Partnership for Work, Health and Safety

An audit-based occupational health and safety recognition program: Is certification associated with lower firm work-injury rates in Alberta?

Background

In the mid-1990s Alberta initiated the Partnerships in Injury Reduction (PIR) Program, a voluntary program that awards Certificates of Recognition (COR) to employers that have developed an occupational health and safety (OHS) management system and met established standards. PIR operates through the combined efforts of the Workers' Compensation Board of Alberta, the Alberta Ministry of Labour, industry partners, safety associations, employers, and labour groups. It was designed to encourage injury prevention and the development of effective workplace health, safety and disability management systems—and is based on the concept that when employers and workers build effective health and safety systems, the human and financial costs of workplace injuries and illnesses can be reduced. COR-certified firms in Alberta can receive up to a 20% reduction in their workers' compensation premiums if they reduce their claim costs below predicted targets.

Voluntary audit-based certification as a way of recognizing or encouraging effective OHS practices is a common approach of regulators in Canada and internationally. However, there has been little research examining whether these programs lead to improved OHS outcomes. This study aimed to determine:

Based on research presented in:

McLeod C, Macpherson R, Quirke W, Koehoorn M, Aderounmu A. (2018). Is COR associated with lower firm-level injury rates? An evaluation of the effect of an audit-based occupational health and safety recognition program on firm work-injury rates in Alberta, Canada. Final Report to Alberta Ministry of Labour. Vancouver: Partnership for Work, Health and Safety, University of BC.

1. If COR certification is associated with lower firm-level injury rates, and;

2. If COR audit scores are associated with firm-level injury rates.

Approach

To answer the first question, we combined a "difference-in-differences" (DiD) observational research design with a matching approach. Firms were matched on observable characteristics at baseline (including industry subsector, firm size, industry rate, year) and DiD was statistically modelled to estimate the effect of COR certification on two work-related injury rates (lost time injuries and disabling injuries) for 2001-2015. In addition to matching COR and non-COR firms at baseline, regression models were adjusted for the industry subsector, firm size, industry rate, industry rate adjustment, year, and whether the address of the firm was in Alberta or elsewhere.

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Regression modelling was performed to examine the overall impact of COR, and also its impact by time period, industry sector, and firms with a regular COR vs. small employer COR (SECOR).

To answer the second question, the analysis was restricted to COR firms with audit score data between 2006 and 2015. The average audit score in a given year was categorized into five categories (100%, 95-99%, 90-94%, and 80-84%) and regression modelling techniques were used to examine the association between the average audit score category and firm-level lost time and disabling injury rates. The regression models adjusted for industry sector, firm size, industry rate, industry rate adjustment, and year.

What we found—Injury rates

Overall

Certified firms had, on average, a 14% lower lost time injury rate and 3% lower disabling injury rate between 2001 and 2015, compared to non-certified firms.

Over time

Certification was associated with a lower lost time and disabling injury rate over time. Lost time injuries decreased by 12% for COR firms in the first two time-periods (2001-2005 and 2006-2010) and by 21% in the most recent period (2011-2015). The rate of disabling injuries increased in 2001-2005 but decreased by 2% in 2006-2010 and 13% in 2011-2015. (See Figure 1.)

Figure 1 | Effect of COR certification on injury rates, overall, over time, across sectors, and by COR vs. SECOR

Rate ratio of effect of COR certification, with 95% confidence interval
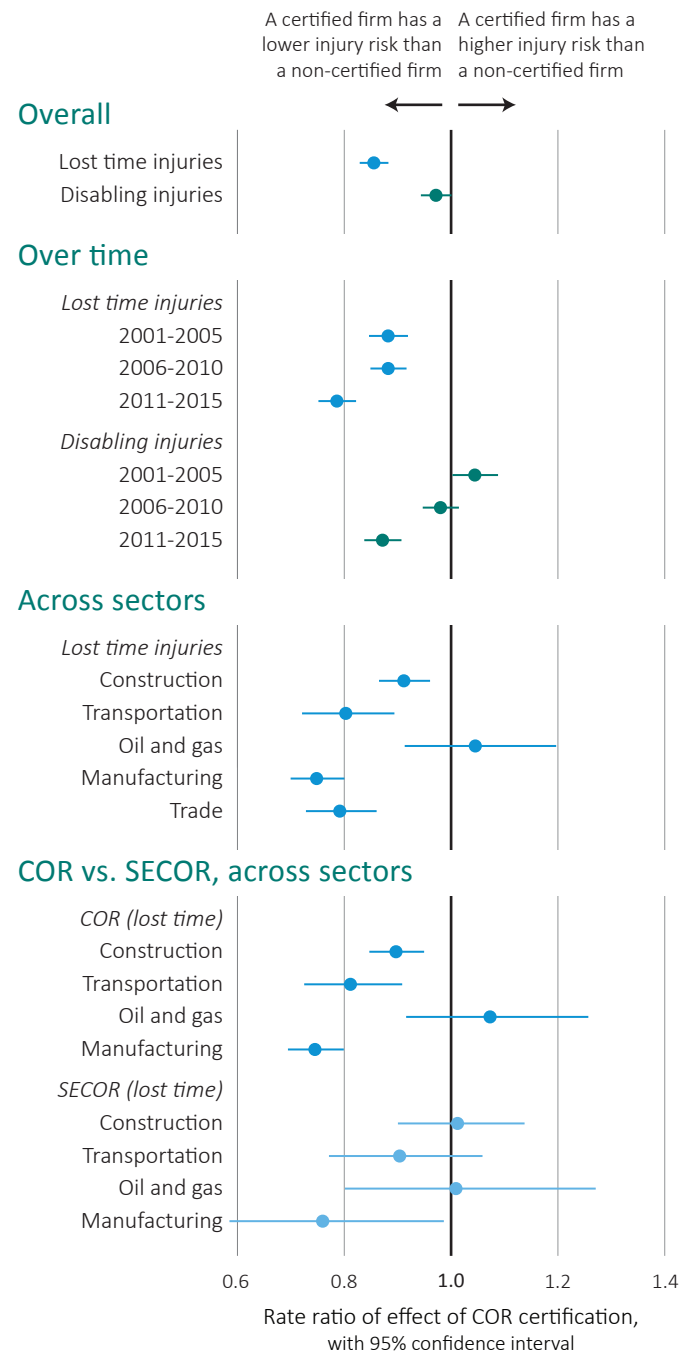
Injury rate estimates below 1.0 indicate that certified firms have lower injury rates than non-certified firms. Where confidence intervals cross 1.0, the difference in the injury rate may be due to chance.

What are lost time injuries?

Lost time injuries are occupational injury or disease claims that cause the worker to have time away from work beyond the day of injury. This includes claims receiving reimbursement of full or partial lost wages due to occupational illness or injury, or payment for permanent loss of function.

What are disabling injuries?

Disabling injuries include both lost time injuries and non-lost time injuries that required modified duties.

Across sectors and over time

Reductions in the risk of lost time injuries were observed in all industries, except oil and gas, and forestry. Similar reductions were observed for disabling injuries. The greatest effect of COR was observed in manufacturing (25% reduction in lost time injuries, 11% reduction in disabling injuries), trade (21% reduction in lost time injuries, 10% reduction in disabling injuries), and transportation (20% reduction in lost time injuries, 10% reduction in disabling injuries). The reduction in these injury rates was largest in recent years.

COR vs. SECOR

Certification via a regular COR audit (businesses with 10 or more employees) was consistent with findings from the full sample. Certification via a Small Employer Certificate of Recognition (SECOR) audit (up to 10 employees) had little or no effect on reducing lost time and disabling injuries. (See Figure 1.)

What we found—Audit scores

Audit scores were highly skewed towards 100% and this was driven by SECOR-certified firms. For both lost time and disabling injuries, injury rates increase as audit scores decrease. (See Figure 2). This association is seen overall for all COR and for the three largest certifying partners: Alberta Construction Safety Association (ACSA); Energy Safety Canada (ESC), and Alberta Association for Safety Partnerships (AASP).

What this means

COR program certification is associated with lower injury rates, particularly in the manufacturing, trade and transportation sectors and in the years 2011 to 2015. Our interpretation of this finding is that the COR audit process is effective at identifying firms

Figure 2 | Effect of COR audit score on the lost time injury rate in certified firms, for all audits, COR audits, and SECOR audits, 2006-2015
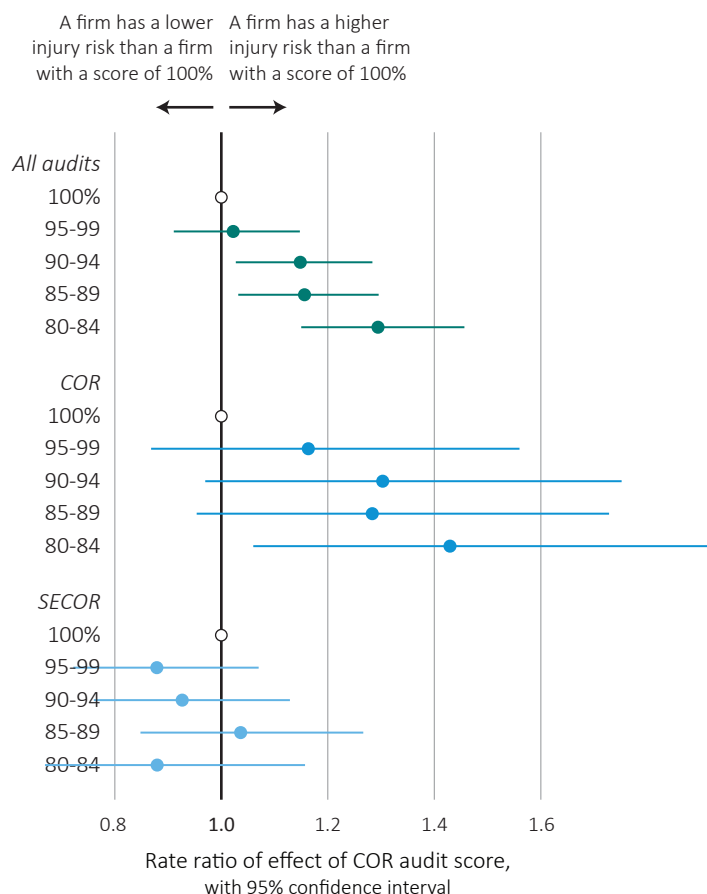
Injury rate estimates above 1.0 indicate that certified firms with an audit score in the stated range have higher injury rates than certified firms with an audit score of 100. Where confidence intervals cross 1.0, the difference in the injury rate may be due to chance.

with lower work injury risk; however, caution should be exercised in inferring that the certification itself caused any reduction injury risk. While the difference-in-difference evaluation design attempts to account for pre-certification differences in injury risk between certified and non-certified firms, we cannot rule out that certification served as a marker for existing OHS practices (or other factors) that drove changes in injury risk once a firm became certified.

The implications of our study are threefold:

1. The difference in COR effectiveness on lost time and disabling injuries indicates that a broader range of work injury measures need to be examined, including the effect on overall work injuries as well as component injuries such as medical aid only through to fatalities;

2. We found no association of SECOR certification or audit score on firm injuries. This finding, coupled with similar research in British Columbia (on the distribution of audit scores among small firms and via internal auditing), indicates that OHS management systems certification is not effective in all circumstances and that validity of the audit may vary by audit and auditor type. Improvements to the COR program could focus on these areas; and

3. Our study found that COR certification was effective when comparing COR-certified firms to similar non-certified firms. These findings may not generalize to firms with different characteristics, sectors or jurisdictions. The effectiveness of COR certification may be context- and firm-dependent and relate to quality of the audit, auditor and certification process, as well as the ability of a firm to adopt OHS policies and practices.

More information

Please contact Chris McLeod, Partnership for Work, Health and Safety Co-Director, at *chris.mcleod@ubc.ca* with questions about the methods, results, or interpretation of this evaluation, or to request a copy of the full report. General enquiries should be directed to Suhail Marino, Partnership for Work, Health and Safety Director of Privacy and Operations, at *suhail.marino@ubc.ca.*

Is COR associated with lower firm-level injury rates?

An evaluation of the effect of an audit-based occupational health and safety recognition program on firm work-injury rates in Alberta, Canada

Final Report

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Lay summary

In 2016, the Alberta Ministry of Labour (AB MOL), through its Occupational Health and Safety (OHS) Futures Program, funded Dr. Christopher McLeod to undertake a research study to evaluate Alberta's Certificate of Recognition (COR) program. The study's hypothesis was that if the COR audit process is effective at identifying "good" OHS practices, then COR-certified firms will be associated with lower injury rates compared to similar non-certified firms.

The research team first abstracted information on firms in classification units eligible for COR certification during the period of interest. It then compared injury rates over this time period in certified *vs*. non-certified firms, using statistical methods designed to: (1) determine if COR is associated with lower firm-level injury rates; and (2) examine the association between COR audit scores and firm-level injury rates.

