An impact evaluation of the Infrastructure Health and Safety Association Certificate of Recognition (COR™) program

Final Report

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Robert A Macpherson[1], Christopher B McLeod[1]

[1] Partnership for Work, Health and Safety, School of Population and Public Health, University of British Columbia, Vancouver, British Columbia

Partnership for Work, Health and Safety

www.pwhs.ubc.ca

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Ethics

This research was based on secondary use of administrative workers' compensation data from the Workplace Safety and Insurance Board (WSIB) and Certificate of Recognition (COR) audit and registration data from IHSA. The data were made available in accordance with the research agreements between the WSIB, IHSA, and the Partnership for Work, Health and Safety (PWHS) that governs the privacy and confidentiality conditions for use of the data for research purposes. The University of British Columbia Behavioural Research Ethics Board has provided research ethics approval for this research (certificate number H21-02492).

Disclosure statement

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Disclaimer

All inferences, opinions, and conclusions drawn within this publication are those of the authors, and do not reflect the opinions or policies of the data stewards.

Main research findings

- The effect of achieving Certificate of Recognition (COR) on firm-level injury rates was assessed using a matched difference-in-differences observational research design that compared COR firms to similar non-COR firms. The effect of certification was assessed for 2012-2019 overall, for 2012-2015 and 2016-2019, and by firm size (small versus large) and sector (construction versus other sectors).
- A comparable group of COR firms and non-COR control firms was identified using Coarsened Exact Matching applied to classification unit, firm size, year of assessment, and lagged lost time injury claim rate. The study sample comprised of 346 COR and 310 non-COR firms. Population averaged negative binomial regression with an exchangeable correlation matrix was used to estimate the intervention effect.
- On average, in any given year, participation in COR was associated with a 28% reduction in the lost time injury rate (IRR: 0.72; 95% CI 0.63-0.84), a 20% reduction in the high-impact injury rate (IRR: 0.80, 95% CI: 0.66-0.97) and no reduction in the no lost time injury rate (IRR: 1.00, 95% CI: 0.92-1.08), relative to the change in matched non-COR firms, after adjusting for differences in firm characteristics and year.
- The overall reduction in the lost time and high-impact injury rate was driven by more recently certified and larger COR firms, particularly construction firms.
- The results support the conclusion that COR certification is associated with lower firm-level injury rates but the strength of this association is dependent on context, such as firm size and industry.
- Firms with lower overall audit scores were associated with higher lost time and no lost time injury rates, especially firms scoring in the bottom two quartiles (91% or less).
- Firms scoring less than 100% on the following elements were associated with higher lost time injury rates: 2 (hazard assessment, analysis and control), 10 (investigations and reporting), 3 (safe work practices), 4 (safe job procedures), and 6 (personal protective equipment).

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List of acronyms and abbreviations

Acronym/Abbreviation	Description
BC	British Columbia
BCCSA	BC Construction Safety Alliance
CAD-7	Council Amendment to Draft #7 (construction industry experience rating plan)
CEM	Coarsened Exact Matching
CFCSA	Canadian Federation of Construction Safety Associations
CI	Confidence interval
COR	Certificate of Recognition
DiD	Difference in differences
FTE	Full-time equivalent
GEE	Generalised estimating equation
IHSA	Infrastructure Health and Safety Association
IRR	Incidence rate ratio
JHSC	Joint health and safety committee
MAP	Merit Adjusted Premium Plan
NAICS	North American Industrial Classification System
NEER	New Experimental Experience Rating Plan
OHS	Occupational health and safety
OHSMS	Occupational health and safety management system
PWHS	Partnership for Work, Health and Safety
RTW	Return-to-work
SECOR	Small employer Certificate of Recognition
WSIB	Workplace Safety and Insurance Board

Introduction

The Certificate of Recognition (COR) is a voluntary, audit-based certificate program offered by occupational health and safety (OHS) organisations across Canada for the purposes of promoting and acknowledging good workplace health and safety practice. Impact evaluations of COR show that firms becoming COR certified experience greater reductions in their injury rates compared to the change observed in similar non-certified firms over the same period of time (Macpherson et al., 2021; McLeod et al., 2019, 2018, 2015). However, the level of effectiveness varies by injury type, time period, sector, type of COR certification, and certifying partner. Research has also shown that firms scoring higher on their overall audit and element scores are strongly associated with lower firm-level injury rates (McLeod et al., 2018, 2020).

In Ontario, the Infrastructure Health & Safety Association (IHSA) is the only organisation with the authority to grant COR. COR was first introduced in Ontario in 2012 and is a pre-bid requirement for many contracts for both public and private sector construction projects. In contrast to other provinces, the IHSA COR audit tool includes more elements (19 compared to 14) and a higher score threshold to pass each element (65% or above compared to 50% or above) (IHSA, 2015) (Appendix 1).[1] Furthermore, while some other provinces offer a small employer COR (SECOR) or Small COR that does not require external auditors for certification, maintenance or recertification audits, all baseline and recertification audits for IHSA COR require an external auditor. Given the growth and investment in the COR program in Ontario, and the differences in the program and audit tool compared to other provinces, this project set out to address the following objectives:

(1) To determine if COR is associated with lower firm-level injury rates when compared to similar firms
(2) To examine whether there is an association between the overall COR audit scores and audit element scores and firm-level injury rates[2]

[1] As of October 1, 2022, all new external audits will be completed using the 14-element COR™ 2020 audit tool.

[2] The original second objective of this project was "To examine whether there is an association between the overall COR audit scores and audit element scores and changes in firm-level injury rates (year over year)". However, due to small sample sizes – more specifically, too few COR firms with multiple COR cycles to observe changes in external audit scores over time – it was not possible to conduct the appropriate analytical method to address this objective.

Methodology

Evaluation approach

To address objective 1, this study used a matched difference-in-differences (DiD) research design to identify the intervention effect of COR certification on firm-level injury rates (see Macpherson et al., 2021; McLeod et al., 2019, 2018). This approach compares changes over time in a group without the program intervention and attributes the "difference-in-differences" to the effect of the program by accounting for difference in the baseline or pre-intervention level of the outcome. DiD can provide an unbiased effect estimate of the intervention if changes over time between the control and intervention group would otherwise have been the same in the absence of the intervention.

Matching

The COR program is largely voluntary and firms self-select into the program by design. As a result, firms are not randomized and interpretation of program outcomes from DiD analysis may be incorrect if the study groups are not comparable, given that changes over time in the outcome may differ independently from the intervention. Inspection of the baseline characteristics of COR and non-COR firms showed that COR firms were, on average, larger, in higher risk industries or sub-sectors, registered with the WSIB longer and had lower lost time injury rates. To balance COR and non-COR firms on observable characteristics, Coarsened Exact Matching (CEM) was used (Blackwell et al., 2009). COR firms were matched with non-COR firms on the following four characteristics during their first year of COR: industry classification unit, firm size, year, and pre-baseline lost time injury rate (lagged three-year average). A multivariate imbalance measure of covariate combinations was used to select the most effective matching attributes.

Statistical model

Matched DiD multivariable regression analysis was conducted to assess the impact of COR certification on firm-level injury rates. Population-averaged (generalised estimating equation [GEE]) negative binomial regression with an offset of the log of the full-time equivalent employees (FTEs) was chosen for its ability to estimate over-dispersed count data (i.e., the presence of many zero injury counts and few extreme high injury counts) and to account for correlation across years at the firm-level.

Three separate work-related injury claim rates were analysed: 1) lost time claims, 2) high-impact claims and 3) no lost time claims. A lost time claim is created when a worker suffers from a work-related injury/disease which results in: being off work past the day of accident, loss of wages/earnings, or a permanent disability/impairment. High-impact claims are allowed lost time claims that have large health and financial impacts on employees and businesses: low back, shoulder, and fracture claims (Workplace Safety and Insurance Board, 2022a). No lost time claims are defined as accepted claims from work-related injury where no time is lost from work, other than on the day of accident, but where health care is required. The health care costs resulting from the injury are paid by the WSIB. The effect of certification on the three firm-level injury rates was estimated: 1) overall (2012-2019); 2) by time period (2012-2015 and 2016-2019); 3) by firm size (small versus large); and, 4) by sector (construction versus other sectors). Models were adjusted for a series of firm-level characteristics to balance the differences in injury risk between COR and non-COR firms across time. A full list of the dependent (injury outcomes), intervention and independent (controls) variables are included in Table 1.

To address objective 2, the distribution of overall audit scores and element scores for all passed external audits were explored before using multivariable, population-average negative binomial regression models to examine the association between overall audit score (quartiles) of COR firms with all three firm-level claim rates, as well as the associations between firms with less than 100% (versus 100%) for each of the 19 separate elements and lost time claim rates. A full list of the dependent (injury outcomes), and independent variables are included in Appendix 2. Sensitivity analyses were also conducted whereby differing scores for high variation elements were compared (100%, 80-99%, 65-79%) as well as the number of sub-elements without a maximum score within each element (0, 1, 2+).

Table 1 Variables used in the statistical models of objective 1

Dependent variables	Description
Lost time claim	Claims from a work-related injury/disease which results in: being off work past the day of accident, loss of wages/earnings, or a permanent disability/impairment
High-impact claim	Lost time claims that have large health and financial impacts on employees and businesses: low back, shoulder, and fracture claims
No lost time claim	Claims from work-related injury/disease where no time is lost from work, other than on the day of accident, but where health care is required
Intervention variables	**Description**
Baseline	Controls for differences in baseline risk between control and intervention firms
Intervention	Captures the intervention effect of COR participation
Independent variables	**Description**
NAICS class/subclass*	10 categories indicating the primary sector/sub-sector of business
Firm size	7 categories indicating the firm size (at the WSIB account level) for each study year: 1-4 full-time equivalent employees (FTEs), 5-9 FTEs, 10-19 FTEs, 20-49 FTEs, 50-99 FTEs, 100-499 FTEs, 500+ FTEs
Firm years	4 categories indicating the years of operation at the level of the WSIB account: <5 years, 5-9 years, 10-19 years, 20+ years
Premium rate adjustment	3 categories indicating whether the firm received an industry premium surcharge, discount, or no adjustment
OHS program	Binary variable indicating whether the firm was participating in one of the following WSIB OHS programs: Small Business, Safety Groups, Workwell, Health and Safety Excellence
Province	Binary variable indicating whether the firm head office was located in Ontario or elsewhere
Year of assessment	12 categories from 2009 to 2020, indicating the year of assessment

Note: * Classification unit (54 categories) was used for matching whereas NAICS class/subclass was used for statistical models.

Study data and cohort definition

Study data

WSIB data included firm and claim-level data for the years 2009 to 2020. IHSA data included COR registration, COR audit-level, element-level and sub-element data extracted from their Calvin database. Firm and claim-level WSIB data were linked to create a dataset at the level of the account-year (firm-year). In contrast to previous COR evaluations that have been conducted at the level of the account-industry-year, WSIB data available for this study was aggregated to the level of the account number. Therefore, firm characteristics such as classification unit, NAICS, rate group were assigned based on the account classification unit with the largest insurable earnings. Meanwhile, insurable earnings, assessable payroll, and FTEs were summed to the level of the account number. Experience rating adjustments data were available at the account number, including dollar amount discounts/surcharges from Council Amendment to Draft #7 (CAD-7) program and New Experimental Experience Rating (NEER) program, and percentage change in insurance premiums according to the Merit Adjusted Premium Plan (MAP) (Workplace Safety and Insurance Board, 2022b). Another minor difference between the firm and claim-level data available for this study compared to previous studies was that it included only WSIB accounts that were still active in 2020.[3] While this data limitation meant this study could not evaluate COR for all COR firms, this excluded only a small number of COR firms and did not bias the results as it applied to both control and intervention groups.

