	3.26	326%	0.00 *	14.59	15.65	-7%	0.13
Establishment age missing	0.12	0.81	-85%	0.00 *	0.09	0.07	25%	0.34
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
ISO 9001 certified, prior year	0.31	0.01	3000%	0.00 *	0.41	0.46	-13%	0.17
ISO 14001 certified, prior year	0.19	0.00	n/a	0.00 *	0.32	0.30	10%	0.46

Notes. This table reports variable means and p-values from two-sample t-tests comparing the means. The *sample eligible for matching* refers to the sample used to generate propensity scores. This includes all certified establishments' establishment-years between 2005 and their certification year (N = 2,474) and all noncertified establishments' establishment-years starting in 2005 (N=3,274,943). The *matched sample* columns report averages of the 274 certified establishments' observations and the 274 noncertified establishments' observations in their match year. The match year for the former (treatments) is their OHSAS 18001 certification year. The match year for each noncertified establishment (control) is the certification year of the treatment establishment to which it was matched. *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.

♦ Averaged over prior five years, then logged after adding 1.

♠ Difference in means is calculated as difference between the certified and noncertified establishments' means, divided by the latter's mean.

* p < 0.05.

Table A-8. Primary Matched Sample Summary Statistics

	Mean	Std. dev.
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

Notes. N = 3,295 establishment-years from 548 establishments (274 certified and 274 noncertified). Sample includes all available observations ranging from 6 years before to 6 years after the match year. 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 A-9. Difference-in-Differences Treatment Effects Analysis of OHSAS 18001 on Injuries and Illness Cases: 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** [0.059]	-0.167 [0.112]	-0.229** [0.085]	-0.146+ [0.075]
Log total hours worked	1.023** [0.097]	1.115** [0.145]	1.023** [0.134]	0.953** [0.098]
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)	2,028	1,840	1,834	1,979
Establishments (certified/noncertified)	239/235	208/200	209/197	232/223
Mean dependent variable	19.0	4.7	7.9	7.8

Notes. Poisson regression coefficients, with standard errors clustered by establishment in brackets. Estimated on the primary matched sample, using the narrower window of observations 3 years before through 3 years after the match year.
** p<0.01, * p<0.05, + p<0.10.

Table A-10. Difference-in-Differences Treatment Effects Analysis of OHSAS 18001 on Injuries and Illness Cases: Controlling for ISO Certifications

	(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, prior year	-0.232** [0.072]	-0.304* [0.136]	-0.271** [0.095]	-0.151+ [0.091]
Log total hours worked	1.007** [0.068]	1.015** [0.148]	1.095** [0.090]	0.919** [0.077]
ISO9k certified by prior year	0.029 [0.084]	-0.106 [0.109]	0.116 [0.121]	-0.037 [0.102]
ISO14k certified by prior year	0.02 [0.059]	0.229* [0.089]	-0.038 [0.082]	-0.017 [0.081]
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	8.4	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 DAFW 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.

Table A-11. Analysis of OHSAS 18001 on Injuries and Illness Cases: Alternative Matched Group

Alternative matched group created via nearest-neighbor matching of propensity scores generated from a model that omits the NETS variables from the primary specification reported in Table A-5.

Panel A: Balance Table

	Matched certified (mean)	Matched non-certified (mean)	Diff in means ♠	t-test p-value
Part 1: Variables included in alternative logistic regression model that generated propensity scores for this robustness test				
All injury and illness cases (log) ♦	2.18	2.26	-4%	0.44
All injury and illness cases ♦	16.03	17.88	-11%	0.43
DAFW injury and illness cases (log) ♦	1.00	1.01	-1%	0.91
DAFW injury and illness cases ♦	3.34	3.73	-11%	0.52
DJTR injury and illness cases (log) ♦	1.30	1.35	-4%	0.61
DJTR injury and illness cases ♦	6.16	6.16	0%	0.99
Other cases (log) ♦	1.49	1.57	-5%	0.35
Other cases ♦	6.53	7.98	-22%	0.20
All injury cases (log) ♦	2.07	2.13	-3%	0.54
All injury cases ♦	13.67	15.27	-12%	0.37
All illness cases (log) ♦	0.60	0.65	-9%	0.46
All illness cases ♦	2.35	2.60	-10%	0.76
Average annual employment (log) ♦	5.58	5.62	-1%	0.68
Average annual employment ♦	442.29	417.48	6%	0.57
ISO 9001 certified, prior year	0.41	0.41	-1%	0.93
ISO 14001 certified, prior year	0.32	0.29	10%	0.41
Part 2: Variables excluded from the alternative logistic regression model that generated propensity scores for this robustness test				
Establishment age	16.64	17.30	-4%	0.38
Standalone	0.16	0.22	-38%	0.14
Branch	0.64	0.56	13%	0.11
Publicly owned	0.39	0.38	1%	0.91
Foreign owned	0.44	0.26	41%	0.00 *
Government contractor	0.14	0.06	56%	0.01 *

Notes. This table reports variable means and p-values from two-sample t-tests comparing the means. In Part 1, the *matched sample* columns report averages of the 274 certified establishments' observations and the 274 noncertified establishments' observations in their match year. The match year for the former (treatments) is their OHSAS 18001 certification year. The match year for each noncertified establishment (control) is the certification year of the treatment establishment to which it was matched. *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. Part 2 reports comparisons of NETS variables that were omitted from the alternative logistic regression model used to generate propensity scores for this robustness test, for the subset of the matched group where both paired members have NETS data (N=180 pairs for all but age, where N = 172 pairs)

♦ Averaged over prior five years, then logged after adding 1.