To answer the first question, the team combined a "difference-in-differences" (DiD) observational research design with a matching approach. Firms were matched on observable characteristics at baseline (including industry subsector, firm size, industry rate, and year of observation) and the DiD was statistically modelled to estimate the effect of COR certification on two work-related injury rates (lost time injuries and disabling injuries). In addition to matching COR and non-COR firms at baseline, the regression models were adjusted for the industry subsector, firm size, industry rate, industry rate adjustment, year of observation, and whether the address of the firm was located in Alberta or elsewhere. Regression modelling was performed to examine not only the overall impact of COR, but also its impact by specific parameters (i.e., sector, SECOR *vs*. regular COR, funded *vs*. non-funded certifying partner, sector by certifying partner, firm size, and years of COR certification).

To answer the second question, the team restricted the analysis to only COR firms with audit score data between the years 2006 and 2015. The average audit score within a given year was categorized into five categories (100%, 95-99%, 90-94%, 85-89%, and 80-84%) and regression modelling techniques were then used to examine the association between the average audit score category and firm-level lost-time and disabling injury rates. The regression models adjusted for industry sector, firm size, industry rate, industry rate adjustment, and year of observation. Analyses were conducted to examine the overall impact of COR, as well as its impact by specific parameters (i.e., sector, SECOR *vs*. regular COR, and the top six certifying partners).

The findings show that COR certification is associated with lower injury rates, especially in more recent years. Lower audit scores, for most partners and sectors, are associated with higher injury rates. When SECOR is examined separately, no association is found between certification or audit scores and firm injury rates. A greater effect is consistently seen for the lost-time injury rate compared to the disabling injury rate – suggesting that some of the lost time injury reduction is due to an increased provision of modified return to work programs. These results are consistent with similar research conducted in British Columbia.

The implications of our findings are threefold. First, the difference in COR effectiveness on lost time and disabling injuries indicates that a broader range of work injury measures need to be examined, including

the effect on overall work injuries as well as component injury types such as medical aid only through to fatalities. Second, we found no association of SECOR certification or audit score on firm injuries. This finding coupled with similar research in British Columbia on the distribution of audit scores among small firms and via internal auditing indicates the OHSMS certification is not effective in all circumstances and that validity of the audit may vary by audit and auditor type. Improvements to the COR program could focus on these areas. Third, our study found that COR certification was effective when comparing COR certified companies to similar non-certified companies. These findings may not generalize to firms with different characteristics, sectors or in different jurisdictions. The effectiveness of COR certification may be context- and firm-dependent and relate to quality of the audit, auditor and certification process and the ability of a firm to adopt OHS policies and practices.

This study leads to the following areas of future research. First, while we found a relationship between the overall COR score and firm injury rates, for many component elements there was very little score variation. Additional research examining which elements and specific audit questions are associated with injury outcomes may help improve the audit process and also identify where to prioritize OHS education and training. Second, evaluating the economic aspects of the program such as the effect of different rebate types on COR participation and injury outcomes, as well as the relationship of COR certification on claim cost can assess the economic incentives related to COR certification and support a formal cost-benefit analysis. Third, COR is only one of many OHS program or tools available to OHS regulators. Examining the relationship between COR certification and other regulatory approaches such as inspection or compliance may lead to a more integrated approach across the spectrum of OHS activities.

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List of acronyms and abbreviations

Acronym/Abbreviation	Description
AASP	Alberta Association for Safety Partnerships
ACSA	Alberta Construction Safety Association
AFOODPA	Alberta Food Processors Association
AHSA	Alberta Hospitality Safety Association
AMHSA	Alberta Municipal Health and Safety Association
AMTA	Alberta Motor Transport Association
ASC	Alberta Safety Council
COR	Certificate of Recognition
CCSA	Continuing Care Safety Association
DiD	Difference in differences
ESC	Energy Safety Canada
FTE	Full time equivalent
MHSA	Manufacturers' Health & Safety Association
MECOR	Medium enterprise certificate of recognition
OHS	Occupational health and safety
OHSMS	Occupational health and safety management system
PSC	Public Service Commission
SECOR	Small enterprise certificate of recognition
SIC	Standard industrial classification
WWTA	Western Wood Truss Association of Alberta

Introduction

Encouraging the implementation of occupational health and safety management systems (OHSMS) as a workplace injury prevention measure is now a common regulatory practice across Canada and internationally. The underlying rationale of these voluntary certification programs is that firms achieving certification should have lower injury rates and that sectors with a high percentage of certified firms should see lower industry-wide injury rates, as well as decreases in the sector's workers compensation base rate. Within Canada, voluntary audit-based certification programs have been implemented in most Canadian provinces, particularly in the construction sector. International examples include: WorkSafe Victoria's (Australia) Safety Management Achievement Program (WorkSafe Victoria, 2018), the British Safety Council's Five Star Audit Tool (British Safety Council, 2018), and the OHSA Voluntary Protection Program in the United States (United States Department of Labor, 2018). While these programs adopt different definitions of OHSMS and have different audit and scoring criteria, the common approach across all these systems is objective assessment of OHS practices, ongoing monitoring and emphasis on continual improvement. Despite the growing popularity of voluntary audit-based OHSMS programs and the significant investment required from both regulators and employers, there has been little research examining whether these programs lead to improved OHS outcomes.

Background

Reduction in workplace injury rates is a key outcome for the measurement of intervention effectiveness. Robson and colleagues conducted a systematic review of 13 studies examining the effectiveness of OHSMS on injury and economic outcomes (Robson et al., 2007). While the results of these studies were generally positive, several research gaps and limitations were identified that prevented definitive conclusions being drawn on the effectiveness of OHSMS. These limitations included: a lack of rigor in the research methods (e.g., simple cross-sectional designs with no comparison groups, no control for confounding factors, limited information on measurement methods and sources of potential bias) and a lack of generalizability (e.g., studies conducted in single workplaces).

Previous research has found a relationship between OHSMS certification and lower injury rates, including three cohort studies (Abad, Lafuente, & Vilajosana, 2013; Liu et al., 2010; Lo, Pagell, Fan, Wiengarten, & Yeung, 2014) and a variety of cross-sectional and case studies (Autenrieth et al., 2016; Bottani, Monica, & Vignali, 2009; Ghahramani & Summala, 2017; Hedlund, 2014). However, limitations in research design and follow-up in most of these studies impacted the ability to test the effectiveness of OHSMS certification.

More recently, members of the project team conducted a study in British Columbia that evaluated the association between firms achieving an audit-based OHS Certificate of Recognition (COR) and firm-level claim injury rates (McLeod, Quirke, & Koehoorn, 2015). Using a "difference-in-differences" observational research design, the researchers compared COR-certified firms to non-COR firms drawn from COR-eligible industrial classification units (CU). They found that COR certification was associated with a lower injury rate for short-term disability (STD), long-term disability (LTD), fatalities and serious injuries across all years of the study. In the years with the largest number of COR-certified firms (2009 – 2012), the reduction in STD, LTD and fatal injury rate ranged between 10% and 16% and between 14% and 17% for

the serious injury rate. In addition to analyzing overall rates, the researchers also conducted sector-specific analyses for COR-certified firms in construction, forestry, manufacturing and transportation/warehousing. In construction and forestry, the injury rate in COR-certified firms was, on average, 12% and 16% lower for STD, LTD and fatalities and 16% and 21% lower for serious injuries, compared to their respective control groups. For construction COR-certified firms, the largest reduction in injury rates occurred between 2009 and 2012, while for forestry, the reduction in injury rates was similar between 2003 and 2012. Small reductions or no differences in these injury rates were observed between COR-certified firms and non-COR firms in the manufacturing and transportation/warehousing sectors. Overall, the study found that participation in the COR program is associated with lower injury rates, particularly in the construction and forestry sectors and for the years 2009 to 2012 – suggesting that the audit process is effective at identifying firms with a lower work injury risk. The British Columbia study is being updated with newer data through to 2016 and with the methods that are applied in this report. These findings are being released in a report that is concurrent with this report (McLeod et al., 2018).

In 2016, the Alberta Ministry of Labour (AB MOL), funded Dr. Christopher McLeod to undertake the first rigorous evaluation of COR in Alberta via an OHS Futures grant. The project was designed to build on the findings of the British Columbia study and to generate Alberta-specific results of the COR program's impact on firm-injury rates. The AB MOL subsequently initiated its own evaluation of the COR program in 2017, following changes to the *Occupational Health and Safety (OHS) Act*. The AB MOL approached Dr. McLeod In December 2017 to expand his original project and to undertake additional analyses. This report presents the findings from the original OHS Futures grant and the additional analysis requested by the AB MOL. The findings of this evaluation will support the implementation of the changes to the *OHS Act* and will provide information on the elements of OHS management systems (OHSMS) that should be required by regulation for health and safety programs.

The Partnerships in Injury Reduction program

In the mid-1990's, Alberta initiated the Partnerships in Injury Reduction (PIR) Program, a voluntary program that awards Certificates of Recognition (COR) to employers that have developed an OHSMS and met established standards. PIR operates through the combined efforts of the Alberta Workers' Compensation Board, the AB MOL, industry partners, safety associations, employers and labour groups. It was designed to encourage injury prevention and the development of effective workplace health, safety and disability management systems – and is based on the concept that when employers and workers build effective health and safety systems, the human and financial costs of workplace injuries and illnesses can be reduced. COR-certified firms in Alberta can receive up to a 20% reduction in their workers compensation premiums if they reduce their claim costs below predicted targets. Between 1998 and 2015, the number of Alberta employers in all sectors who received COR certification grew from 1,400 to 10,722 (Hendley, 2016). Companies entering the PIR program work towards attaining a COR, which shows that the employer's health and safety management system has been evaluated by a certified auditor and meets PIR's program standards. Once a COR has been issued, it is typically valid for a three-year period provided that all maintenance requirements are met. The employer is responsible for completing internal audits for each of the next two years. When the COR expires after three years, another external audit must be conducted to renew the COR. Usually, an employer will renew their COR near the end of the three-year period; however, an employer may renew their COR at any time by conducting another successful external audit. Major companies in sectors such as construction or oil and

gas require their contractors to hold a valid COR in order to bid for contracts. In 2016, 47% of Alberta's workforce was covered by an employer with a valid COR. PIR refunds for that same year were forecasted at over $72 million (Workers' Compensation Board of Alberta, 2018a, 2018b).

Research objectives

The over-arching purpose of the research project was to assess the effect of the COR program on firm-level injury rates in Alberta across time and industry sectors and to identify where specific practice improvements (if any) could be made. The study's hypothesis was that if the COR audit process is effective at identifying "good" OHS practices, then COR-certified firms will be associated with lower injury rates compared to similar non-certified firms.

The specific research objectives were to determine if 1) COR is associated with lower firm-level injury rates and 2) COR audit scores are associated with firm-level injury rates. The first objective falls under the original research proposal and the second objective was at the request of the AB MOL. The additional analyses were performed between January and March 2018. This report presents the findings for both the original project and the additional analyses.

Methodology

Evaluation approach

To address objective 1, this study used a retrospective observational research design to identify the causal effect of COR certification on firm-level injury rates. This used a difference-in-differences (DiD) method in conjunction with a matching method (see McLeod et al. 2018 for a more detailed description of the methodology). DiD is a common method for evaluating the effects of programs such as the COR certification program. It compares changes over time in a group unaffected by 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 provides unbiased effect estimates of the intervention if changes over time is the same between the control and intervention group would otherwise have been the same in the absence of the intervention. To estimate the treatment effect of COR certification on the outcome of interest Y_{it}, the model is specified as follows:

$$Y_{it} = \alpha + \beta INT_i + \delta T_{it} + \lambda(INT_i . T_{it}) + \gamma_j X_{it} + \mathcal{E}_{it}, \qquad (1)$$

where T is the indicator of the time period (0 for baseline, 1 for follow-up), INT is an indicator variable for being in the intervention group (0 for non-COR firms, 1 for COR-certified firms), $INT*T$ (variable of interest) is the variable that indicates the intervention period for the COR group. β, δ, λ are the respective parameter estimates, γ represents a set of estimates for the effects of j time-varying covariates, and ε is the usual error term. This model can be extended to examine different period effects of the COR intervention.

The COR certification 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 as changes over time in the outcome may differ independent of the intervention. Inspection of COR firms and non-COR firms on baseline characteristics show that COR firms are, on average larger, from higher risk industries (e.g., construction) and have more years of assessable data. Matching methods can be used to handle this type of selection, such that the non-COR firms are similar to COR-certified firms on observable characteristics.

Matching

To balance the COR and non-COR firms on observable characteristics prior to the DiD analyses, "Coarsened Exact Matching" (CEM) was used (Blackwell, Iacus, King, & Porro, 2009). CEM has been found to yield estimates of causal effects with the lowest variance and bias for any sample size than other matching methods (e.g., propensity score matching). Using CEM, COR firms were matched to non-COR firms on five characteristics of their baseline (i.e., the first year they received COR certification): industry subsector, industry rate, firm size, and year. A multivariate imbalance measure of covariate combinations was used to select the most effective matching attributes.