Cohort definition

The study cohort for objective 1 was defined as all firms with WSIB accounts in classification units identified among COR-certified firms, with at least 1 FTE and positive insurable earnings for at least three consecutive years between 2009 and 2020. Firms that did not meet the criteria were excluded, as firms with short tenure with the WSIB would likely have been unable to achieve COR certification. In order to measure the first difference in the DiD model, the intervention group had to have an observable pre-intervention baseline. Therefore, the intervention group was defined as all

[3] 26 of 437 (5.9%) of COR firms with passed external audits in 2012-2019 were excluded as they were not registered with the WSIB in 2020. A separate data request for COR firms was requested and descriptive statistics of those firms suggest that they were similar to COR firms retained in the study (Appendix 3).

firms that first became COR-certified between 2012 and 2019. COR firms with no pre-COR baseline (yearly observations prior to their first year of COR) were excluded, as were COR firms with only one year of COR (firms first certified in 2020). The control group was defined as non-COR firms meeting the above conditions as shown in Table 2. The summary of firms by cohort restriction of objective 2 analysis is summarized in Table 3.

The study cohort for objective 2 was defined as all COR firms with WSIB accounts with at least 1 FTE and positive insurable earnings for the year of their passed external audit, and up to a maximum of 3 years per external audit, for the years 2012 and 2020 (see Table 3 for summary).

Table 2 Summary of firms by cohort restriction, objective 1 analysis

	COR	Non-COR
COR firms with passed external audits (2012-2019)	437	
COR firms linked to WSIB data extract	411	305,124
Firms with 3+ consecutive years of 1+ FTEs and insurable earnings	392	167,020
COR firms with pre-COR baseline and 2+ years of COR	390	
Non-COR firms in COR eligible classification units		41,994
Non-COR firms from organizations without COR		41,964
Non-COR firms with baseline 3-year moving average LT injury rate 0-10 per 100 FTEs		41,346
Matched	346	310*

Note: * As non-COR firms could be matched to COR firms more than once, 310 non-COR firms were matched during 346 non-COR firm-years.

Table 3 Summary of firms by cohort restriction, objective 2 analysis

	COR
Firms with passed external audits (2012-2020)	526
Firms with complete audit, element and sub-element data*	479
Firms linked to WSIB data extract	448
Firms with 1+ FTEs and insurable earnings for at least one year**	442 (606 audits)

Note: * Firms with COR equivalency certifications are automatically assigned 100% in the Calvin database. These firms and others with missing audit element and sub-element data were removed. 1 firm transitioned from the "Small business (2-4 workers) audit" to the "Standard (20+ worker)" audit. ** Firms required at least one year of 1+ FTEs up to a maximum of three years.

Results 1: Impact evaluation of COR participation on firm-level injury rates

Characteristics of the cohort

Prior to matching, COR firms were more likely to be classified in construction NAICS subclasses than non-COR firms (86% vs 73%) (Figure 1). COR firms were more likely to be large firms, with firms with 20+ FTEs making up (85% vs 10%) (Figure 2). COR firms made up increasingly larger proportions of the total number of firms as the firm size thresholds increased, representing one tenth, one fifth, and one third of all firms with 50-99 FTEs, 100-499 FTEs, and 500+ FTEs, respectively. Table 4 summarizes all of the baseline characteristics of COR and non-COR firms for the unmatched and matched cohorts. In addition to the differences in sector and firm size, COR firms were older, more likely to receive a premium rate discount, participate in WSIB OHS programs and have a head office outside of the province. Following matching, the observable baseline characteristics between COR and non-COR firms were balanced.

Figure 1 Sectoral distribution of COR and non-COR firms before and after matching

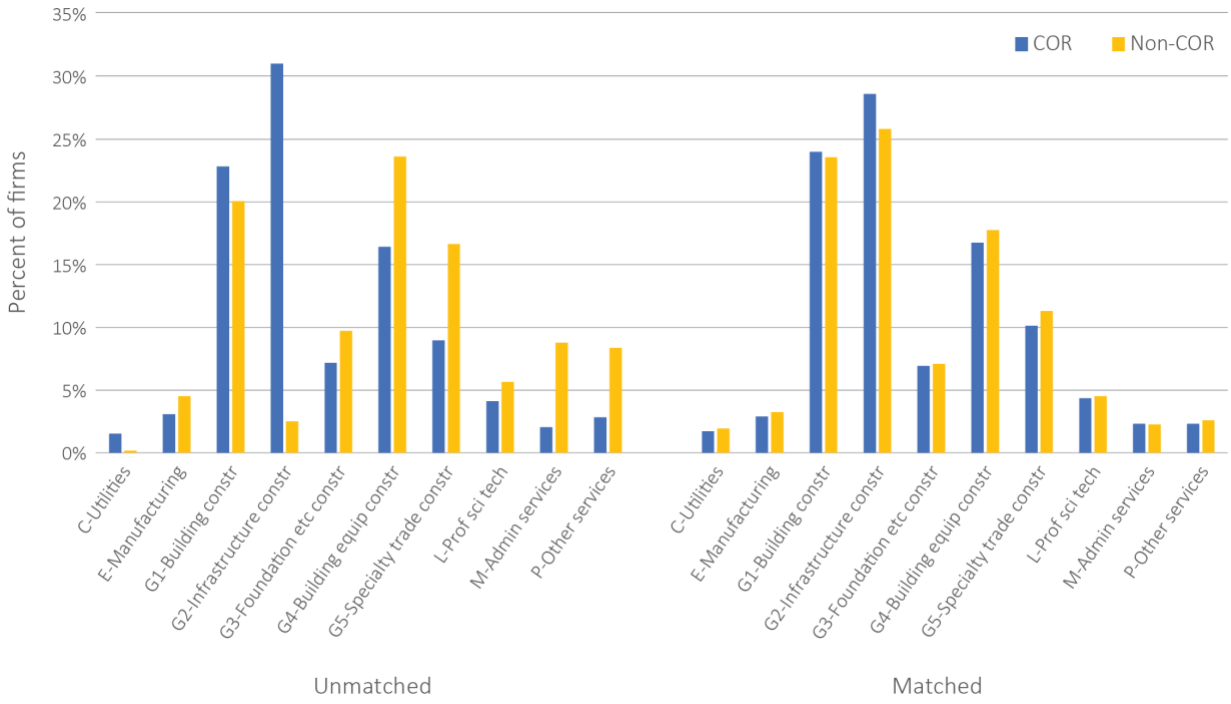


Figure 2 Firm size distribution of COR and non-COR firms before and after matching

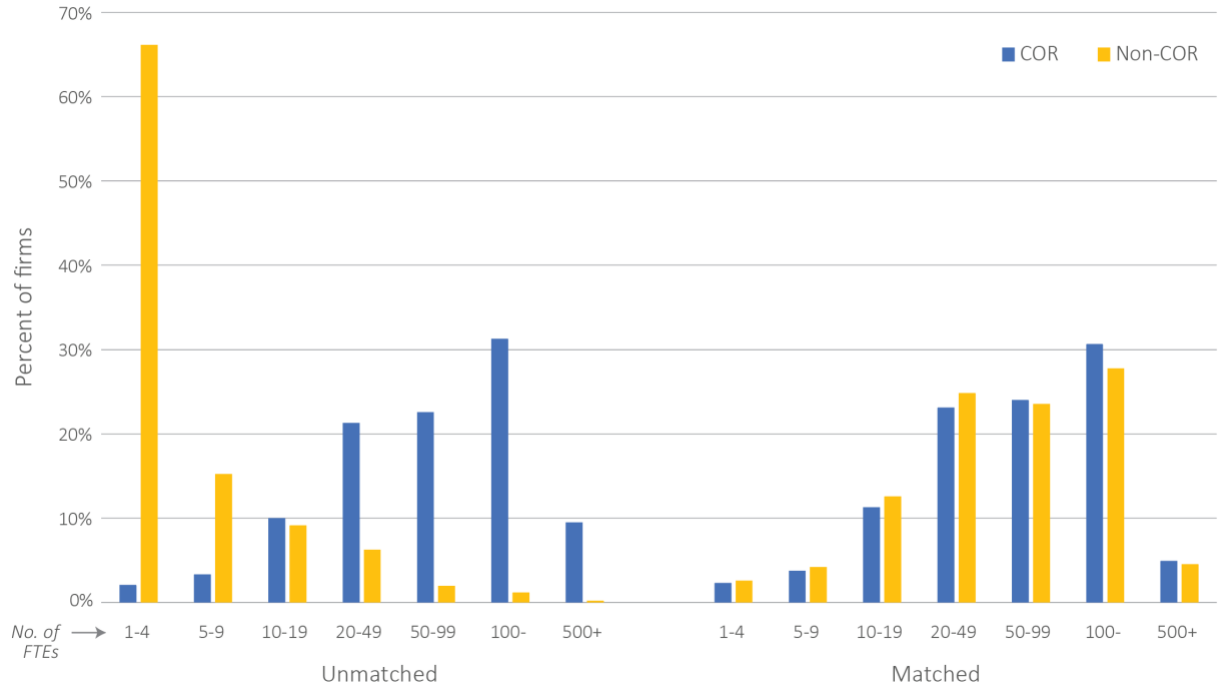


Table 4 Baseline characteristics of COR and non-COR firms, unmatched and matched cohorts

	Unmatched		Matched	
	COR	Non-COR	COR	Non-COR
NAICS class/subclass				
C: Utilities	1.5	0.2	1.7	1.9
E: Manufacturing	3.1	4.5	2.9	3.2
G1: Building construction	22.8	20.1	24.0	23.6
G2: Infrastructure construction	31.0	2.5	28.6	25.8
G3: Foundation, structure and building exterior construction	7.2	9.7	6.9	7.1
G4: Building equipment construction	16.4	23.6	16.8	17.7
G5: Specialty trade construction	9.0	16.6	10.1	11.3
L: Professional, scientific and technical	4.1	5.7	4.3	4.5
M: Administrative, services to buildings, dwellings and open spaces	2.1	8.8	2.3	2.3
P: Other services	2.8	8.4	2.3	2.6
Firm size				
1-4 FTEs	2.1	66.1	2.3	2.6
5-9 FTEs	3.3	15.2	3.8	4.2
10-19 FTEs	10.0	9.1	11.3	12.6
20-49 FTEs	21.3	6.2	23.1	24.8
50-99 FTEs	22.6	2.0	24.0	23.6
100-499 FTEs	31.3	1.2	30.6	27.7
500+ FTEs	9.5	0.2	4.9	4.5
Firm years				
<5 years	8.5	39.1	9.0	11.6
5-9 years	8.7	18.7	8.1	11.0
10-19 years	24.9	21.1	26.6	25.8
20+ years	58.0	21.1	56.4	51.6
Premium rate adjustment				
Surcharged	21.5	4.9	22.8	19.4
Unadjusted	4.4	41.0	4.9	8.4
Discounted	74.1	54.2	72.3	72.3
OHS program				
Yes	23.9	1.8	22.5	9.7
No	76.2	98.2	77.5	90.3
Province				
Ontario	89.7	96.7	90.5	93.6
Other	10.3	3.3	9.5	6.5

Note: Classes F (Transportation and warehousing), H (Wholesale), K (Finance, management and leasing) were grouped with class P (Other services) due to small sample sizes. Column percentages for COR and non-COR firms in the matched cohort are not identical due to some non-COR firms being eligible to match with multiple COR firms across different years.

Overall impact of COR participation

The main effect estimates of the matched DiD analysis for the three firm-level injury rates are presented in Table 5. The first coefficient represents the baseline difference in the injury rate between COR firms and non-COR firms. The second coefficient represents the intervention effect, or in other words, the change in the injury rate for COR firms, had they never been COR certified. Accordingly, the second coefficient, if the COR program is effective, will show a greater reduction (value of less than 1) in injury risk for COR firms when compared to the change over time for the non-COR firms. *It does not mean at any given time point COR firms have a lower injury risk, rather that COR certification leads to a greater reduction in injury risk.* The 95% confidence intervals indicate the precision of the estimates (confidence intervals overlapping with '1' indicate no difference).