♠ Difference in means is calculated as difference between the certified and noncertified establishments' means, divided by the latter's mean.

* p< 0.05.

Table A-11. (continued)

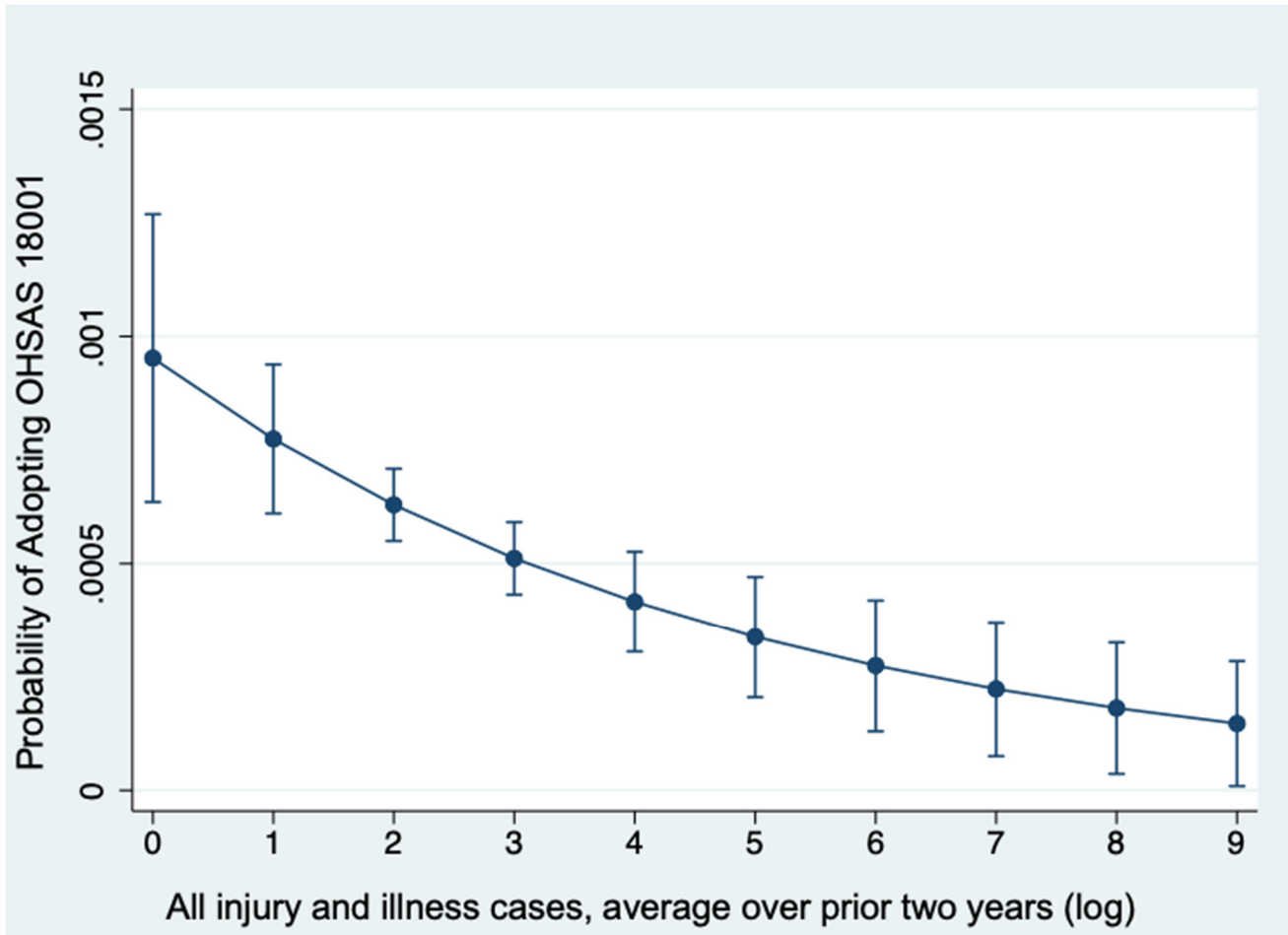
Panel B: Difference-in-Differences Treatment Effects Analysis of OHSAS 18001 on Injuries and Illness Cases: Alternative Matched Groups

	(A-1)	(A-2)	(A-3)	(A-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	-0.141+ [0.074]	-0.077 [0.130]	-0.210* [0.093]	-0.120 [0.088]
Log total hours worked	0.882** [0.075]	0.756** [0.128]	1.125** [0.106]	0.746** [0.095]
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)	3385	3234	3134	3321
Establishments (certified/noncertified)	263 / 262	240 / 241	235 / 232	256 / 253
Mean dependent variable	20.0	4.5	7.7	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 DAFW 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.

Figure A-1. Less-injurious Establishments Are More Likely to Become OHSAS 18001 Certified



This graph depicts predictive margins (with 95% confidence intervals) associated with the primary selection model reported in Model 1 of Table 2.