Regression model

Matched DiD multivariable regression analysis was conducted to assess the impact of COR certification on firm injury rates. Population-averaged (GEE) negative binomial regression was used to estimate the effects of COR certification on two work-related injury rates: 1) lost time injuries, and 2) disabling injuries. Lost time injuries were defined as accepted injury claims that resulted in lost time. Disabling injuries included lost time injuries and non-lost time injuries that required modified duties. The effect of certification on the two firm-level injury rates was calculated overall from 2001-2015 and for the three time-periods of 2001-2005, 2006-2010, and 2011-2015. Population-averaged (GEE) negative binomial regression 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. More details of this approach, as well as a comparison to other methods, can be found in the report describing a similar study conducted with British Columbia data (McLeod et al. 2018). Models were used to estimate the effect of COR: 1) overall and by time period, 2) by sector, overall and by time period, 3) by COR type (COR *vs.* SECOR)[1], 4) by funded *vs.* non-funded certifying partner, 5) by certifying partners in key sectors, 6) by firm size (0-19 FTEs *vs.* 20+ FTEs), and 7) by time period interacted with the years a firm held COR certification.

The intervention variables and covariates[2] used in the models are listed in Table 1.

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[1] For the stratifications by COR type, MECOR firms were dropped. In addition, the COR and SECOR were re-matched separately.
[2] Balances the differences in injury risk between COR firms and controls and across time that may influence the change in injury rate.

Table 1: Variables used in the models

Intervention variables	Description
Indicator of COR firm	Controls for differences in baseline risk between control and intervention firms
Indicator of COR years	Captures the effect of COR participation

Covariates	Description
Industry rate	Continuous variable denoting the premium rate at the 5-digit industry code for each year. Captures underlying injury risk at the industry level and is used to control for other unmeasured.
Industry rate adjustment	3 categories indicating whether the firm received an industry premium surcharge, discount or no adjustment (reference)
Industry subsector	45 categories denoting the industry sub-sector of the firm. Using a look-up-table provided by WCB-Alberta, 5-digit firm-level industry codes were mapped to 4-digit Standard Industrial Classification (SIC) 1980 class codes. Based on firm-numbers across SIC 1980 division (18 categories), major groups (76 categories), minor groups (317 categories), 45 subsector categories were created in which the detailed minor group were identified in sectors with large numbers of firms and sectors with low firm numbers were assigned division codes.
Employer location	Binary variable denoting whether the main address of the firm was located in Alberta (reference) or elsewhere
Firm size	6 categories denoting firm size (at the industry subsector level) for each study year. These were defined as less than one full-time equivalent (FTE) (reference), 1-4 FTEs, 5-9 FTEs, 10-19 FTEs, 20-99 FTEs, and 100+ FTEs.
Year of analysis	16 categories from 2000 (reference) to 2015 denoting the year of the analysis.

Study data and cohort definition

Study data

Data for the study were provided by WCB-Alberta and included: WCB-Alberta claims and registered firm data for the period of 2000 to 2015 and Alberta Ministry of Labour COR audit and registration data. The Quality Assurance Certifying Partner Report files included data on COR audits scores. The Government of Alberta Weekly Report files included information on COR audits and COR firm registration dates. COR certification is granted at the level of the industry and a firm may be certified in multiple industries. The base unit of analysis was firm-industry. Start year and, where relevant, ending year of COR certification was derived at the level of the industry for each COR firm. The yearly total claim count for selected injury types was derived for each firm-industry. Data on firm activity status, payroll, and assessment premiums were derived from firm-level assessment files. All data were linked by firm-industry for each year.

The following steps were required to prepare the COR data before it could be linked to the claims data:

1. Industry codes in both data sets were reclassified to facilitate linkage with the corresponding compensation claims data.
2. The audit data were restricted to completed certification and recertification audits. Maintenance audits and site-specific[3] audits were excluded.
3. The restricted audit data were merged with the COR registration data.
4. Records associated with the University of Alberta and the Government of Alberta were dropped as these employers had site-specific certifications that were incorrectly registered as regular certifications.
5. The data were further restricted to drop any COR records where the audit scores were less than 70[4] or the COR expiry dates were earlier than the audit completed dates.

The final dataset included only audits completed in 21,124 firms between the 1st of January 2000 and the 31st of December 2015 (Table 2).

COR-specific variables for model stratifications were created using information from the first year a COR firm received certification. Accordingly, COR type was categorized as COR or SECOR based on the most common audit type used in the first year of COR (Table 3), as was the certifying partner, which was identified as funded or non-funded (Table 4).

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[3] Only a small portion of a firm-industry would be represented by COR in these instances.
[4] For COR certification, an audit score of 80 or above is required. A score of 70 or above is required for limited scope audits.

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Table 2: COR audit and COR registration data preparation

Quality Assurance Certifying Partner Report		Government of Alberta Weekly Report	
Restriction	Firms	Restriction	Firms
No restrictions	20,881	No restrictions	23,109
Industry reclassification	20,644	Industry reclassification	22,859
Certification audits	20,182	Drop University of Alberta	22,858
Industry specific and multiple account audits	20,165	Drop Government of Alberta	22,849
Completed audits	19,930	Audit scores 70+	22,848
		COR expiry date is after audit completed date	22,586
		Audit completed dates between 1st January 2000 and 31st December 2015	21,124

Note: Firm is identified using a combination of employer account number and industry code.

Table 3: COR type and audit type

COR type	Audit type
SECOR	Small (owner/operator), small (2014-revision), small 2015, SECOR 2016, SECOR 2014-ACSA, small (with contracting services), SECOR 2015, SECOR 2, owner/operator 2015, small (no off-site work), small 2013 (2 to 10 workers)
MECOR	MECOR 2015, small modified
COR	Regular - ENFORM (2010), regular - MHSA 2009, regular - AHSA 2011, regular - ENFORM, PASE (Partnerships Standard Audit Equivalency), PASE 8 Elements, AHSA interim audit, regular - AHSA, regular - CHR 2014, roll-up audit, regular - ACSA, regular - CHR 2014, roll-up audit, regular - ASC, ACSA - regular, ENFORM - regular, MHSA, regular - CHR 2012, regular - MHSA, regular - Partnerships

Table 4: Funded and non-funded certifying partners

Funded	Non-funded
Alberta Construction Safety Association (ACSA)	Alberta Association for Safety Partnerships (AASP)
Alberta Hospitality Safety Association (AHSA)	Alberta Food Processors Association (AFOODPA)
Alberta Motor Transport Association (AMTA)	Alberta Safety Council (ASC)
Alberta Municipal Health and Safety Association (AMHSA)	Public Service Commission
Continuing Care Safety Association (CCSA)	Western Wood Truss Association of Alberta (WWTA)
Energy Safety Canada (ESC)	
Manufacturers' Health & Safety Association (MHSA)	

Cohort definition

Objective 1: Is COR is associated with lower firm-level injury rates?

The study cohort was defined as all firms with an active workers' compensation registration between 2000 and 2015, in an industry eligible for COR-certification. Firms were required to have a minimum of three years of assessable data in a given industry and have positive payroll in a given year to be included in that year. Therefore, firms with less than three years of assessable data were excluded as firms with short registration tenure with WCB-Alberta would unlikely achieve COR participation. The **intervention** group was defined as all firms that became COR certified between 2001 and 2014. COR firms with no pre-COR baseline (yearly observations prior to their first year of COR-certification) were excluded, as were COR firms with only one year of COR-certification. The control group was defined as non-COR firms meeting the above conditions. A summary of the cohort restrictions is shown in Table 5.

Table 5: Study cohort preparation

Restriction	Number of firms	
	COR	Non-COR
No restrictions	22,124	402,851
COR firms with claim data	20,871	402,851
Firms with insurable earnings	20,816	396,343
Firms with 3+ years of assessment	19,536	260,942
COR firms with pre-COR baseline	16,152	260,942
COR firms with 1+ year of COR certification	15,174	260,942
Firms with industry codes eligible for COR	15,174	250,304
Unmatched firms	15,174	250,304
Matched firms	14,377	11,338

Note: In most cases, COR firms without claims data may be registered in another jurisdictions' workers' compensation system.

Table 6 summarizes the study cohort by sector and COR participation. Overall, 14,377 COR firms were matched to non-COR firms at the level of the industry subsector. Because the matching method allowed for non-COR firms to be matched to multiple COR firms depending on the year of the non-COR firm[5], 11,338 non-COR firms are included in the final matched study cohort.

Table 6: Study cohort by sector

Sector code	Unmatched			Matched		
	COR	Non-COR	Total	COR	Non-COR	Total
Agriculture and Forestry	433	6,045	6,478	391	322	713
Mining and Petroleum Development	1,908	23,900	25,808	1,687	1,201	2,888
Manufacturing, Processing and Packaging	1,381	21,681	23,062	1,346	1,049	2,395
Construction and Construction Trade Services	6,337	78,821	85,158	5,390	4,449	10,379
Transportation, Communication and Utilities	2,538	32,020	34,558	2,501	2,179	4,680
Wholesale and Retail	1,233	32,307	33,540	1,211	1,027	2,238
Municipal Government, Education and Health Services	483	6,874	7,357	460	361	821
Business, Personal and Professional Services	861	48,656	49,517	851	750	1,601
Total	15,174	250,304	265,478	14,377	11,338	25,715

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[5] This is because COR firms were matched to non-COR firms based on their baseline characteristics during the year of first COR-certification.

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Objective 2: Is there an association between COR audit scores and firm-level injury rates?

To address this question, the unadjusted cohort from objective 1 was used and restricted to only COR firms and firm years from 2006 and onwards. The dataset was further restricted to exclude firm years in which COR certification was achieved using a limited scope audit. As a result, audit scores below 80 were dropped. The resulting cohort included 9,221 firms with audit scores in a given year. In cases of overlapping audits, an average audit score was assigned.

The distribution of audit scores was first analyzed using histograms. The GEE negative binomial regression model of objective 1 was then used to statistically model the association between the audit score and firm-level injury rates for both lost time and disabling injuries. In this model, the DiD indicator variables of COR firm and COR years were excluded. We first examined the relationship using linear model but identified that the relationship between audit score and injury rate was non-linear. Accordingly, audit scores were categorized into five strata:

1. scores between 80 and 84
2. scores between 85 and 89
3. scores between 90 and 94
4. scores between 95 and 99, and
5. scores of 100 (reference)

These models were adjusted for industry sector (using 8 WCB-Alberta sectors), firm size, industry rate, industry rate adjustment, and year. Models were first run on the overall dataset, before stratifying by COR *vs.* SECOR, and by the top six certifying partners in the cohort.

Research Ethics

This study was based on secondary usage of existing administrative data on workers' compensation claims. The data was made available in accordance with the research agreement between WorkSafeBC and the Partnership for Work, Health and Safety that governs the privacy and confidentiality conditions for use of the data for research purposes. The Behavioural Research Ethics Board of the University of British Columbia reviewed and approved the research protocol (certificate # H17-00034).

Results

Overall impact of COR participation

Participation in COR was associated with a lower injury rate for lost time injuries and for disabling injuries (Table 7). Complete regression results are provided in "Regression tables".

Table 7: GEE negative binomial regression results, full sample, lost time and disabling injuries

	Lost time injuries		Disabling injuries	
	IRR	95% CI	IRR	95% CI
COR firm	1.02	(0.98, 1.06)	1.08	(1.04, 1.12)
COR participation (years 2001-2015)	0.86	(0.83, 0.88)	0.97	(0.94, 1.00)

Note: IRR = incidence rate ratio. CI = confidence interval.

Figure 1 presents matched and unmatched estimates illustrating the overall effect of COR for all industries. It can be seen from the figure that COR certification reduced lost time and disabling injuries and that matched and unmatched estimates provide similar results. However, the matched estimates are smaller.

Figure 1: Overall effect, all industries, unmatched vs matched
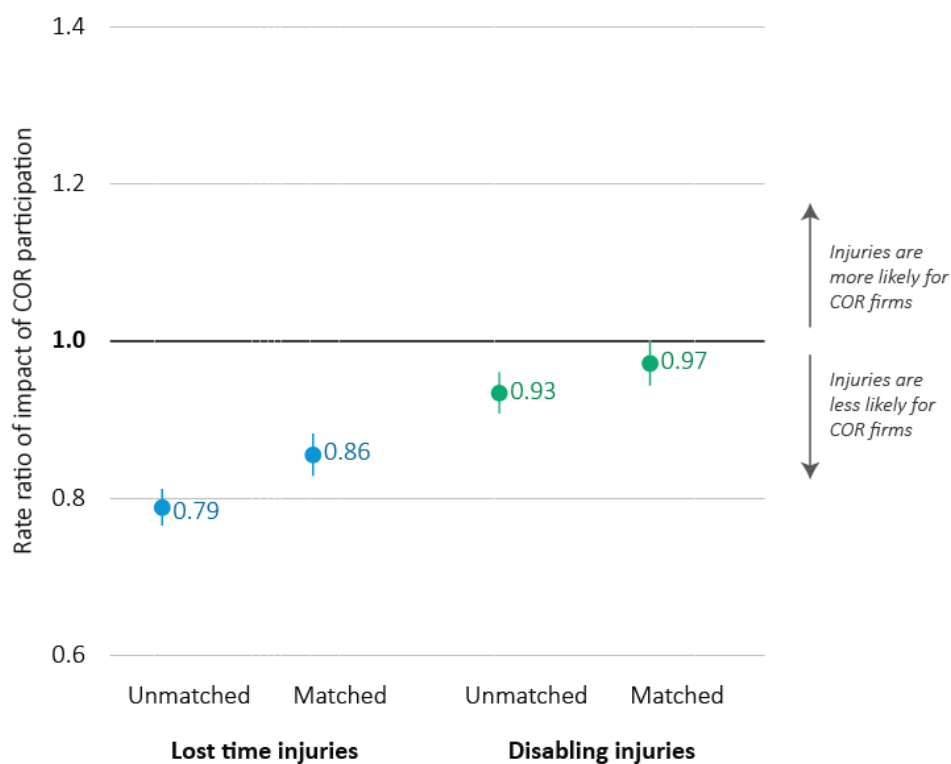
Figure 2 presents the overall impact of COR by time period. For lost time, disabling and disabling injuries without lost time, there has been a decrease in the injury rate over time. Lost time injuries decreased by 12% for COR firms in the first two time-periods (i.e., 2001-2005 and 2006-2010) and by 21% in the most recent period (2011-2015). The rate of disabling injuries increased in 2001-2005 but decreased 2% in 2006-2010 and 13% in 2011-2015. These findings illustrate that COR certification was more effective in recent years than it was in early years.