The intervention estimates suggest that COR firms were associated greater reductions in the lost time and high-impact injury rates and no difference in the no lost time injury rate, compared to non-COR firms. More specifically, when COR firms participated in the program, the change in their lost time injury rate was 28% lower (IRR 0.72; 95% CI: 0.64-0.84), and their high-impact injury rate 20% (IRR: 0.80, 95% CI: 0.66-0.97), compared to the change among non-COR firms. Further, the estimates of the baseline indicator suggest that, following matching, the firms were no different than one another at baseline as the 95% confidence intervals overlapped with '1'.

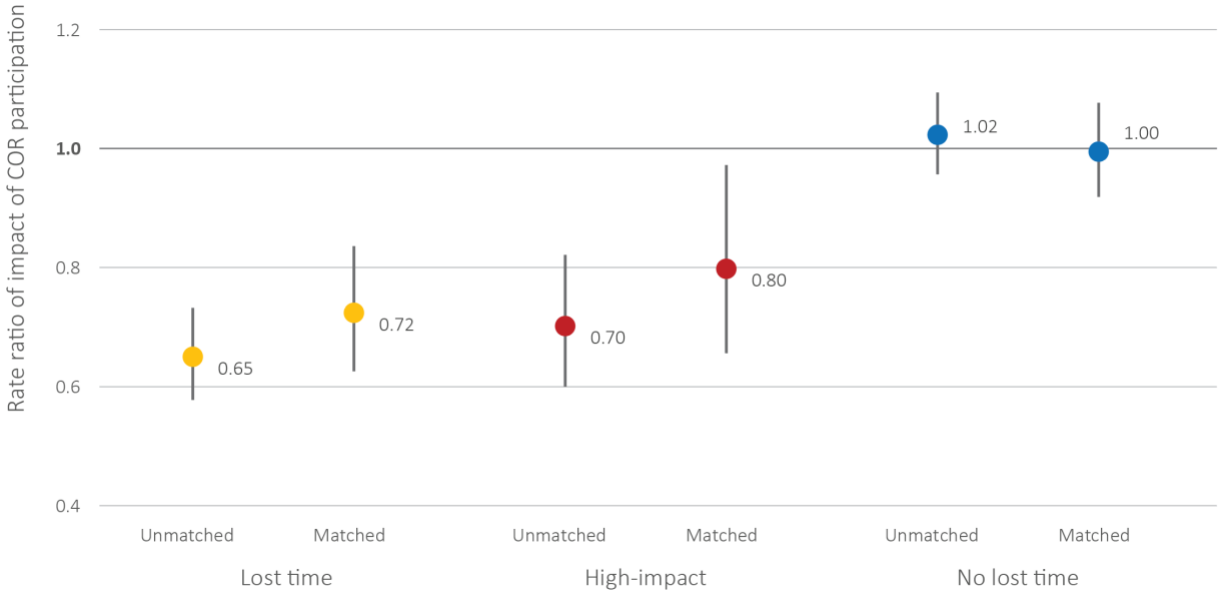
Figure 3 shows the main COR intervention effect for both the unmatched and matched cohorts and illustrates how, after matching on observable characteristics, the direction of the effect remained the same but the size and precision of effect was smaller. Subsequent figures focus on the matched results where the sample sizes provided estimates in which clear interpretations could be drawn.

Table 5. Negative binomial regression results for the matched cohort, lost time, high-impact, and no lost time injuries

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.75-1.03)	0.87	(0.74-1.03)	1.07	(0.94-1.22)
Intervention	0.72	(0.63-0.84)	0.80	(0.66-0.97)	1.00	(0.92-1.08)
Firm years	7,255		7,255		7,255	
Firms	656		656		656	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from fully adjusted, population-averaged models with offsets of logged FTEs, including non-COR firms and COR firms.

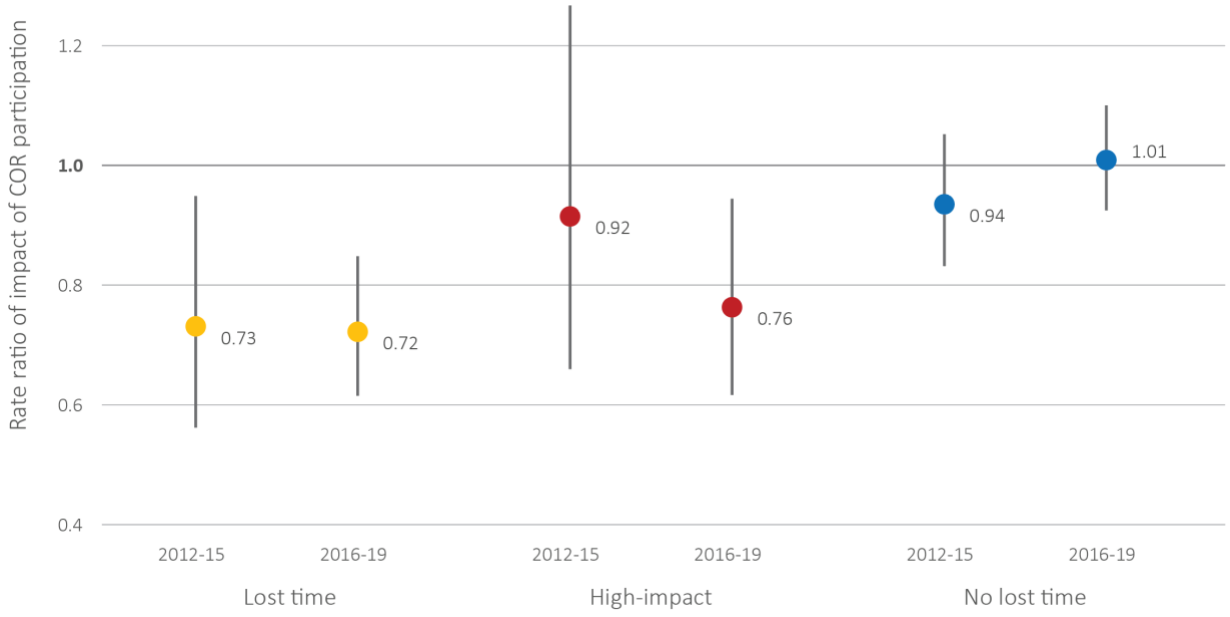
Figure 3 Overall effect of COR participation on firm-level injury rates, unmatched and matched cohorts



Impact of COR participation by time period

When comparing the effectiveness of COR across two separate time periods, there was very little change for lost time and no lost time injury rates (Figure 4). In terms of the high-impact injury rate, COR participation was associated with a larger and more precisely estimated reduction between 2016 and 2019.

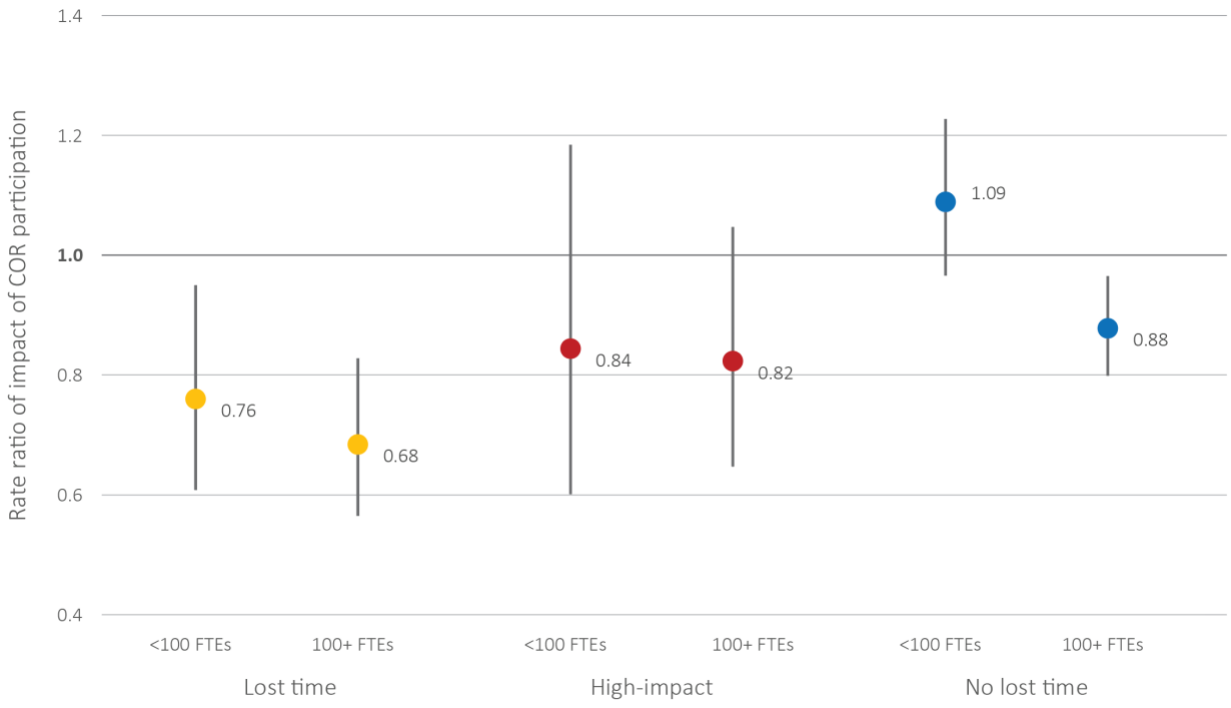
Figure 4 Effect of COR participation on firm-level injury rates of matched cohorts, by time period



Impact of COR participation by firm size

When stratifying the cohort by firm size, COR participation was associated with larger injury rate reductions for large firms (100+ FTEs) than small firms (<100 FTEs) (Figure 5). For lost time injuries, COR was associated with reductions of 24% among small firms and 32% among large firms, compared to the change in non-COR firms. The effect of COR participation among the high-impact injury rate did not differ between small and large firms but was only precisely estimated for the latter. There was no difference in the change in no lost time injury rate for small firms but a 12% reduction for COR firms with compared to non-COR firms among large firms. When using firm size thresholds used by the WSIB (small firms: <50 FTEs; medium firms: 50-99 FTEs; large firms: 100+ FTEs), the overall pattern of findings is the same (see Appendix 6).

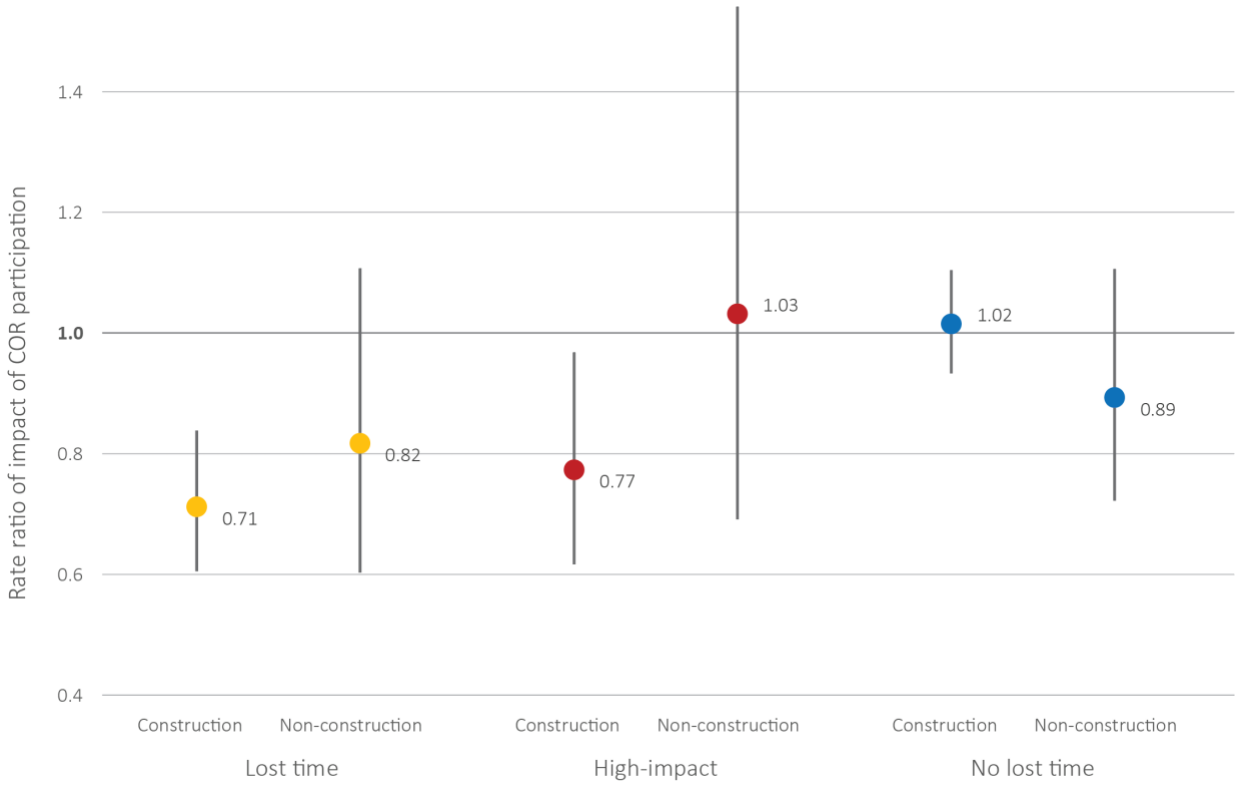
Figure 5 Effect of COR participation on firm-level injury rates of matched cohorts, by firm size



Impact of COR participation by sector

Stratifying the analysis by sector (Figure 6), the majority of the overall COR intervention was driven by construction firms whereas no effect was observed for non-construction firms.

Figure 6 Effect of COR participation on firm-level injury rates of matched cohorts, by sector

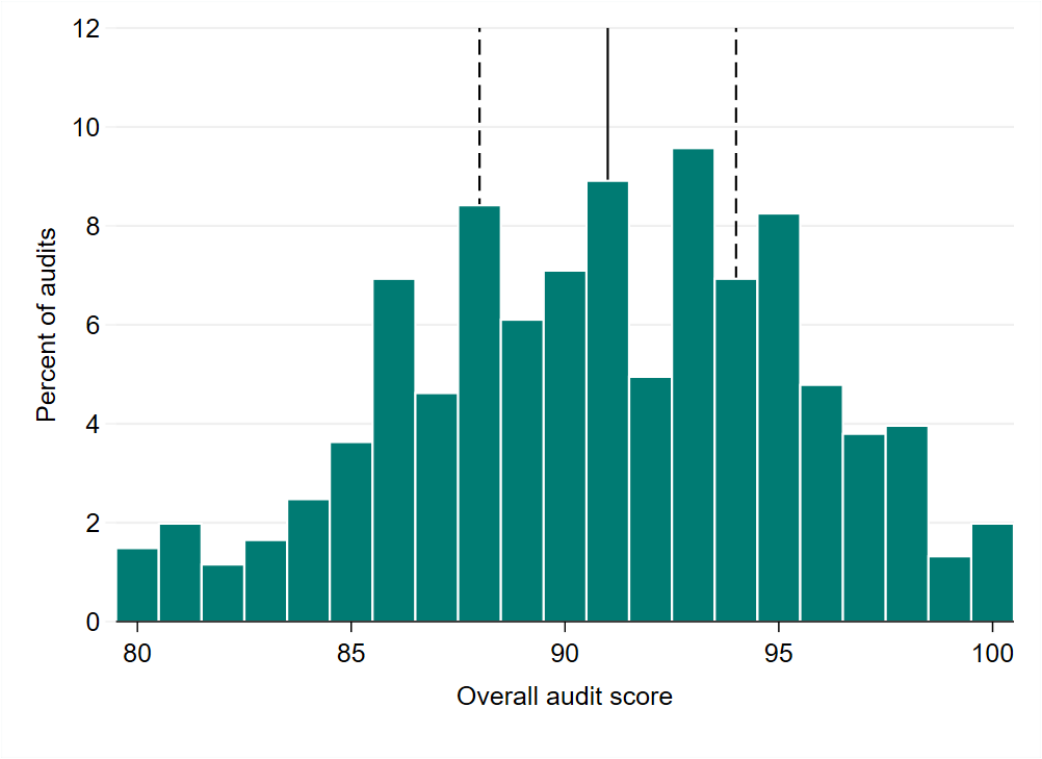


Results 2: Association between COR overall score and element scores and firm-level injury rates

Distribution of overall audit score

Figure 7 shows the distribution of the overall audit scores for COR firms with passed external audits. The audits scores displayed a natural distribution with a median overall audit score was 91% and the lower and upper quartiles were 88% and 94%.

Figure 7 Distribution of the overall audit score for firms with passed external audits, 2012-2020



Note: Solid vertical line indicates the median overall audit score. Dashed vertical lines indicate the overall audit score at the 25th and 75th percentiles, respectively.

Association between overall audit score and firm-level injury rates

Firms with lower overall audit scores were associated with higher no lost time and lost time injury rates, especially firms scoring in the bottom two quartiles (91% or less) (Figure 8). When repeating this analysis for construction firms (Figure 9), the overall findings were similar, albeit with larger effect estimates.

Figure 8 Effect of overall audit score on firm-level injury rates

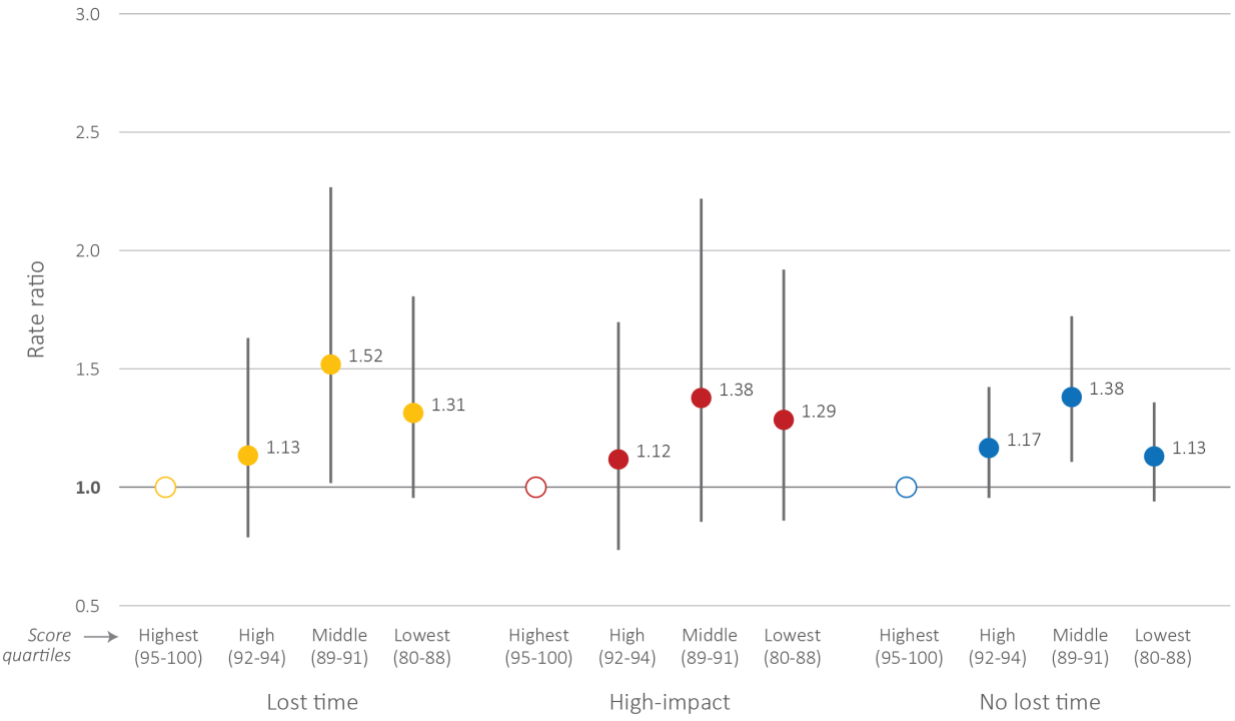
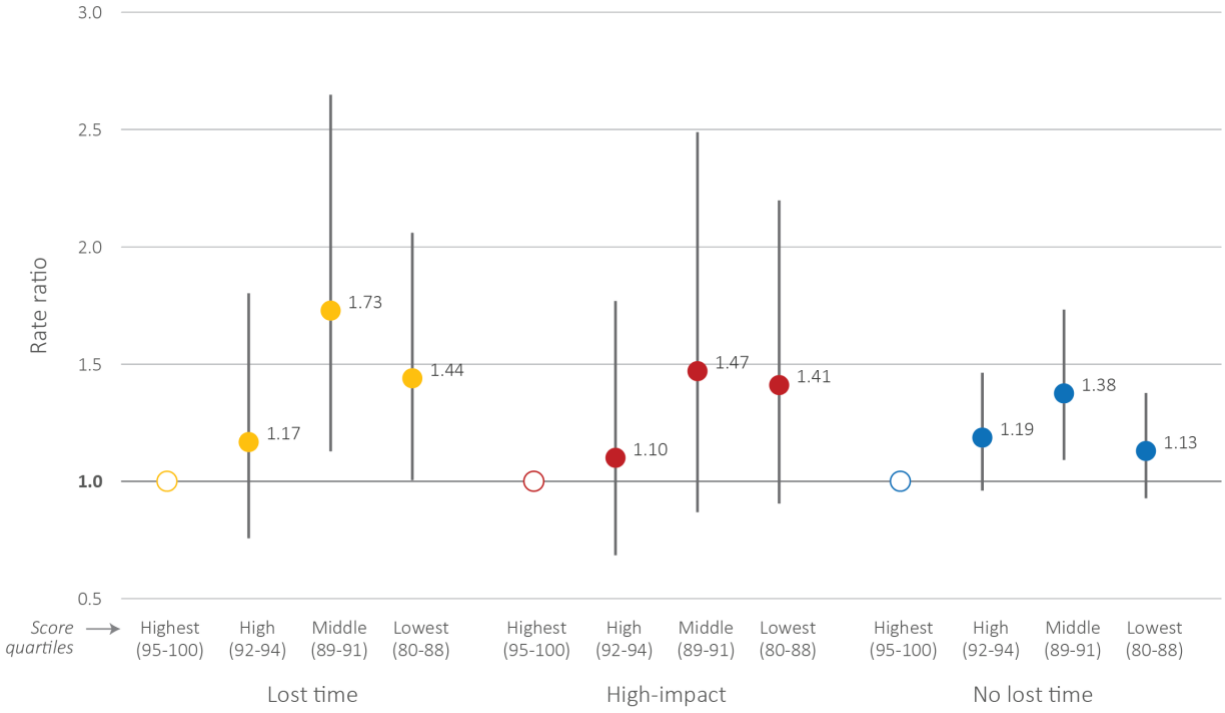


Figure 9 Effect of overall audit score on firm-level injury rates, construction sector



Distribution of audit element scores

Focusing on the 19 individual audit elements, the proportion whereby firm audits scored 100% ranged from as low as 9% for element 2 (hazard assessment, analysis and control) to 96% for element 16 (health and safety representative, and joint health and safety committee) (Figure 10). Using a threshold of 50% to distinguish between high and low score variation, 10 audit elements were identified as having high score variation: 2 (hazard assessment, analysis and control), 19 (management review), 11 (emergency preparedness), 3 (safe work practices), 10 (investigations and reporting), 4 (safe job procedures), 14 (occupational health), 8 (training and communications), 7 (preventative maintenance), 12 (statistics and records). The distribution of element scores for each of the high variation elements are shown in Figure 11, whereas and low variation elements in Figure 12.