Figure 2: All industries, by time period
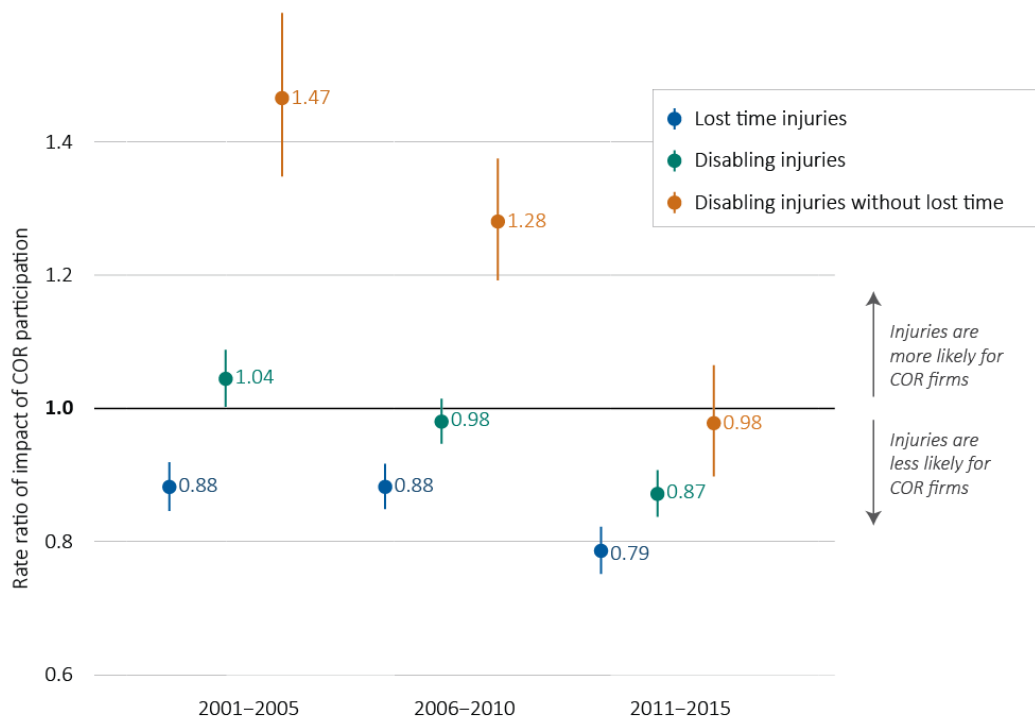
Impact of sector

Sector-specific analyses

When the data were analyzed by sector, reductions in the risk of lost time injuries were observed in all industries, except oil and gas, forestry and agriculture (Figure 3)[6]. Similar reductions in risk were observed for disabling injuries (Figure 4). As both figures illustrate, the greatest effect of COR was observed in: manufacturing, processing and packaging (25% reduction in lost time injuries, 11% reduction in disabling injuries); trade (21% reduction in lost time injuries, 10% reduction in disabling injuries); transportation, communication and utilities (20% reduction in lost time injuries, 10% reduction in disabling injuries).

Figure 3: Overall effect, by industry sector, for lost time injuries
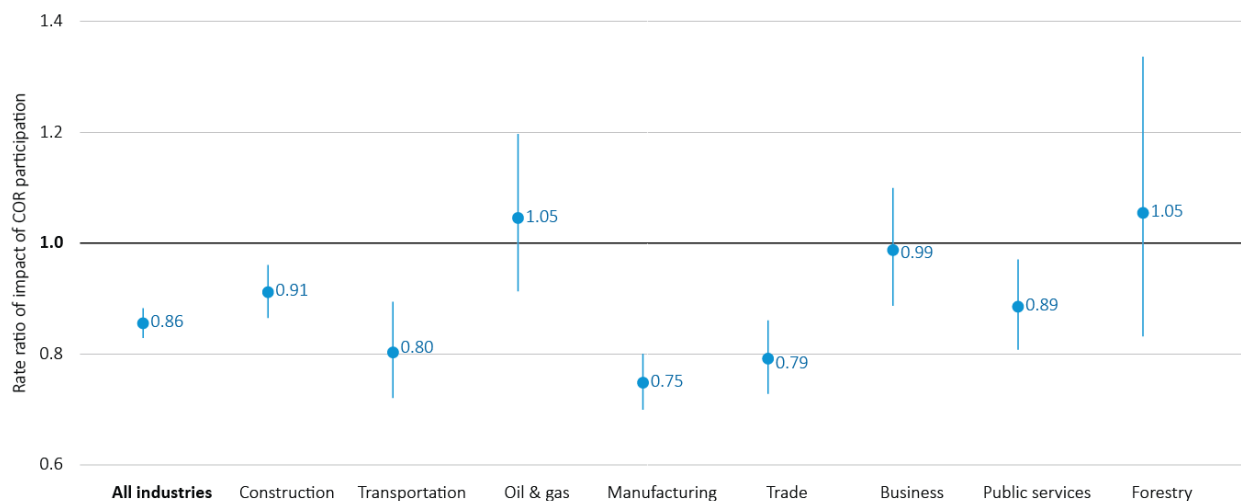
Figure 4: Overall effect, by industry sector, for disabling injuries
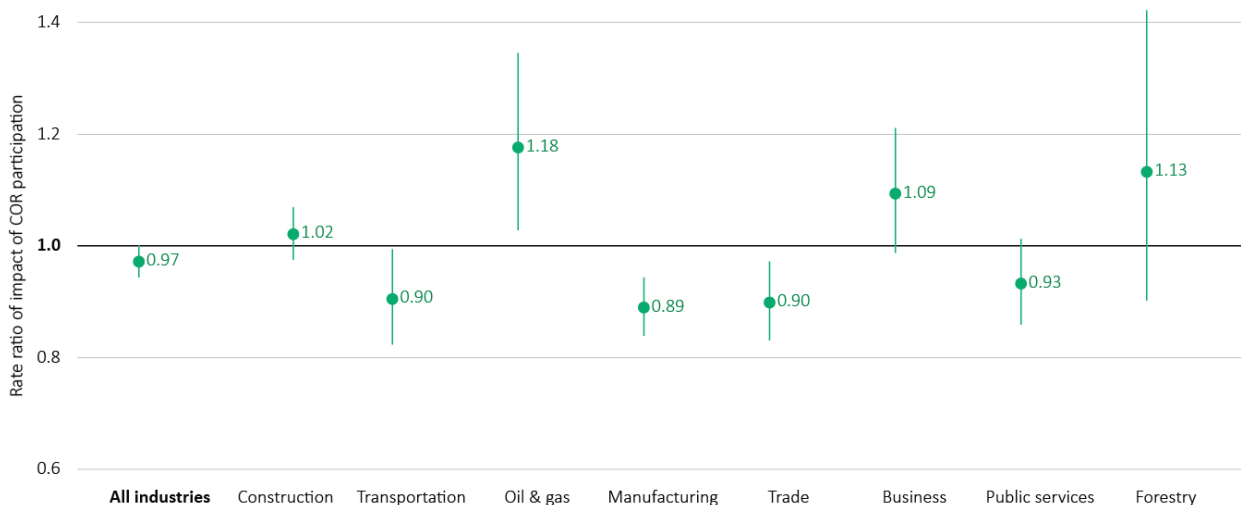
[6] Sector labels are abbreviations of the full WCB-Alberta industry sector labels displayed in Table 6.

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Sector-specific analyses, by time period

When the data were analyzed by sector and by time period, reductions in both lost time and disabling injuries were observed across multiple sectors (Figure 5 and Figure 6). Injury rates have trended down over time, indicating that COR has had a bigger impact in recent years than in earlier ones.

Figure 5: By industry sector and time period, for lost time injuries
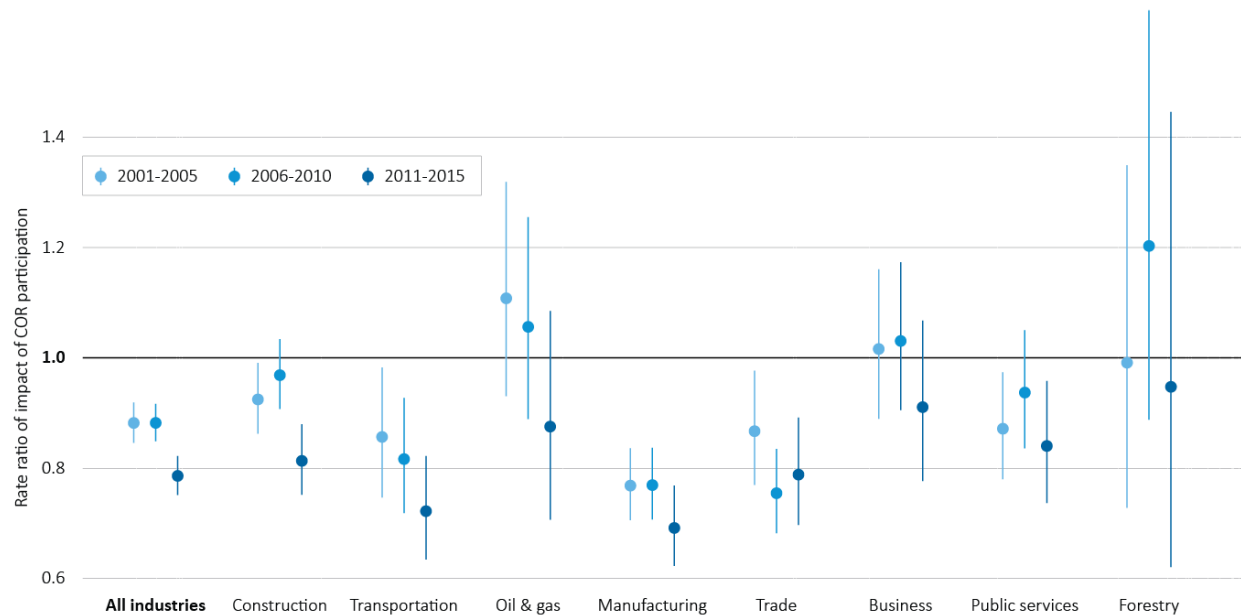
Figure 6: By industry sector and time period, for disabling injuries
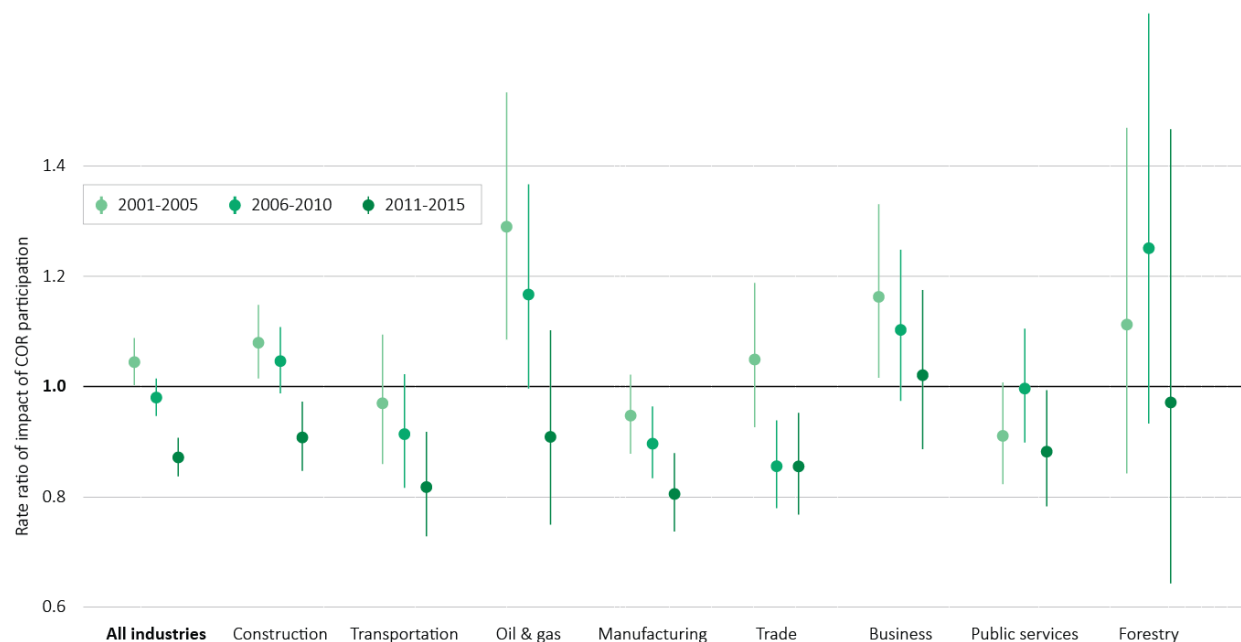
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Impact of type of COR

A consistent and similar relationship was found for COR-certified firms compared to the full sample. However, overall and by sector, no or little effect was found for firms with SECOR certification (Figure 7 and Figure 8).

Figure 7: COR vs. SECOR, by selected industry sector, for lost time injuries
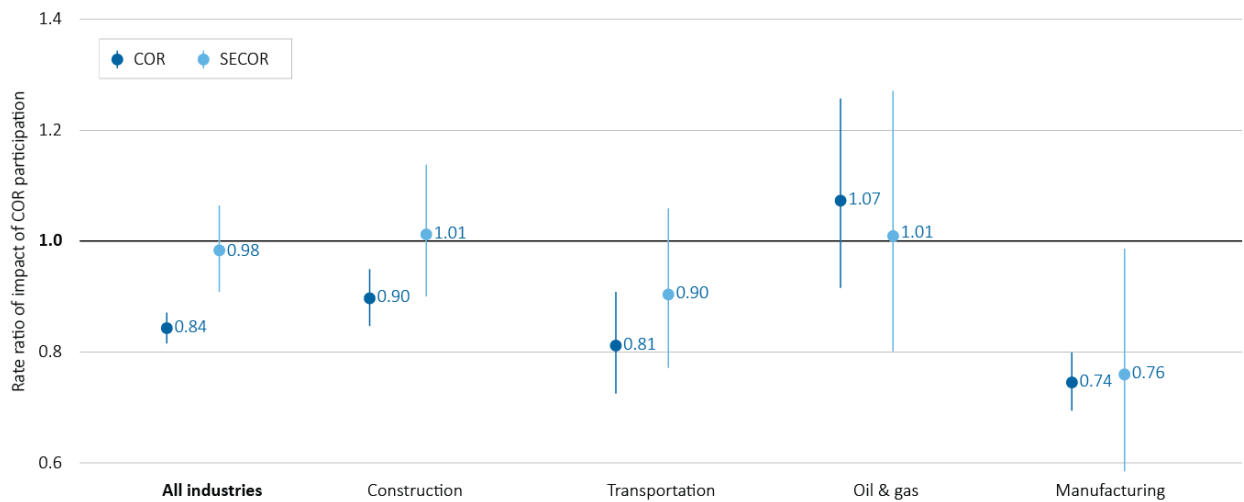
Figure 8: COR vs. SECOR, by selected industry sector, for disabling injuries
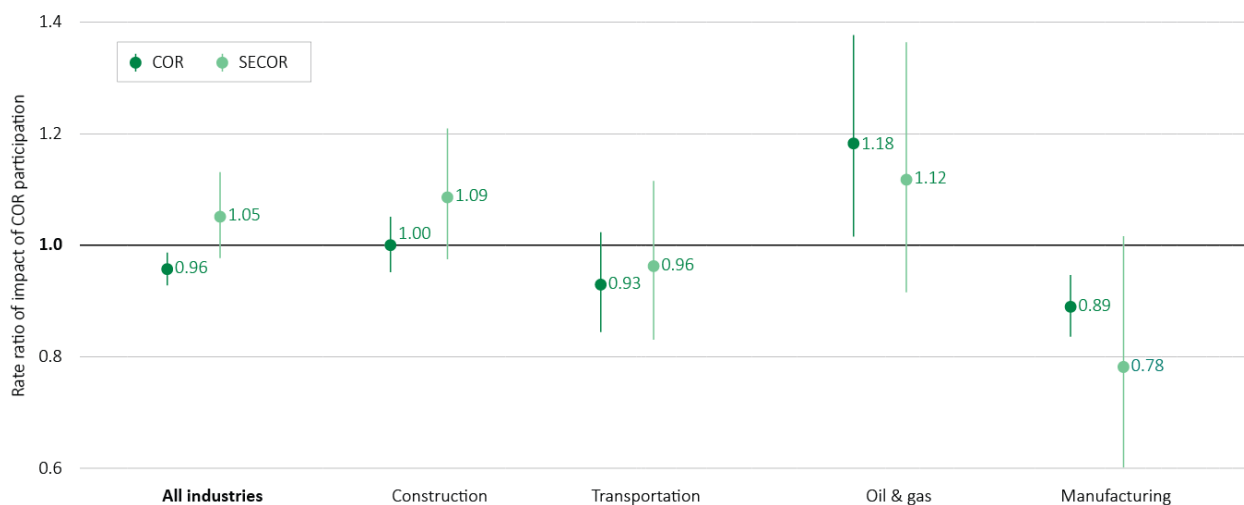
Impact of certifying partner

The impact of certifying partner on lost time and disabling injury rates in COR certified firms was examined on the basis of funded status and by sector.

Impact of funded vs. non-funded status

For all industries, no difference in the lost time or the disabling injury rate was observed between funded and non-funded certifying partners (Figure 9). For both funded and non-funded certifying partners, a 14% decrease in lost time injuries and no significant decrease in disabling injuries was observed.

Figure 9: All industries, funded vs. non-funded certifying partner
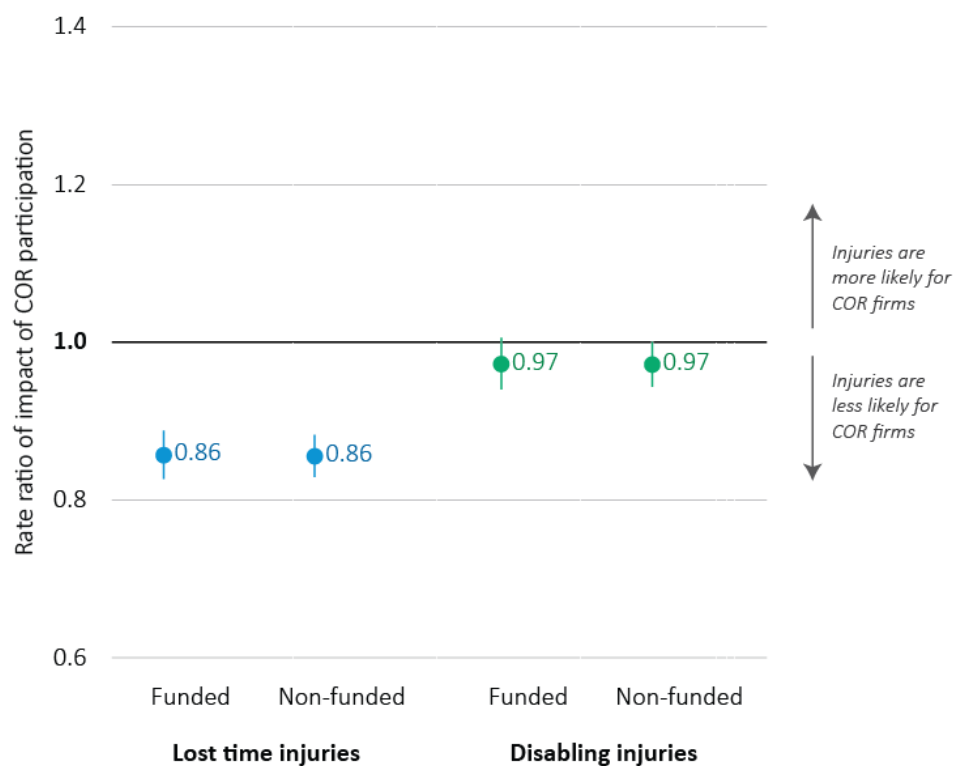
Impact of certifying partner by sector

For both lost time injuries and disabling injuries, differences were observed between COR effectiveness and certifying partner (Figure 10 and Figure 11). The PIR audit tool used by Alberta Association for Safety Partnerships (AASP), Alberta Safety Council (ASC), Alberta Motor Transport Association (AMTA) had a similar reduction in lost time injuries in all industries, transportation, and manufacturing, and no effect in construction and oil and gas. The Alberta Construction Safety Association (ACSA) audit had an 11% reduction in lost time injuries in construction, 23% reduction in manufacturing, and no effect in transportation, and oil and gas. The Energy Safety Canada (ESC, formerly ENFORM) audit had no effect in any sector. The Manufacturing Health & Safety Association (MHSA) audit had the largest reduction of 31% in the manufacturing sector. For disabling injuries, reductions in the injury rate were only found for the AMTA audit in transportation and the ACSA and MHSA audit in manufacturing. The AASP audit was associated with an increase of 16% in construction.

Figure 10: Certifying partner, by industry sector, for lost time injuries
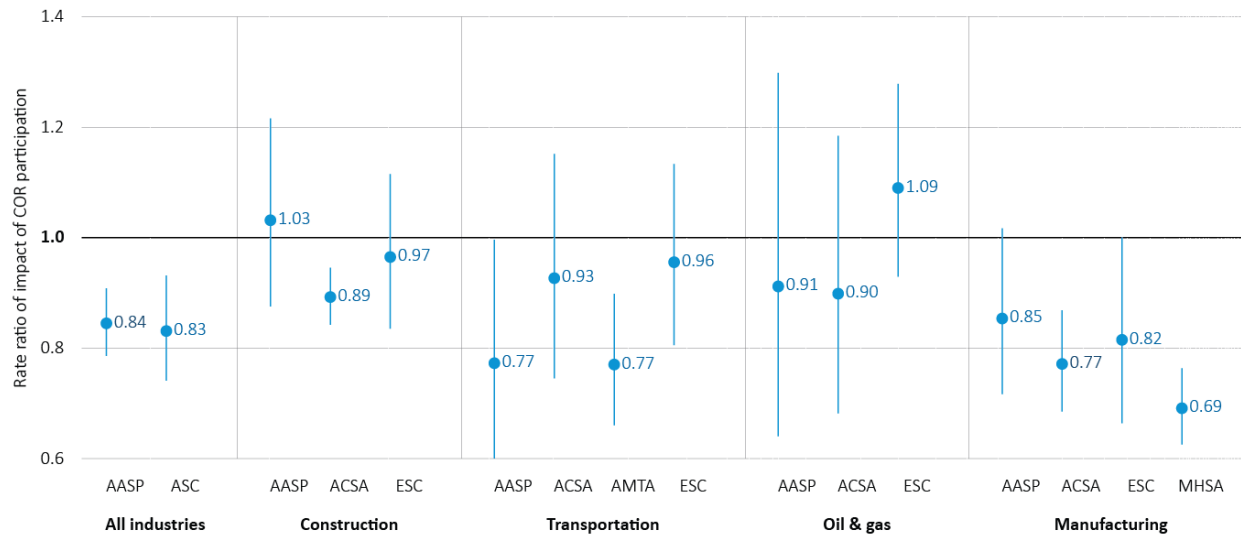
Figure 11: Certifying partner, by industry sector, for disabling injuries
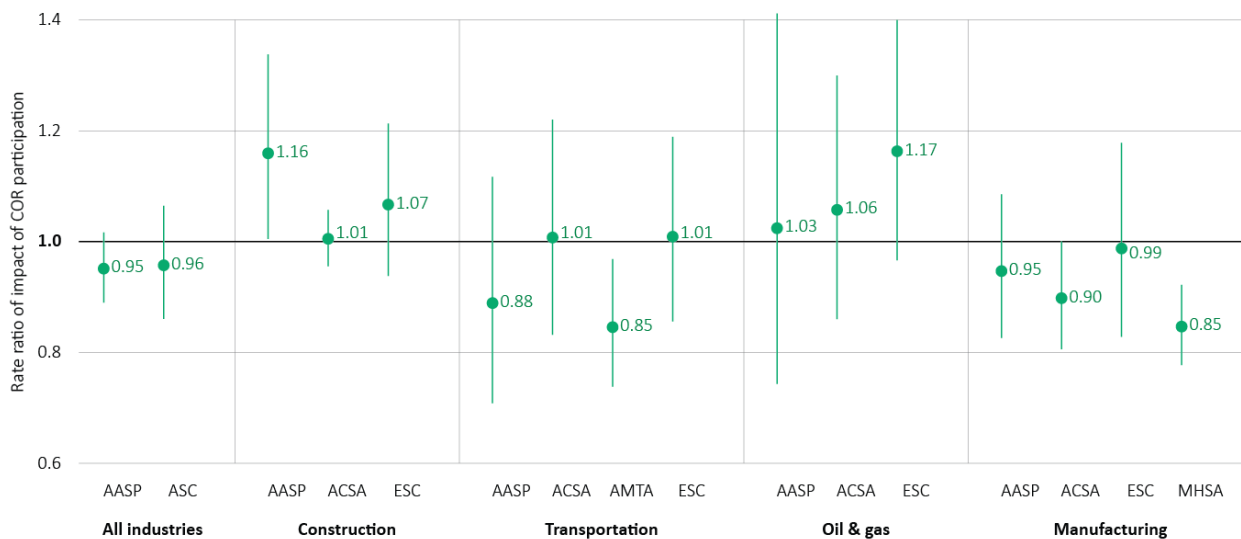
Impact of firm size

Analysis by firm size indicated a similar effect as the analysis by type of COR program (i.e., COR *vs*. SECOR). Overall, small firms had smaller reduction in lost time injuries (9% for firms with 0-19 employees vs. 16% for firms with 20+ employees). Small firms had no reduction in disabling injuries, compared to a 4% decrease for firms with 20+ employees (Figure 12).