Figure 10 Distribution of audit achieving scores of 100% on each audit element, external audits, 2012-2020

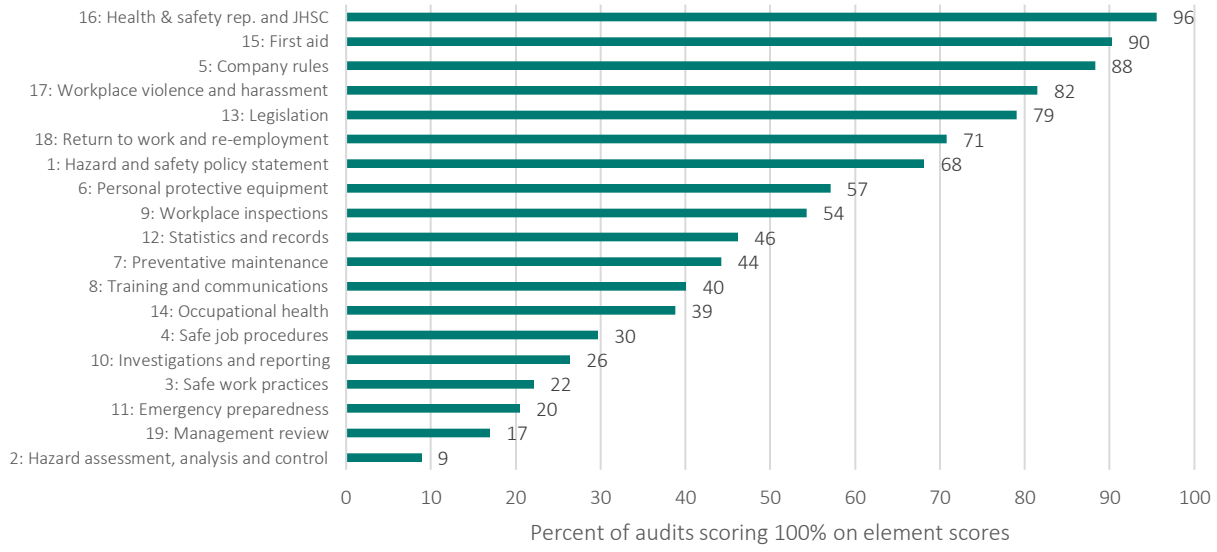


Figure 11 Distribution of element scores with high score variation

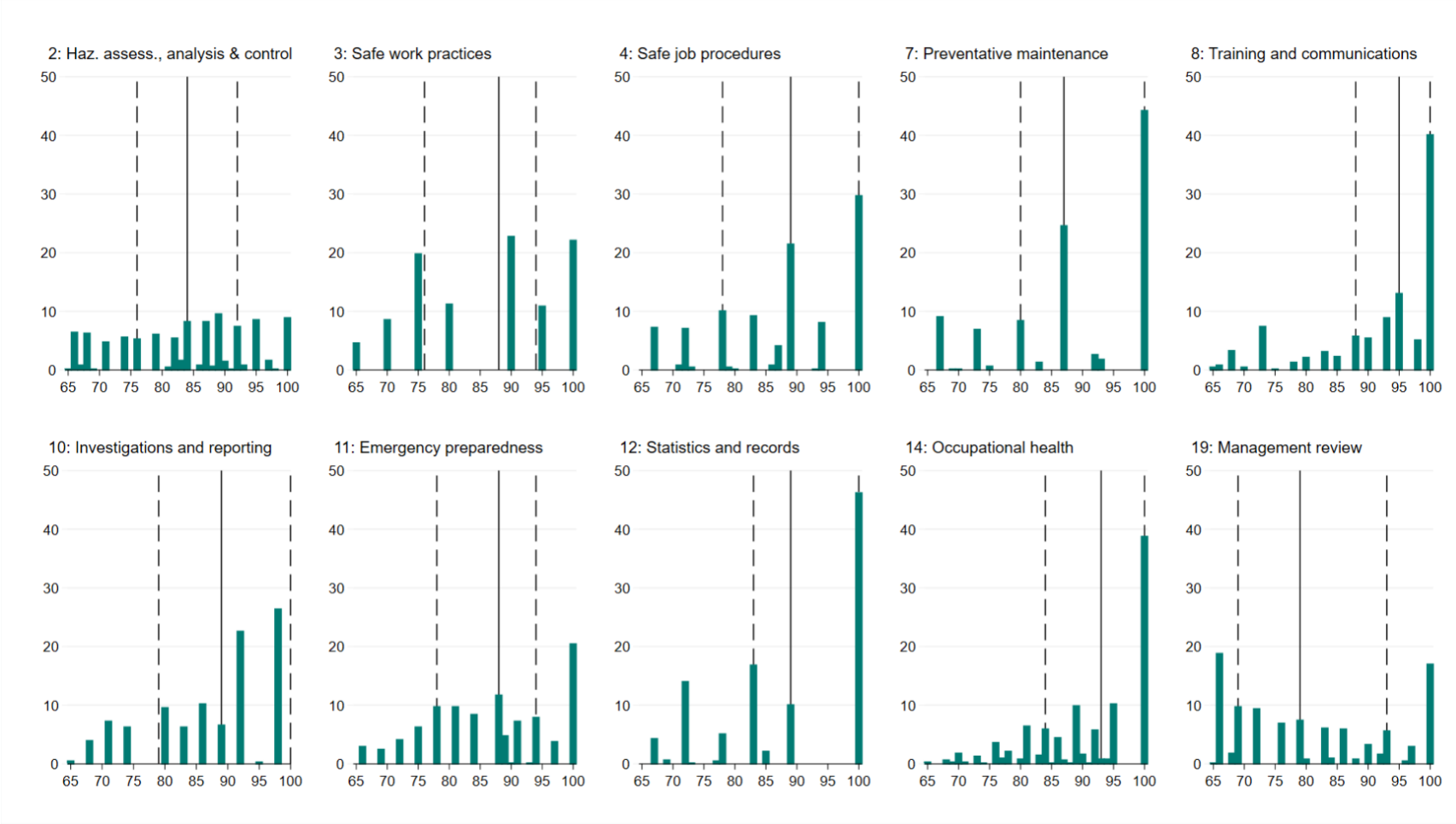
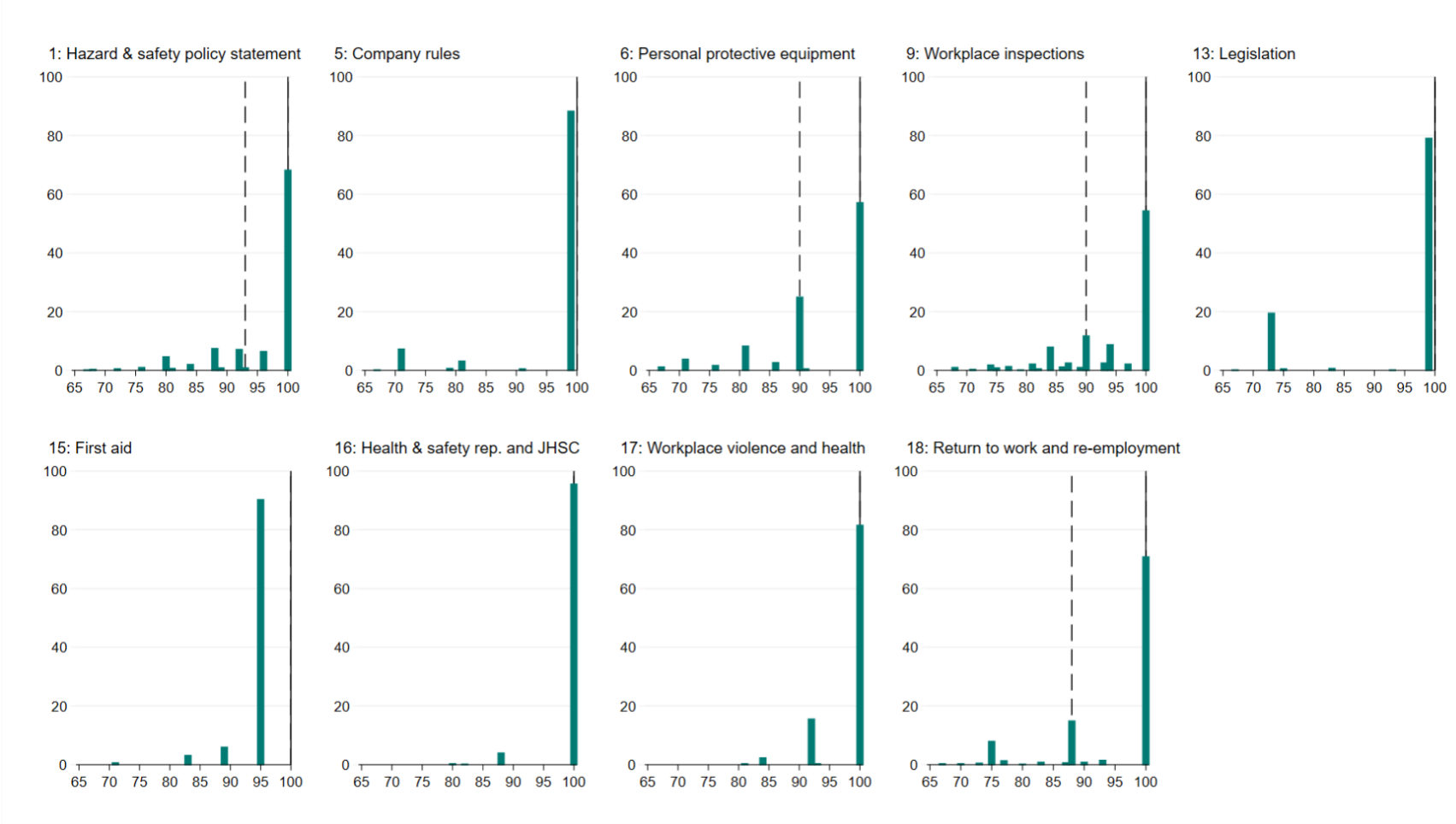


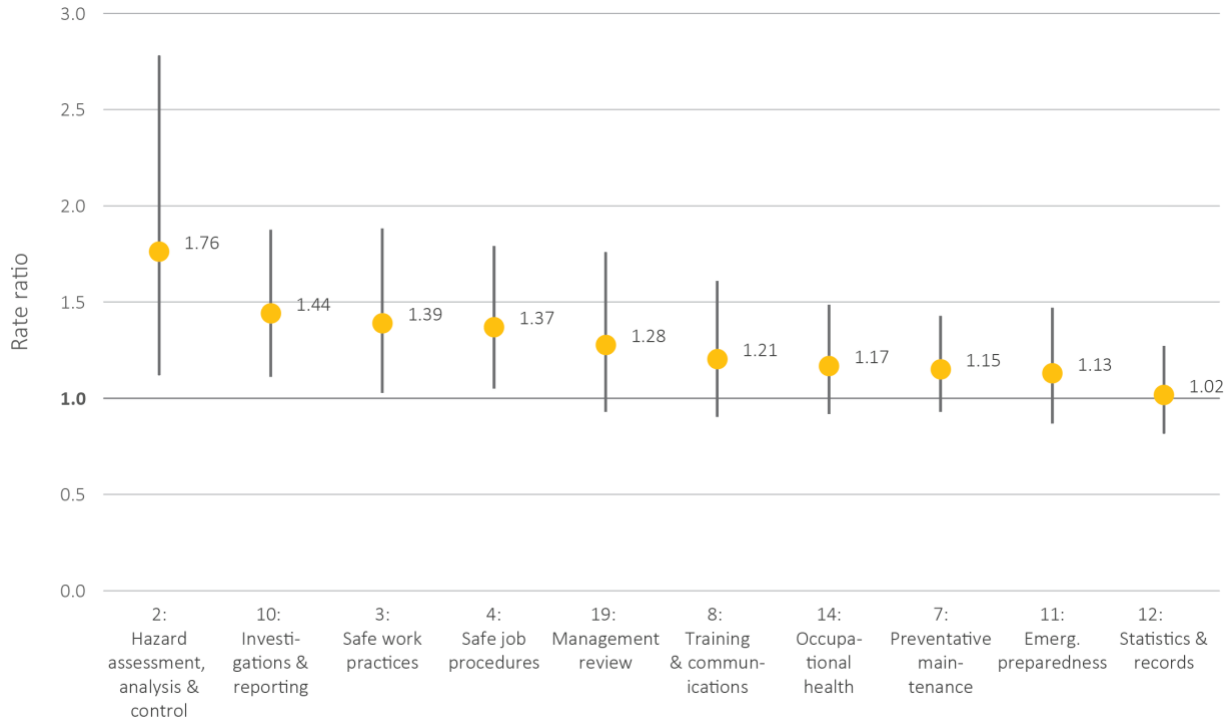
Figure 12 Distribution of element scores with low score variation



Association between audit element scores and lost time claim rates

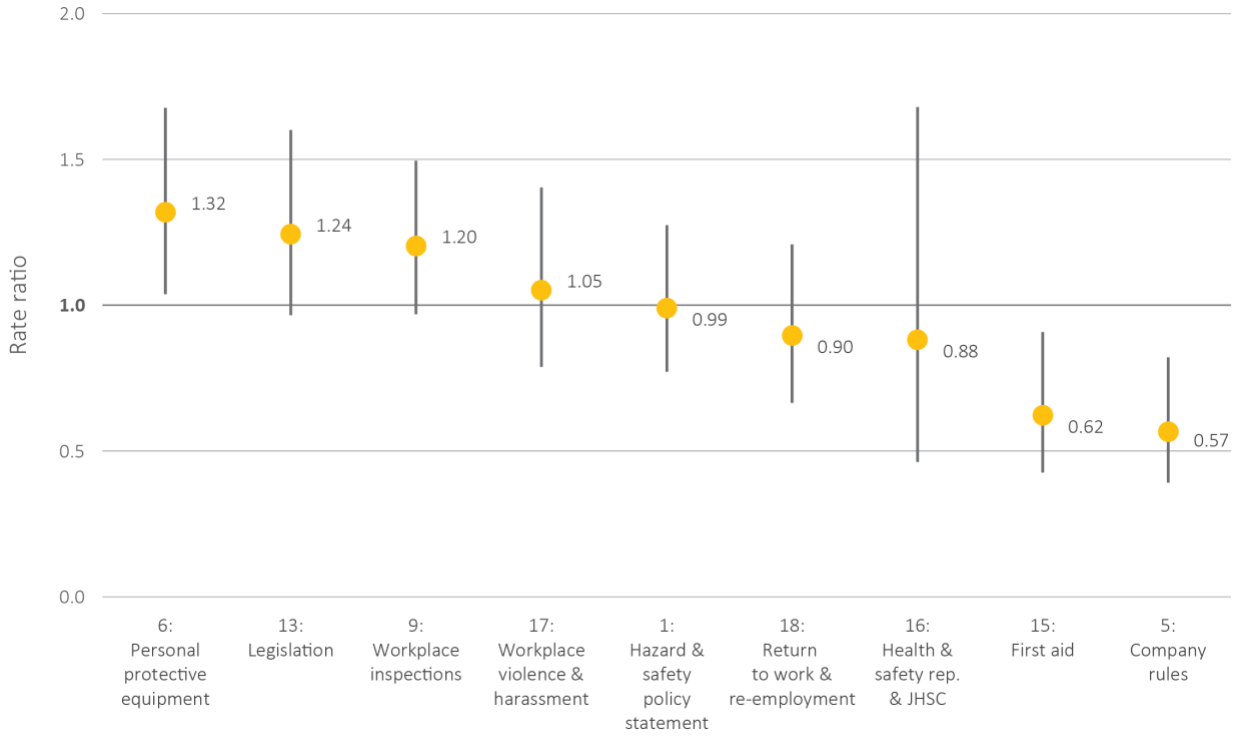
Focusing on the 10 high variation elements, compared to firms scoring 100% on each element, firms scoring less than 100% were associated with higher lost time claim rates, adjusting for firm-level characteristics (Figure 13). More specifically, elements 2 (hazard assessment, analysis and control), 10 (investigations and reporting), 3 (safe work practices), and 4 (safe job procedures) were associated lost time claim rates that were between 76% and 37% higher. When comparing firms scoring 65-79% and 80-99%, to firms scoring 100%, a gradient was observed for some elements, although the confidence intervals suggest that there were no differences between these scores (Appendix 15).

Figure 13 High variation elements: element scores and lost time injury rates, negative binomial regression



Among low score variation elements, higher lost time claim rates were observed for firms with less than 100% on elements 6 (personal protective equipment), 13 (legislation) and 9 (workplace inspections), where rates were 32%, 24%, 20% higher, respectively (Figure 14). Only element 6 was precisely estimated. In some elements (15: first aid; 5: company rules), scoring less than 100% was associated with lower lost time claim rates. However, these lower rates were driven by small numbers of firms (9-11%) that happened to be, on average, larger and safer than those scoring 100%. Estimates from the construction specific cohort showed consistency to the overall findings, with the exception being element 8 (workplace inspections) being precisely estimated (Appendix 13, Appendix 14 and Appendix 16).

Figure 14 Low variation elements: element scores and lost time injury rates, negative binomial regression



Discussion

Key findings

The overall findings for objective 1 demonstrate that COR participation is associated with lower firm-level injury rates in Ontario. However, the degree of this association varies due to the type of injury outcome being measured, the period of time, and the size of firm or sector being examined. Participation in COR was associated with a 28% reduction in the lost time injury rate, a 20% reduction in the high-impact injury rate and no reduction in the no lost time injury rate, relative to the change in non-COR firms, after adjusting for differences in firm characteristics and year. The overall reduction in the lost time and high-impact injury rate was driven by more recently certified and larger COR firms, particularly construction firms.

The findings for objective 2 suggest that higher overall audit score and specific element scores were associated with lower firm-level injury rates. However, the general pattern showed that there was a similar elevated risk for firms scoring in the lower two quartiles on their overall audit. Scoring less than 100% on an element was associated with higher lost time injury rates, particularly on elements with high score variation. Elements with the strongest and most precisely estimated association with lost time injury rates were elements 2 (hazard assessment, analysis and control), 10 (investigations and reporting), 3 (safe work practices), 4 (safe job procedures), and 6 (personal protective equipment).

Comparisons to previous COR evaluations

The reduction in the lost time injury rate in Ontario after matching on observable firm-level characteristics, is consistent with the reduction in the short-term, long-term injury and fatality rate in BC (McLeod et al., 2019), the reduction in the lost-time injury rate in Alberta (McLeod et al., 2018), and the time loss injury rate in Saskatchewan (Macpherson et al., 2021). The finding that COR participation was generally not associated with a reduction in the no lost time injury rate is consistent with there being no effect on the health care only claim rate in BC and no time loss injury rate in Saskatchewan.

Similar to evaluations of COR in other provinces, the effectiveness of COR appears to be stronger in more recent years, indicating a maturation of the program. The effectiveness of COR also appears

to be stronger among larger firms as has been seen in evaluations of COR in BC and Alberta. An important distinction between the COR firms in the Ontario study compared to the previous studies is that they are much larger than firms certified in other provinces. While some of the difference may be due to differences in data aggregation, this likely indicates that that the typical construction firm participating in COR in Ontario differs from those in other provinces.

Using the most comparable effect estimates across separate PWHS COR evaluations,[4] COR participation in the construction sector was associated with a lost time injury rate reduction of 9% in BC and Alberta, 19% in Saskatchewan, and 29% in Ontario. The differences in lost time injury rate reduction could be to differences in firm composition (i.e., larger firms in Ontario), availability of workers' compensation premium rebate that could lead to differences in firm motivation to seek certification (i.e., monetary versus safety or compliance), and a lower baseline lost-time rate in construction in Ontario (a similar absolute reduction in the injury rate will translate to a larger relative or percentage reduction in the injury rate when injury rates are lower than when higher).

In terms of the audit tool, the overall audit scores displayed a more normal distribution than that observed in evaluations in BC and Alberta, with fewer companies scoring 100% on the large external audit. In general, the elements also used in audit tools provided by other members of the Canadian Federation of Construction Safety Associations (CFCSA) (elements 1-13), showed greater score variation than elements unique to the IHSA audit (elements 15-19), with the exception being element 19 (management review). Similar to the findings in BC and Alberta, there was an association between the overall audit score and firm-level injury rates. However, the association was less linear, smaller in size, and less precisely estimated. In terms of audit element score distributions, there were similarities and differences with the findings of the BCCSA audit evaluation (McLeod et al., 2020). For example, five of the elements identified as having high score variation in this study were also identified as having high score variation in the BC study: element 2 (hazard assessment, analysis and control), 8 (training and communications), 10 (investigations and reporting), 11 (emergency preparedness), and 12 (statistics and records). In contrast, this study also identified elements 3 (safe

[4] Estimates in BC and Alberta are restricted by construction industry codes whereas Saskatchewan pooled estimates are based largely on firms classified in construction rate codes but also includes smaller numbers of other rate codes. Estimates of BC short-term, long-term and fatality claims is similar to time loss claims, with the exception of fatalities being included.

work practices), 4 (safe job procedures) and 7 (preventative maintenance) as having high score variation and element 9 (workplace inspections) with low score variation (in contrast to BC).

While the direction of the effect estimates suggests that scoring less than 100% on high score variation elements was associated with higher lost time injury rates, the elements associated with the strongest and most precisely estimated effects were elements 2 (hazard assessment, analysis and control), 10 (investigations and reporting), 3 (safe work practices), 4 (safe job procedures), and 6 (personal protective equipment). Collectively, these elements account for 27% of the overall audit score. This finding is similar to research of the BCCSA audit that found that elements 2 (hazard assessment and control), 8 (training and communications), and 10 (investigations and reporting) were the most important in predicting firm injury performance, albeit with slightly different statistical models (McLeod et al., 2020). Among the 13 elements in common to the CFCSA, this suggests similarity in how some elements are scored and differences in other which warrants further research in how the audits is being used and how better performance predicts firm safety outcomes.

Differences in the association between audit element scores and firm-level injury rates between this study and the BC study could be due to differences in scoring thresholds. For example, the IHSA audit requires a higher threshold to pass each individual element (65% and above as opposed to 50% and above) and allows for partial scores on sub-elements (Infrastructure Health & Safety Association, 2015).

Strengths and limitations

Strengths

A key strength of this study is the use of an observational research design with DiD and exact matching, which offers a robust methodological approach to evaluate COR effectiveness in the absence of a randomized research design. DiD enabled the comparison of changes over time in the non-COR control group versus the COR intervention group to provide effect estimates as if the intervention had taken place. The matching meant that COR firms could be matched with similar or comparable non-COR firms on baseline characteristics. The population-averaged negative binomial regression accounted for any remaining bias in confounders not used in the matching.