Figure 12: All industries, by firm size
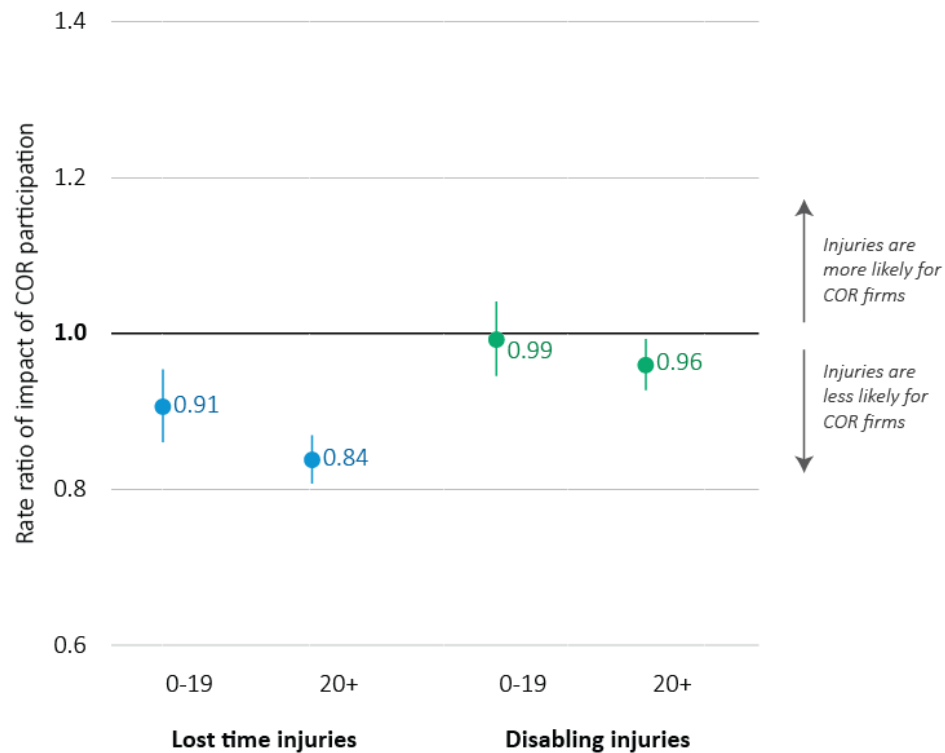
Impact of years certified

When the impact of years certified was examined, the period effect was still observed for both lost time and disabling injuries (i.e., the injury rate decreases over time). Adjusting for years of COR certification attenuated the period effect. Looking at lost time injuries in firms certified for 1-3 years, the injury rate was 12% lower in 2001-2005, 10% lower in 2006-2010, and 19% lower in 2011-2015. A similar trend was seen in firms certified for 4-12 years (14% lower in 2006-2010 and 22% lower in 2011-2105). Alternatively, looking at the trajectory of firms certified the longest, there was a 12% reduction in the lost time injury rate for firms in their first three years, followed by a 14% reduction in firms certified 4-12 years, and a 27% reduction in firms certified for 13-15 years.

Figure 13: All industries, period effect by years certified,
for lost time injuries (left) and disabling injuries (right)
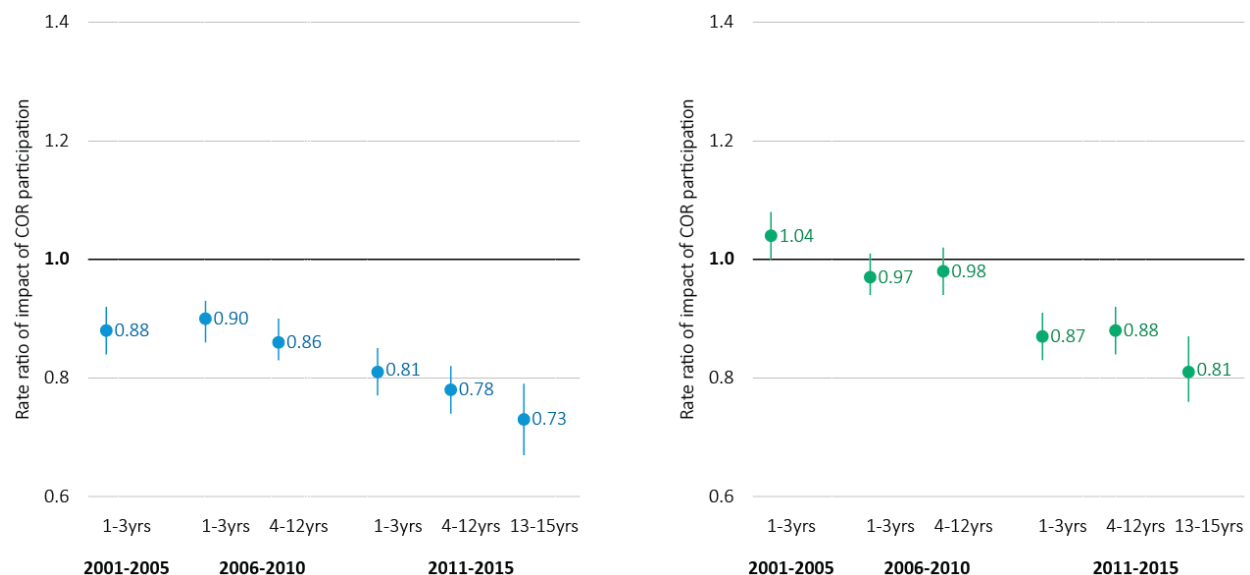
Relationship between COR audit scores and firm-level injury rates

Audit score distributions overall, by COR type, and three most common certifying partners are presented in Figure 14 and Figure 15. Audit scores were highly skewed towards 100% and this was driven by SECOR and firms certified by ACSA. The association between audit score and firm-level injury rates are presented in Figure 16 and Figure 17. For both lost time and disabling injuries, injury rates increase as audit scores decrease. This association is seen overall for all COR and for the three largest certifying partners (ACSA, ESC, AASP). When the impact of COR *vs*. SECOR is examined, no association is seen for SECOR.

Figure 14 Audit score distribution overall and by COR type
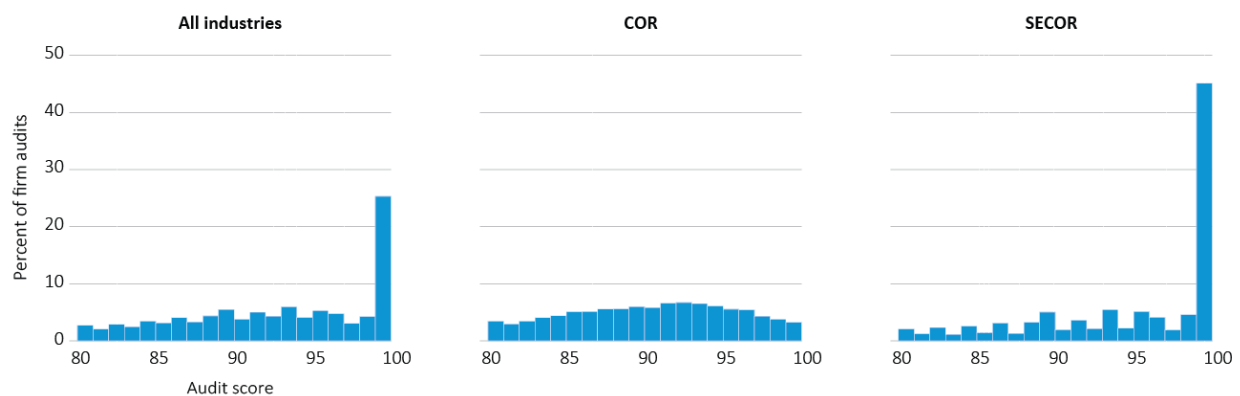
Figure 15 Audit score distribution by three most common certifying partners
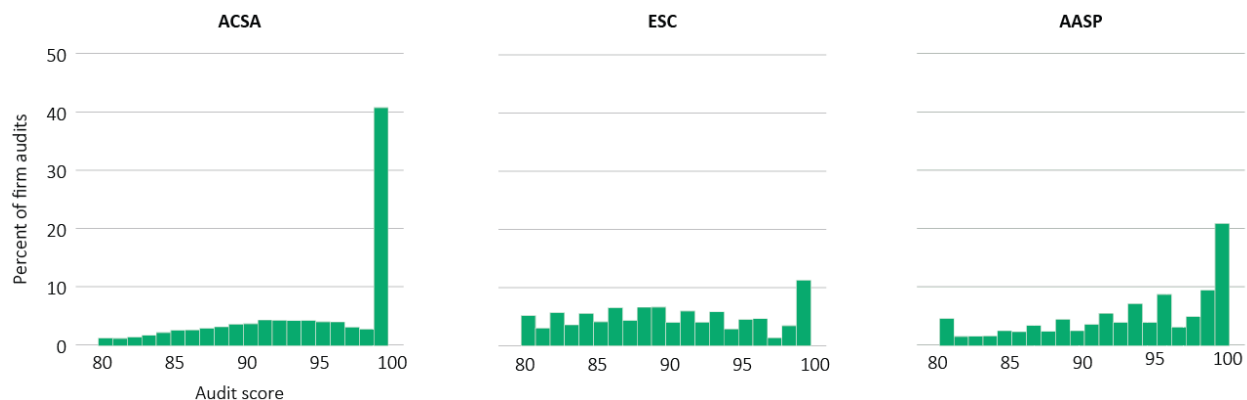
**Figure 16: Audit score, by COR type and certifying partner, for lost time injuries,
compared to firms with an audit score of 100**
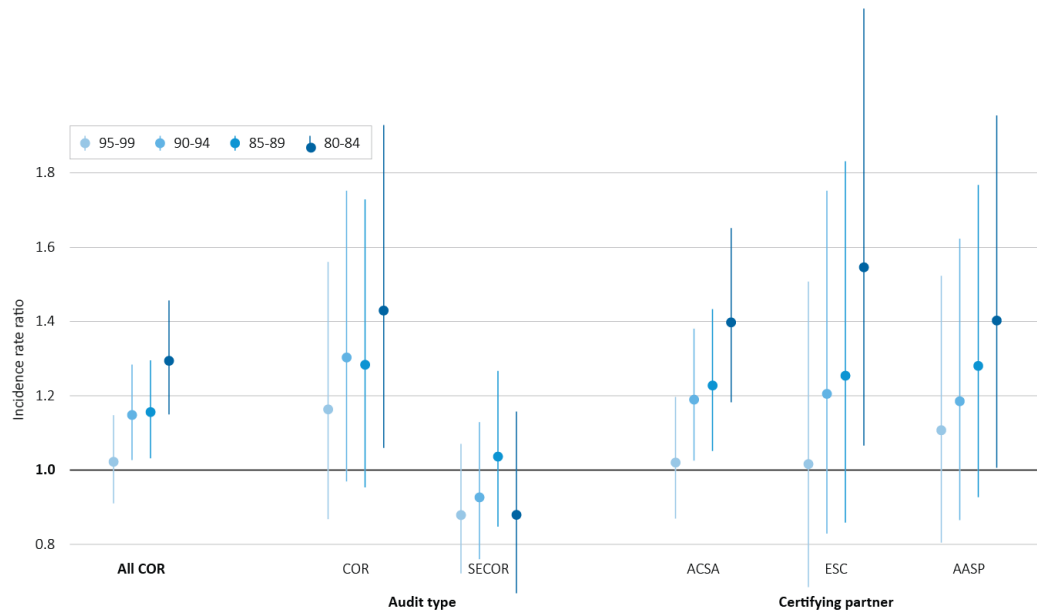
**Figure 17: Audit score, by COR type and certifying partner, for disabling injuries,
compared to firms with an audit score of 100**

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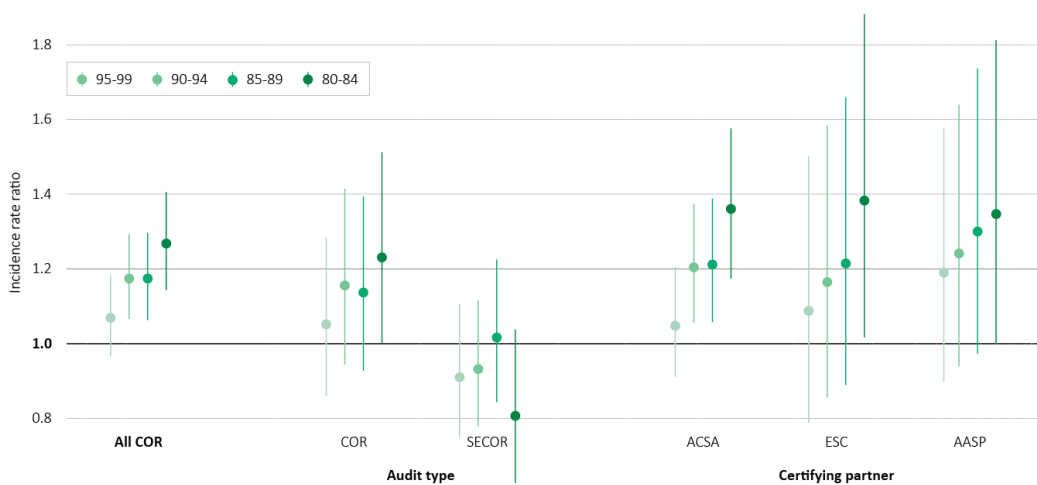
Discussion

Key findings

The central findings of this study are that COR certification is associated with lower injury rates, especially in recent years. Lower audit scores, for most partners and sectors, are associated with higher injury rates. When SECOR is examined separately, no association is found between certification or audit scores and firm injury rates. A larger effect is consistently seen for the lost-time injury rate compared to the disabling injury rate indicating that some of the lost time injury reduction is due to an increased provision of modified return to work programs. COR certification was found to be effective in the Construction, Transportation, Trade and Manufacturing sectors, but not in Oil and Gas, Forestry/Agriculture, Business and Public Service Sector. By certifying partner and audit instrument, except for the ESC audit, there was either an overall relationship (AASP and ASC) or sector-specific relationship (ASCA, AMTA, AMSA) with COR certification and the lost time injury rate.