Another strength of this study has been the quality of data and the extensive work on data development. The availability of detailed WSIB claim-level data enabled the valid measurement of various types of injury claims that are most likely to be affected by COR certification. Comprehensive firm-level data from the WSIB allowed for matching of firms on a range of characteristics, including classification unit, firm size, assessment year, and lagged lost time injury rate, as well as control for additional characteristics such as premium rate adjustment, OHS program participation, and firm location in the statistical models.

Limitations

Given the small sample sizes available for this study, it is important to highlight the effect estimates that were precisely estimated (i.e., confidence intervals not overlapping with '1'), as well as the direction and size of estimates, when drawing conclusions on the effectiveness of COR and associations between overall audit and element scores with firm-level injury rates. Various cohort criteria were applied in this study in order to meet the requirements of the DiD statistical model. The cohort of the overall impact evaluation does not represent all construction firms, but generally large firms in subsectors eligible for COR. As such, the intervention effect of COR may not be generalizable to broader construction firms, particularly small firms and firms in other sectors. Lastly, the model estimates the average treatment effect and consequently, for any given firm, their observed injury rate reduction may be different.

Comparisons between this COR evaluation and previous evaluations in other provinces is challenging due to various factors, such as the differences in coverage of COR programs across

industries, injury outcome definitions, and data availability. COR is only offered by IHSA in Ontario and therefore COR participants in this study are focused on industries covered by IHSA, such as construction, transportation and warehousing, and utilities. Due to data limitations, analysis was conducted at a lower level of granularity than previous COR evaluations (firm as opposed to firm-industry), therefore comparing the results of this study with previous studies should be done with caution. The analysis excluded COR and non-COR firms that were no longer registered with the WSIB in 2020. While this reduces the generalizability of findings, the number of COR firms excluded was minimal and since the same restriction was applied to non-COR firms, this restriction is not believed to bias the estimates.

Data used in the study were collected primarily for administrative rather than research purposes, such as workers' compensation registration, payment of insurance premiums and adjudication of accepted work-related injuries and illnesses. Therefore, there may be bias due to errors in the data and misclassification. Previous research has shown that workers' compensation claims data are known to underestimate the true work-injury rate (Koehoorn et al., 2015). However, in order for under-reporting to have biased the results towards from the null (or show no effect of COR participation on reducing firm-level injury rates), COR firms, while certified, would have required a greater under-reporting rate than when not certified. Another limitation of the WSIB data is how FTEs are calculated. The FTEs variable is a key component of the negative binomial regression model in that it enabled the estimation of a rate ratio conditional on the number of workers exposed. FTEs are calculated by dividing the firm assessable payroll by the Statistics Canada average weekly wage based on their rate group. This measure can underestimate the number workers and may introduce bias if the assessment of firm payroll is distributed differentially across COR and non-COR firms.

Implications for policy and practice

The implications of this study are threefold.

1) Similar to COR evaluations in other provinces, COR certification in Ontario is effective in reducing the lost time and high-impact injury rates, but not the no lost time injury rate. While the human and financial cost savings of COR certification could be substantial for lost time and high-impact injuries, understanding how COR certification can lead to a reduction in no lost time injuries should be an objective in improving the certification program.
2) Expansion of the COR program should focus on recruiting firms with less than 50 FTEs given that COR firms already account for one tenth, one fifth, and one third of firms meeting the cohort criteria with 50-99 FTEs, 100-499 FTEs, and 500+ FTEs, respectively.
3) The initial assessment of performance on specific audit elements finds that four elements (2, 10, 4, 5) have the greatest association with firm injury outcomes, indicating that in Ontario these elements may be good candidates to focus providing additional training and support to firms that do not do well on these elements. Conversely, it suggests an examination of low variation elements and those that do not predict injuries as areas for audit or auditor improvement.

Further research

The research presented in this study suggest that COR certification is associated with a reduction in firm-level injury rates in some but not all contexts. These findings are consistent with previous COR evaluations conducted in BC, Alberta and Saskatchewan. In alignment with the evaluation of COR in other provinces, future research could focus on the following areas:

1) Further evaluation of which injury types (i.e., serious injuries overall or specific types of injuries such as musculoskeletal) are most responsive to COR certification.
2) Identifying the mechanisms through which COR certification leads to improved health and safety practices and improved firm-level injury performance.
3) Continued investigation of the association between element and sub-element and firm safety performance to identify areas focus both for OHSMS prevention, but also for COR audit and auditor improvement.
4) Investigating the effect of workers' compensation rebates or incentives and the impact of pre-bid qualification on the uptake and effectiveness of COR programs.
5) Investigating whether introducing the new COR 2020 audit tool changes the overall effectiveness of COR participation, the overall audit and element score distributions, and associations with firm-level injury rates

   Investigating the relationship between other certification programs (e.g., International Standards Organisation [ISO]), regulatory enforcement (inspections) or OHS indicators (safety culture) in understanding how OHSMS certifications like COR integrate with other injury prevention initiatives.

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Appendices

Appendix 1 Description of the IHSA COR audit tool (version 3, 2014)

Element	Sub-elements	Possible score	% Total score
1: Hazard and safety policy statement	9	25	5.6
2: Hazard assessment, analysis and control	11	38	8.6
3: Safe work practices	6	17	3.8
4: Safe job procedures	6	18	4.1
5: Company rules	5	10	2.3
6: Personal protective equipment	9	21	4.7
7: Preventative maintenance	7	15	3.4
8: Training and communications	15	40	9.0
9: Workplace inspections	11	31	7.0
10: Investigations and reporting	10	28	6.3
11: Emergency preparedness	12	32	7.2
12: Statistics and records	8	18	4.1
13: Legislation	5	12	2.7
14: Occupational health	16	37	8.3
15: First aid	8	17	3.8
16: Health & safety rep. and joint health and safety committee	7	15	3.4
17: Workplace violence and harassment	11	25	5.6
18: Return to work and re-employment	10	16	3.6
19: Management review	7	29	6.5
Total elements score		444	100.0
CFCSA score (elements 1-13)		305	68.7

Appendix 2 Variables used in the statistical models of objective 2

Dependent variables	Description
Lost time claim	Claims from a work-related injury/disease which results in: being off work past the day of accident, loss of wages/earnings, or a permanent disability/impairment
High-impact claim	Lost time claims that have large health and financial impacts on employees and businesses: low back, shoulder, and fracture claims
No lost time claim	Claims from work-related injury/disease where no time is lost from work, other than on the day of accident, but where health care is required
Independent variables	**Description**
Overall audit score	4 categories (quartiles) indicating the overall audit score percentage: 95-100%, 92-94%, 89-91%, 80-88%
Element score	2 categories indicating each of the 19 element score percentages: 100% vs <100%
NAICS class/subclass	11 categories indicating the primary sector/sub-sector of business
Firm size	7 categories indicating the firm size (at the WSIB account level) for each study year: 1-4 full-time equivalent employees (FTEs), 5-9 FTEs, 10-19 FTEs, 20-49 FTEs, 50-99 FTEs, 100-499 FTEs, 500+ FTEs
Firm years	4 categories indicating the years of operation at the level of the WSIB account: <5 years, 5-9 years, 10-19 years, 20+ years
Premium rate adjustment	3 categories indicating whether the firm received an industry premium surcharge, discount, or no adjustment
OHS program	Binary variable indicating whether the firm was participating in one of the following WSIB OHS programs: Small Business, Safety Groups, Workwell, Health and Safety Excellence
Province	Binary variable indicating whether the firm head office was located in Ontario or elsewhere
Audit type	2 categories indicating whether the audit was a baseline or recertification audit
Year of assessment	9 categories from 2012 to 2020, indicating the year of assessment

Appendix 3 Baseline characteristics of IHSA COR firms excluded from the analysis

	N	%
NAICS class		
Construction	21	80.8
Other	5	19.2
Firm size		
<100 FTEs	13	50.0
100+ FTEs	13	50.0
Premium rate adjustment		
Surcharged*	8	30.8
Discounted	18	69.2
Firm years		
<20 years	5	19.2
20+ years	21	80.8
OHS program		
No	17	65.4
Yes	9	34.6
Province		
Ontario	26	100.0
Year		
2012-2015	18	69.2
2016-2019	8	30.8
Firms	26	

Note: Surcharged category also includes firms with unadjusted premium rates.

Appendix 4 Negative binomial regression results of the unmatched and matched cohorts, lost time, high-impact, and no lost time injuries

Unmatched

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.65	(0.57-0.73)	0.66	(0.59-0.75)	1.06	(0.97-1.15)
Intervention	0.65	(0.58-0.73)	0.70	(0.60-0.82)	1.02	(0.96-1.09)
Firm years	358,683		358,683		358,683	
Firms	41,736		41,736		41,736	

Matched

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.75-1.03)	0.87	(0.74-1.03)	1.07	(0.94-1.22)
Intervention	0.72	(0.63-0.84)	0.80	(0.66-0.97)	1.00	(0.92-1.08)
Firm years	7,255		7,255		7,255	
Firms	656		656		656	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province.

Appendix 5 Negative binomial regression results of the matched cohort by intervention period, lost time, high-impact, and no lost time injuries

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.75-1.03)	0.88	(0.74-1.03)	1.07	(0.93-1.22)
Intervention (2012-15)	0.73	(0.56-0.95)	0.91	(0.66-1.27)	0.94	(0.83-1.05)
Intervention (2016-19)	0.72	(0.61-0.85)	0.76	(0.62-0.94)	1.01	(0.93-1.10)
Firm years	7,255		7,255		7,255	
Firms	656		656		656	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province.

Appendix 6 Negative binomial regression results of the matched cohort by firm size, lost time, high-impact, and no lost time injuries

20+ FTEs

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.75-1.04)	0.89	(0.75-1.06)	1.04	(0.90-1.21)
Intervention	0.71	(0.61-0.82)	0.78	(0.64-0.95)	0.97	(0.90-1.06)
Firm years	5,639		5,639		5,639	
Firms	498		498		498	

<100 FTEs

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.81	(0.66-0.99)	0.78	(0.62-0.97)	0.97	(0.82-1.14)
Intervention	0.76	(0.61-0.95)	0.84	(0.60-1.18)	1.09	(0.97-1.23)
Firm years	5,021		5,021		5,021	
Firms	462		462		462	

100+ FTEs*

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.72-1.08)	0.85	(0.68-1.07)	1.26	(1.00-1.58)
Intervention	0.68	(0.56-0.83)	0.82	(0.65-1.05)	0.88	(0.80-0.96)
Firm years	2,234		2,234		2,234	
Firms	194		194		194	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province.

* Firm size collapsed to 5 categories (<20 FTEs, 20-49 FTEs, 50-99 FTEs, 100-499 FTEs, 500+ FTEs)

Appendix 6 Negative binomial regression results of the matched cohort by firm size (cont.)

<50 FTEs*

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.64	(0.49-0.83)	0.62	(0.44-0.86)	0.97	(0.78-1.21)
Intervention	0.8	(0.56-1.13)	0.93	(0.55-1.57)	1.07	(0.89-1.28)
Firm years	3,356		3,356		3,356	
Firms	313		313		313	

50-99 FTEs**

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	1.07	(0.78-1.46)	0.97	(0.70-1.35)	1.06	(0.81-1.38)
Intervention	0.75	(0.56-1.01)	0.86	(0.54-1.37)	1.05	(0.89-1.24)
Firm years	1,665		1,665		1,665	
Firms	149		149		149	

100+ FTEs**

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.88	(0.72-1.08)	0.85	(0.68-1.07)	1.26	(1.00-1.58)
Intervention	0.68	(0.56-0.83)	0.82	(0.65-1.05)	0.88	(0.80-0.96)
Firm years	2,234		2,234		2,234	
Firms	194		194		194	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province.
* NAICS class/subclass collapsed to 9 categories (C: Utilities combined with P: Other services).
** Firm size collapsed to 5 categories (1-19 FTEs, 20-49 FTEs, 50-99 FTEs, 100-499 FTEs, 500+ FTEs)

Appendix 7 Negative binomial regression results of matched cohorts by sector, lost time, high-impact, and no lost time injuries

Construction

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.83	(0.71-0.97)	0.83	(0.70-0.98)	1.03	(0.90-1.18)
Intervention	0.71	(0.60-0.84)	0.77	(0.62-0.97)	1.01	(0.93-1.10)
Firm years	6,207		6,207		6,207	
Firms	564		564		564	

Non-construction

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Baseline	0.94	(0.68-1.29)	0.92	(0.67-1.26)	1.29	(0.90-1.85)
Intervention	0.82	(0.60-1.11)	1.03	(0.69-1.54)	0.89	(0.72-1.11)
Firm years	1,048		1,048		1,048	
Firms	92		92		92	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province.