The finding that COR, but not SECOR, was associated with lower injury rates indicates that the SECOR certification may not be identifying safer firms and that the SECOR certification may not be leading to certified firms adopting safer work practises. Moreover, higher scores on the SECOR audit were not associated with lower injury rates and almost 50% of SECOR audits received scores of 100%. As such, the implementation of the SECOR audit and the audit tool may need improvement. Notwithstanding, the effectiveness of implementing OHSMS among small firms is challenging given the limited resources and OHS expertise these firms may have.

The study finding that COR is effective in reducing lost time injuries, but not disabling injuries, could be due to two reasons. First, COR certification may not completely prevent an injury. Rather, it may shift or reduce the injury risk toward less serious injury types. Second, COR certification may be associated with more effective claims or work disability management in that injuries prior to certification would have led to lost time, but post certification lead to modified RTW or medical aid only. The distinction between these two explanations is that in the former the injury is less severe, while in the latter the management of the injury is more effective. Further research examining the relationship between COR certification and claims management and work disability management practices could explore this finding in more detail. Additional and broader work injury measures (i.e., covering near misses, medical aid only, through to more serious injuries) may also help uncover the relationship between COR certification and prevention across all injuries types as opposed to specific injuries types.

We found that COR certification was not associated with a lower injury rate in the Oil and Gas sector and that COR firms certified by ESC were not associated with lower injury rates across sectors. A possible explanation for this finding is that ESC COR certified firms are drawn from industry sectors for which there is an alternative OHSMS certification in addition to COR certification. For example, in this sector, the control group (non-COR firms) may have had other forms of certification, such as the International Standards Organisation (ISO) as these firms may require other OHSMS certification to conduct activities in international jurisdictions.

The effectiveness of COR certification was largest in the Manufacturing sector and for the MHSA audit. One explanation for this may be that the working environment is static and it is easier to implement and

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improve OSHMS compared to more dynamic changing working environments associated with sectors such as Construction, Forestry/Agriculture, or Oil and Gas. It is also possible that because of the more stable production environment in the Manufacturing sector, the OHS policies and practices assessed during the audit process are more are more reflective of these practices throughout the year.

Previous OHSMS evaluations

The results of this study show consistencies with similar research conducted in British Columbia (McLeod et al., 2015; McLeod, Quirke, McLeod, & Aderounmu, 2018). Similarities include that COR certification reduced injury rates even after matching for baseline characteristics of the firms, the increased reduction of injuries over time, and the larger reductions taking place within the manufacturing sector. Notable differences were that in British Columbia, COR had a significant effect in reducing injuries in Forestry whereas there were no or small effects in Transportation/Warehousing and only an effect in Construction post 2009 (McLeod et al., 2015). Differences in the results between the provinces may reflect the differences in the COR program and certifying partner audits but may also reflect industry classification systems between WorkSafeBC and WCB-Alberta.

In respect to the broader literature, this study identified findings similar to other OHSMS. Hedlund (2014) examined whether there was an association between adoption of the South African NOSA 5-Star System, a voluntary OHSMS, and incidence rates of fatal and permanent disabling injury. He also examined whether there was an association between the 5-Star audit rating and rates of serious occupational injury. The author found that NOSA firms experienced fewer fatal and permanently disabling injuries than general manufacturing sector firms. He also found an inverse correlation between the 5-Star rating and injury incidence rate. A similar inverse relationship between COR audit scores and firm injury rates was identified in this study.

This study addresses the limitations of previous studies highlighted by Robson et al. (2007), in that it implements a rigorous longitudinal research design with a comparison group and controls for confounding and selection factors. The study's methodology was most similar to that used by Liu et al. (2010) who used DiD with propensity score matching to assess the effect of joining a certified safety committee (CSC) on firm injury rates. Their study found that firms that joined the CSC did not have reductions in injury rates compared to similar firms that did not join and that injury rates for CSC firms increased relative to non-CSC firms. Their finding may be a reflection that having a joint health and safety committee is only one element of OHSMS.

Abad et al. (2013) used a longitudinal research design to study the effect that the adoption of the Occupational Health and Safety Assessment Series (OHSAS) 18001 certification had on safety performance (accidents rate) and labour productivity. They were able to examine the performance differences between OHSAS and non-OHSAS firms over time and, using the number of years of certification, estimate the marginal rate of return on an additional year of certified safety experience. They found that the rate of accidents at the workplace were lower for firms with OHSAS 18001 certification and that this increased with each additional year of certification.

Collectively, the evaluations conducted in Alberta and British Columbia show that COR certification leads to lower injury rates but not in all circumstances, such as differences in sector, differences by audit and

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differences by small vs. large firms. Accordingly, COR certification may not lead to lower injury rates in all circumstances. Small firms face challenges due to resource constraints and implementing an OHSMS. OHSMS may be more easily implemented in less dynamic environments, such as the Manufacturing sector, compared to more dynamic environments such as Construction.

Strengths and limitations

Quality of the data

Access and utilisation of detailed claim-level workers' compensation data enabled us to specify exactly what types of injury claims we could include in our study cohort (e.g., accepted lost time claims), while the firm-level data enabled us to characterize the industry type and size of the firms. The Government of Alberta Weekly Report data permitted derivation of specific cohort restrictions based on COR registration whereas the Quality Assurance Certifying Partner Report data allowed us to examine audit scores in relation to the firm-level injury rates. Together, these data were linked at the firm-level using unique firm and industry identifiers on a yearly basis. The span of 16 years of data for all registered firms and for COR certification yield a large enough sample size to conduct multiple stratified analyses (e.g., sector, period, certifying partner, firm size) and to focus on key modifiable aspects of the program, such as the type of COR (COR *vs*. SECOR) and certifying partner.

Robustness of method

Complementing the rich data, the observational research design using DiD and CEM matching offered a robust methodological approach to evaluate COR effectiveness in the absence of a randomized research design. DiD enabled us to compare changes over time in the non-COR control group with the COR intervention group to provide effect estimates of if the intervention had taken place. The CEM matching enabled us to match a COR firm with a similar or comparable non-COR firm on baseline characteristics. The GEE negative binomial regression enabled us to account for any remaining bias in covariates and eliminate time-invariant unobservable characteristics.

Limitations

This study has a few limitations. For example, data used in the studay are collected primarily for administrative purposes, such as workers' compensation registration, payment of insurance premiums, and adjudication of accepted work-related injuries and illnesses. Accordingly, there may be bias due to errors in the data and misclassification. Additionally, workers' compensation claims data may underestimate the true work-injury rate and this could introduce bias in the study findings. For example, previous research in British Columbia found that while the majority of work-related fatalities and serious injuries were found in workers' compensation data, additional work-related fatalities and injuries could be found in coroners' reports and hospitalization records (Koehoorn et al., 2015). However, for under-reporting to bias the results away from a null (or no effect of COR on injury rates), COR firms, while certified, would have had to have a greater under-reporting rate than when not certified.

The observational research design used with DiD and matching can provide a causal test of the effect of an intervention. Nonetheless, assumptions of the model need to be met with respect to proportionality of changes in the injury rate in the absence of the intervention. Furthermore, the matching method

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should sufficiently identify appropriate control firms. Even after matching, there were instances where a statistically significant difference was observed at baseline between COR and non-COR firms, such as overall disabling injury model (Appendix 3).

Another limitation of the data is how the full-time equivalent (FTE) and firm size variables are calculated. Firm size is derived using assessable payroll and industry average earnings. This measure can underestimate the number of workers in a firm due it being calculated from the assessable payroll and this could introduce bias if the assessment of firm payroll is distributed differentially across COR and non-COR firms. The FTE variable is a key component of the negative binomial in that it enabled the estimation of a rate ratio conditional on the number of workers exposed.

The inclusion of additional variables may have better identified control firms to match to intervention firms. A variable unavailable in the data extract for this project is the registration date of a firm that would have been permitted the calculation of number of years a firm has been in business. Other relevant variables for inclusion in future evaluations could relate to safety compliance of firms and history of regulatory compliance history (e.g., inspections and penalties) as well as baseline measures of firms' occupational health and safety practices and safety culture.

Implications for policy and practice

The implications of our findings are threefold.

First, the difference in COR effectiveness on lost time and disabling injuries indicates that a broader range of work injury measures need to be examined, including the effect on overall work injuries as well as component injury types such as medical aid only through to fatalities.

Second, we found no association of SECOR certification or audit score on firm injuries. This finding, coupled with similar research in British Columbia (on the distribution of audit scores among small firms and via internal auditing), indicates the OHSMS certification is not effective in all circumstances and that validity of the audit may vary by audit and auditor type. Improvements to the COR program could focus on these areas.

Third, our study found that COR certification was effective when comparing COR-certified firms to similar non-certified firms. These finding may not generalize to firms with different characteristics, sectors or jurisdictions. The effectiveness of COR certification may be context- and firm-dependent and relate to quality of the audit, auditor and certification process, as well as the ability of a firm to adopt OHS policies and practices.

Further research

This study leads to the following areas of future research.

First, while we found a association between the overall COR score and firm injury rates, for many component elements there is very little score variation. Additional research examining which elements and which specific audit questions are associated with injury outcomes may help improve the audit process and also identify where to prioritize OHS education and training.

Second, evaluating the economic aspects of the program such as the effect of different rebate types on COR participation and injury outcomes, as well as the relationship of COR certification on claim cost, can assess the economic incentives related to COR certification and support a formal cost-benefit analysis of the program.

Third, COR is only one of many OHS program or tools available to OHS regulators. Examining the relationship between COR certification and other regulatory approaches such as inspections or compliance may lead to a more integrated approach across the spectrum of OHS activities.

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Appendices

List of current knowledge translation activities

Presentations

McLeod C, Aderounmu A, Quirke W, Marino S. (2017). Partners in Injury Reduction evaluation in Alberta. Is COR associated with lower firm-level injury rates in Alberta? Presentation to the Ministry of Labour. 23rd of October, 2017. Edmonton, Alberta.

McLeod C, Aderounmu A, Quirke W, Marino S. (2017). Partners in Injury Reduction evaluation in Alberta. Is COR associated with lower firm-level injury rates in Alberta? Presentation to WCB-Alberta. 24th of October, 2017. Edmonton, Alberta.

McLeod C, Macpherson R, Keefe A, Aderounmu A, Quirke W, Koehoorn M. (2018). Partners in Injury Reduction evaluation in Alberta. Is COR associated with lower firm-level injury rates in Alberta? Presentation to the Ministry of Labour COR evaluation team. 22nd of March, 2017. Edmonton, Alberta.

McLeod C, Macpherson R, Keefe A, Aderounmu A, Quirke W, Koehoorn M. (2018). Partners in Injury Reduction evaluation in Alberta. Is COR associated with lower firm-level injury rates in Alberta? Presentation to the Assistant Deputy Minister of Labour. 22nd of March, 2017. Edmonton, Alberta.

Research brief

McLeod C, Macpherson R, Keefe A, Aderounmu A, Quirke W, Koehoorn M. (2018). Is the Certificate of Recognition program associated with lower firm-level injury rates? Research brief for the Alberta Ministry of Labour. Partnership for Work, Health and Safety. School of Population and Public Health. University of British Columbia, Vancouver, British Columbia.