Appendix 8 Negative binomial regression results of overall audit scores, lost time, high-impact, and no lost time injuries

	Lost time		High impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
95-100%	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
92-94%	1.13	(0.79-1.63)	1.12	(0.74-1.70)	1.17	(0.96-1.42)
89-91%	1.52	(1.02-2.27)	1.38	(0.85-2.22)	1.38	(1.11-1.72)
80-88%	1.31	(0.96-1.81)	1.28	(0.86-1.92)	1.13	(0.94-1.36)
Firm years	1,391		1,391		1,391	
Firms	442		442		442	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type.

Appendix 9 Negative binomial regression results of overall audit scores in construction sector, lost time, high-impact, and no lost time injuries

	Lost time		High-impact		No lost time	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
95-100%	1.00	(1.00-1.00)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
92-94%	1.17	(0.76-1.80)	1.10	(0.69-1.77)	1.19	(0.96-1.46)
89-91%	1.73	(1.13-2.65)	1.47	(0.87-2.49)	1.38	(1.09-1.73)
80-88%	1.44	(1.00-2.06)	1.41	(0.91-2.20)	1.13	(1.93-1.38)
Firm years	1,224		1,224		1,224	
Firms	383		383		383	

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Firm size collapsed to 9 categories (20 FTEs, 20-49 FTEs, 50-99 FTEs, 100-499 FTEs, 500+ FTEs).

Appendix 10 Distribution of element scores, 2012-2020

	Min.	Max.	Mean	Median	IQR	100%
1: Hazard and safety policy statement	67	100	96	100	93-100	68
2: Hazard assessment, analysis and control	65	100	84	84	76-92	9
3: Safe work practices	65	100	86	88	76-94	22
4: Safe job procedures	67	100	88	89	78-100	30
5: Company rules	67	100	97	100	100-100	88
6: Personal protective equipment	67	100	94	100	90-100	57
7: Preventative maintenance	67	100	89	87	80-100	44
8: Training and communications	65	100	92	95	90-100	40
9: Workplace inspections	68	100	94	100	90-100	54
10: Investigations and reporting	65	100	88	89	79-100	26
11: Emergency preparedness	66	100	87	88	78-94	20
12: Statistics and records	67	100	89	89	83-100	46
13: Legislation	67	100	94	100	100-100	79
14: Occupational health	65	100	91	93	84-100	39
15: First aid	71	100	99	100	100-100	90
16: Health & safety rep. and joint health and safety committee	80	100	99	100	100-100	96
17: Workplace violence and harassment	81	100	98	100	100-100	82
18: Return to work and re-employment	67	100	95	100	88-100	71
19: Management review	65	100	81	79	69-93	17

Note: IQR = Interquartile range.

Appendix 11 High variation elements: element scores and lost time injuries, incidence rate ratios and 95% confidence intervals (reference = 100%), negative binomial models

	IRR	95% CI	% Audits < 100	% Total score
2: Hazard assessment, analysis and control	1.76	(1.12-2.78)	91.1	8.6
10: Investigations and reporting	1.44	(1.11-1.87)	73.6	6.3
3: Safe work practices	1.39	(1.03-1.88)	77.9	3.8
4: Safe job procedures	1.37	(1.05-1.79)	70.3	4.1
19: Management review	1.28	(0.93-1.76)	83.0	6.5
8: Training and communications	1.21	(0.90-1.61)	59.9	9.0
14: Occupational health	1.17	(0.92-1.49)	61.2	8.3
7: Preventative maintenance	1.15	(0.93-1.43)	55.8	3.4
11: Emergency preparedness	1.13	(0.87-1.47)	79.5	7.2
12: Statistics and records	1.02	(0.82-1.27)	53.8	4.1

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 442 firms (1,391 firm years)

Appendix 12 Low variation elements: element scores and lost time injuries, incidence rate ratios and 95% confidence intervals (reference = 100%), negative binomial models

	IRR	95% CI	% Audits <100	% Total score
6: Personal protective equipment	1.32	(1.04-1.68)	42.9	4.7
13: Legislation	1.24	(0.97-1.60)	45.7	2.7
9: Workplace inspections	1.20	(0.97-1.60)	21.0	7.0
17: Workplace violence and harassment	1.05	(0.79-1.40)	18.5	5.6
1: Hazard and safety policy statement	0.99	(0.77-1.27)	31.9	5.6
18: Return to work and re-employment	0.90	(0.67-1.21)	29.2	3.6
16: Health & safety rep. and JHSC	0.88	(0.46-1.21)	4.5	3.4
15: First aid	0.62	(0.43-0.91)	9.7	3.8
5: Company rules	0.57	(0.39-0.82)	11.7	2.3

Note: IRR = incidence rate ratio. CI = confidence interval. JHSC = Joint health and safety committee. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 442 firms (1,391 firm years).

Appendix 13 High variation elements in construction sector: element scores and lost time injuries, incidence rate ratios and 95% confidence intervals (reference = 100%), negative binomial models

	IRR	95% CI	% Audits <100	% Total score
2: Hazard assessment, analysis and control	1.61	(0.98-2.65)	92.3	8.6
10: Investigations and reporting	1.54	(1.15-2.06)	75.2	6.3
4: Safe job procedures	1.46	(1.08-1.97)	72.6	4.1
3: Safe work practices	1.44	(1.03-2.02)	79.0	3.8
19: Management review	1.29	(0.91-1.81)	83.7	6.5
8: Training and communications	1.27	(0.93-1.72)	60.2	9.0
14: Occupational health	1.23	(0.94-1.60)	62.8	8.3
7: Preventative maintenance	1.20	(0.94-1.52)	57.1	3.4
11: Emergency preparedness	1.17	(0.87-1.58)	81.4	7.2
12: Statistics and records	1.06	(0.83-1.35)	53.8	4.1

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 383 firms (1,224 firm years).

Appendix 14 Low variation elements in construction sector: element scores and lost time injuries, incidence rate ratios and 95% confidence intervals (reference = 100%), negative binomial models

	IRR	95% CI	% Audits <100	% Total score
6: Personal protective equipment	1.38	(1.07-1.78)	44.0	4.7
13: Legislation	1.31	(1.00-1.71)	20.9	2.7
9: Workplace inspections	1.30	(1.02-1.65)	47.4	7.0
17: Workplace violence and harassment	1.07	(0.79-1.45)	19.4	5.6
1: Hazard and safety policy statement	0.94	(0.51-1.74)	4.9	5.6
18: Return to work and re-employment	0.90	(0.70-1.17)	30.8	3.6
16: Health & safety rep. and JHSC	0.85	(0.61-1.17)	28.4	3.4
15: First aid	0.58	(0.38-0.90)	11.1	3.8
5: Company rules	0.55	(0.37-0.82)	10.0	2.3

Note: IRR = incidence rate ratio. CI = confidence interval. JHSC = Joint health and safety committee. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 383 firms (1,224 firm years).

Appendix 15 Negative binomial regression results of element score changes on lost time injury rates for high-variation elements

		IRR	95% CI	% Audits
2: Hazard assessment, analysis and control	80-99%	1.63	(1.05-2.53)	55.5
	65-79%	1.99	(1.18-3.33)	35.6
10: Investigations and reporting	80-99%	1.43	(1.09-1.88)	46.0
	65-79%	1.47	(1.05-2.05)	27.6
3: Safe work practices	80-99%	1.34	(0.98-1.82)	44.9
	65-79%	1.46	(1.02-2.09)	33.0
4: Safe job procedures	80-99%	1.38	(1.05-1.82)	44.1
	65-79%	1.35	(0.97-1.90)	26.2
19: Management review	80-99%	1.28	(0.90-1.83)	28.7
	65-79%	1.28	(0.92-1.78)	54.3
8: Training and communications	80-99%	1.27	(0.97-1.67)	45.9
	65-79%	1.05	(0.63-1.74)	14.0
14: Occupational health	80-99%	1.12	(0.87-1.45)	49.5
	65-79%	1.36	(0.97-1.90)	11.7
7: Preventative maintenance	80-99%	1.22	(0.96-1.55)	38.8
	65-79%	0.99	(0.72-1.36)	17.0
11: Emergency preparedness	80-99%	1.09	(0.83-1.43)	54.0
	65-79%	1.25	(0.88-1.77)	25.6
12: Statistics and records	80-99%	0.96	(0.74-1.25)	29.0
	65-79%	1.13	(0.85-1.49)	24.8
6: Personal protective equipment*	80-99%	1.26	(0.99-1.60)	36.3
	65-79%	1.62	(0.96-2.73)	6.6

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 442 firms (1,391 firm years). Element score (ref=100%). * Element 6 (Personal protective equipment) is also included here as it had precisely estimated differences in the analysis of firms scoring <100% compared to 100%.

Appendix 16 Negative binomial regression results of element score changes on lost time injury rates for high-variation elements in construction sector

		IRR	95% CI	% Audits
2: Hazard assessment, analysis and control	80-99%	1.41	(0.87-2.27)	55.8
	65-79%	1.90	(1.09-3.29)	36.5
10: Investigations and reporting	80-99%	1.55	(1.15-2.10)	46.2
	65-79%	1.49	(1.04-2.16)	29.0
4: Safe job procedures	80-99%	1.45	(1.06-2.00)	44.9
	65-79%	1.48	(1.03-2.11)	27.6
3: Safe work practices	80-99%	1.29	(0.92-1.82)	44.6
	65-79%	1.63	(1.12-2.38)	34.4
19: Management review	80-99%	1.25	(0.85-1.82)	28.2
	65-79%	1.32	(0.92-1.88)	55.5
8: Training and communications	80-99%	1.32	(0.99-1.76)	46.6
	65-79%	1.15	(0.68-1.96)	13.5
14: Occupational health	80-99%	1.19	(0.89-1.59)	50.6
	65-79%	1.35	(0.94-1.93)	12.2
7: Preventative maintenance	80-99%	1.27	(0.98-1.66)	39.3
	65-79%	0.99	(0.69-1.43)	17.9
11: Emergency preparedness	80-99%	1.12	(0.83-1.52)	55.5
	65-79%	1.31	(0.90-1.91)	25.9
12: Statistics and records	80-99%	1.01	(0.77-1.34)	28.0
	65-79%	1.13	(0.83-1.53)	25.8
6: Personal protective equipment*	80-99%	1.32	(1.02-1.71)	37.0
	65-79%	1.69	(0.99-2.91)	7.0

Note: IRR = incidence rate ratio. CI = confidence interval. Estimates from population-averaged models with offsets of logged FTEs, adjusting for NAICS class/subclass, firm size, firm years, premium rate adjustment, year, OHS program participation, employer province, audit type. Separate models for each element. 383 firms (1,224 firm years). Element score (ref=100%). * Element 6 (Personal protective equipment) is also included here as it had precisely estimated differences in the analysis of firms scoring <100% compared to 100%.