Details of the Certificate of Recognition (COR)

A Certificate of Recognition (COR) is valid for three years from the date of issue (last day of audit data collection), provided that annual maintenance requirements are met. Usually, an employer will renew their COR near the end of the three-year period. However, an employer may renew their COR at any time by conducting another successful external audit.

Appendix 1 COR types

Type	Description
SECOR	The Small Employer Certificate of Recognition (SECOR) program is available to small employers (10 or fewer employees). To obtain a SECOR, an employer must use a version of the Partnerships Audit Standard specifically designed to meet the application and training needs of small employers - a modified instrument with fewer requirements. The employer must conduct a self-assessment of its health and safety management system and then have the assessment reviewed by their certifying partner.
MECOR	The Medium Employer Certificate of Recognition (MECOR) program is available to employers who have a maximum of 30 employees and whose health and safety management system meets the Partnerships standard. The MECOR process is completed over a three-year cycle. An external small employer audit is completed in the first year, and the regular COR audit instrument is used to maintain certification in the two subsequent years. Once the employer successfully completes the three-year MECOR cycle or fails to meet the standard in any of the three participation years, the employer must use the regular COR process to attain certification. The employer may not participate in the MECOR program again.
COR	Regular COR audit for employers with 20 or more employees. To obtain COR, an employer must hire an external auditor to audit their health and safety management system, then have the audit reviewed by their certifying partner.

Appendix 2 Industry subsectors based on SIC 1980 codes

Code	Description
1	Agriculture and related service (UNS)
2	Logging and forestry (UNS)
3	Logging industry
4	Mining (including milling, quarrying and oil well) (UNS)
5	Crude petroleum and natural gas industries
6	Service industries incremental to crude petroleum and natural gas
7	Manufacturing (UNS)
8	Sash, door and other millwork industries
9	Fabricated structural metal products industries
10	Machine shop industry
11	Construction (UNS)
12	Residential building and development
13	Non-residential building and development
14	Industrial construction (other than buildings)
15	Highway and heavy construction
16	Site work
17	Structural and related work
18	Exterior close-in work
19	Plumbing, heating and air conditioning, mechanical work
20	Machinery specialty work
21	Electrical work
22	Interior and finishing work
23	Other trade work
24	Transportation and storage (UNS)
25	Truck transport industries
26	Communication and other utility
27	Wholesale trade (UNS)
28	Petroleum products, wholesale
29	Construction, forestry and mining machinery, equipment and supplies, wholesale
30	Other machinery, equipment and supplies
31	Waste materials, wholesale
32	Motor vehicle repair shops
33	Retail trade (UNS)
34	Other retail stores
35	General administrative services
36	Educational service (UNS)
37	Health and social service (UNS)
38	Other institutional health and social services
39	Offices of other health practitioners
40	Business service (UNS)
41	Architectural, engineering and other scientific and technical services
42	Accommodation, food and beverage service (UNS)
43	Other service (UNS)
44	Machinery and equipment rental and leasing services
45	Services to buildings and dwellings

Note: UNS refers to unspecified subsectors are SIC minor groups aggregated to SIC division codes.

Final Report: Is COR associated with lower firm-level injury rates?

Regression tables

Appendix 3 GEE negative binomial regression results, unmatched and matched sample, lost time and disabling injuries

	Lost time injuries				Disabling injuries			
	Unmatched		Matched		Unmatched		Matched	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.11	(1.07, 1.14)	1.02	(0.98, 1.06)	1.16	(1.13, 1.20)	1.08	(1.04, 1.12)
2001-2015	0.79	(0.77, 0.81)	0.86	(0.83, 0.88)	0.93	(0.91, 0.96)	0.97	(0.94, 1.00)
Firm years	2,066,568		273,083		2,066,568		273,083	
Firms	265,478		25,715		265,478		25,715	

<u>Note</u>: IRR = incidence rate ratio. CI = confidence interval. FTE = full time equivalent. UNS = unspecified.

Appendix 4 GEE negative binomial regression results by time, lost time and disabling injuries with and without lost time injuries

	Lost time injuries		Disabling injuries		Disabling injuries (w/o LT)	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.03	(0.98, 1.07)	1.09	(1.05, 1.14)	1.58	(1.44, 1.74)
2001-2005	0.88	(0.85, 0.92)	1.04	(1.00, 1.09)	1.47	(1.35, 1.59)
2006-2010	0.88	(0.85, 0.92)	0.98	(0.95, 1.01)	1.28	(1.19, 1.38)
2011-2015	0.79	(0.75, 0.82)	0.87	(0.84, 0.91)	0.98	(0.90, 1.07)
Firm years	273,083		273,083		273,083	
Firms	25,715		25,715		25,715	

<u>Note</u>: This table and all subsequent tables use fully matched samples.

Appendix 5 GEE negative binomial regression results by sector, lost time injuries

	Construction		Transportation		Mining		Manufacturing	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.91	(0.85, 0.98)	1.04	(0.93, 1.16)	1.08	(0.92, 1.26)	1.01	(0.93, 1.09)
2001-15	0.91	(0.87, 0.96)	0.80	(0.72, 0.89)	1.05	(0.91, 1.20)	0.75	(0.70, 0.80)
Firm years	109,658		48,561		27,498		27,733	
Firms	10,379		4,680		2,888		2,395	

	Trade		Business		Government		Agriculture	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.11	(0.99, 1.26)	1.04	(0.88, 1.22)	1.37	(1.18, 1.58)	1.01	(0.79, 1.29)
2001-15	0.79	(0.73, 0.86)	0.99	(0.89, 1.10)	0.89	(0.81, 0.97)	1.05	(0.83, 1.33)
Firm years	25,169		17,729		9,444		7,291	
Firms	2,238		1,601		821		713	

Appendix 6 GEE negative binomial regression results by sector, disabling injuries

	Construction		Transportation		Mining		Manufacturing	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.97	(0.91, 1.03)	1.07	(0.96, 1.18)	1.16	(0.99, 1.36)	1.13	(1.04, 1.22)
2001-15	1.02	(0.97, 1.07)	0.90	(0.82, 0.99)	1.18	(1.03, 1.35)	0.89	(0.84, 0.94)
Firm years	109,658		48,561		27,498		27,733	
Firms	10,379		4,680		2,888		2,395	

	Trade		Business		Government		Agriculture	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.18	(1.05, 1.33)	1.09	(0.92, 1.30)	1.40	(1.21, 1.62)	1.02	(0.80, 1.30)
2001-15	0.90	(0.83, 0.97)	1.09	(0.99, 1.21)	0.93	(0.86, 1.01)	1.13	(0.90, 1.42)
Firm years	25,169		17,729		9,444		7,291	
Firms	2,238		1,601		821		713	

Appendix 7 GEE negative binomial regression results by sector and period, lost time injuries

	Construction		Transportation		Mining		Manufacturing	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.92	(0.86, 0.99)	1.05	(0.94, 1.18)	1.10	(0.94, 1.29)	1.01	(0.93, 1.09)
2001-05	0.92	(0.86, 0.99)	0.86	(0.75, 0.98)	1.11	(0.93, 1.32)	0.77	(0.71, 0.84)
2006-10	0.97	(0.91, 1.03)	0.82	(0.72, 0.93)	1.06	(0.89, 1.26)	0.77	(0.71, 0.84)
2011-15	0.81	(0.75, 0.88)	0.72	(0.63, 0.82)	0.88	(0.71, 1.09)	0.69	(0.62, 0.77)
Firm years	109,658		48,561		27,498		27,733	
Firms	10,379		4,680		2,888		2,395	

	Trade		Business		Government		Agriculture	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.12	(0.99, 1.26)	1.04	(0.88, 1.23)	1.37	(1.18, 1.59)	1.01	(0.79, 1.29)
2001-05	0.87	(0.77, 0.98)	1.02	(0.89, 1.16)	0.87	(0.78, 0.97)	0.99	(0.73, 1.35)
2006-10	0.75	(0.68, 0.83)	1.03	(0.91, 1.17)	0.94	(0.84, 1.05)	1.20	(0.89, 1.63)
2011-15	0.79	(0.70, 0.89)	0.91	(0.78, 1.07)	0.84	(0.74, 0.96)	0.95	(0.62, 1.45)
Firm years	25,169		17,729		9,444		7,291	
Firms	2,238		1,601		821		713	

Appendix 8 GEE negative binomial regression results by sector and period, disabling injuries

	Construction		Transportation		Mining		Manufacturing	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.98	(0.92, 1.05)	1.08	(0.97, 1.20)	1.19	(1.02, 1.40)	1.13	(1.04, 1.23)
2001-05	1.08	(1.02, 1.15)	0.97	(0.86, 1.09)	1.29	(1.09, 1.53)	0.95	(0.88, 1.02)
2006-10	1.05	(0.99, 1.11)	0.91	(0.82, 1.02)	1.17	(1.00, 1.37)	0.90	(0.83, 0.96)
2011-15	0.91	(0.85, 0.97)	0.82	(0.73, 0.92)	0.91	(0.75, 1.10)	0.81	(0.74, 0.88)
Firm years	109,658		48,561		27,498		27,733	
Firms	10,379		4,680		2,888		2,395	

	Trade		Business		Government		Agriculture	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.19	(1.06, 1.34)	1.10	(0.92, 1.31)	1.40	(1.21, 1.62)	1.03	(0.81, 1.31)
2001-05	1.05	(0.93, 1.19)	1.16	(1.02, 1.33)	0.91	(0.82, 1.01)	1.11	(0.84, 1.47)
2006-10	0.86	(0.78, 0.94)	1.10	(0.97, 1.25)	1.00	(0.90, 1.10)	1.25	(0.93, 1.68)
2011-15	0.86	(0.77, 0.95)	1.02	(0.89, 1.17)	0.88	(0.78, 0.99)	0.97	(0.64, 1.47)
Firm years	25,169		17,729		9,444		7,291	
Firms	2,238		1,601		821		713	

Appendix 9 GEE negative binomial regression results by sector and COR type, lost time injuries

	Construction				Transportation			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.95	(0.88, 1.03)	0.81	(0.72, 0.91)	1.14	(0.99, 1.32)	0.68	(0.58, 0.79)
2001-15	0.90	(0.85, 0.95)	1.01	(0.90, 1.14)	0.81	(0.72, 0.91)	0.90	(0.77, 1.06)
Firm years		57,298		55,796		15,069		34,997
Firms		5,163		5,450		1,320		3,444

	Mining				Manufacturing			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.23	(1.00, 1.51)	0.77	(0.61, 0.97)	1.06	(0.96, 1.16)	0.96	(0.73, 1.28)
2001-15	1.07	(0.92, 1.26)	1.01	(0.80, 1.27)	0.74	(0.69, 0.80)	0.76	(0.58, 0.99)
Firm years		11,179		17,116		20,001		6,664
Firms		1,173		1,804		1,698		617

	Trade				Business			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm No intervention	1.18	(1.04, 1.34)	0.60	(0.42, 0.86)	1.17	(1.00, 1.37)	0.73	(0.43, 1.24)
2001-15	0.78	(0.72, 0.85)	1.42	(0.98, 2.06)	0.90	(0.80, 1.00)	1.64	(0.93, 2.90)
Firm years		16,352		8,513		12,205		5,697
Firms		1,351		866		1,033		570

	Government				Agriculture			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.35	(1.16, 1.57)	0.44	(0.16, 1.25)	0.93	(0.65, 1.31)	1.31	(0.89, 1.93)
2001-15	0.86	(0.79, 0.95)	1.06	(0.33, 3.41)	1.25	(0.91, 1.70)	0.87	(0.60, 1.26)
Firm years		7,320		1,997		2,780		4,774
Firms		582		234		274		451

Appendix 10 GEE negative binomial regression results by sector and COR type, disabling injuries

	Construction				Transportation			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.02	(0.95, 1.10)	0.82	(0.74, 0.92)	1.17	(1.02, 1.34)	0.70	(0.60, 0.80)
2001-15	1.00	(0.95, 1.05)	1.09	(0.97, 1.21)	0.93	(0.84, 1.02)	0.96	(0.83, 1.12)
Firm years		57,298		55,796		15,069		34,997
Firms		5,163		5,450		1,320		3,444

	Mining				Manufacturing			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.34	(1.10, 1.65)	0.82	(0.67, 1.02)	1.18	(1.07, 1.29)	0.99	(0.76, 1.30)
2001-15	1.18	(1.02, 1.38)	1.12	(0.92, 1.36)	0.89	(0.84, 0.95)	0.78	(0.60, 1.02)
Firm years		11,179		17,116		20,001		6,664
Firms		1,173		1,804		1,698		617

	Trade				Business			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm No intervention	1.24	(1.10, 1.39)	0.61	(0.44, 0.86)	1.23	(1.05, 1.44)	0.64	(0.39, 1.07)
2001-15	0.89	(0.82, 0.96)	1.42	(1.00, 2.02)	0.99	(0.90, 1.10)	2.03	(1.19, 3.44)
Firm years		16,352		8,513		12,205		5,697
Firms		1,351		866		1,033		570

	Government				Agriculture			
	COR		SECOR		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.38	(1.19, 1.60)	0.44	(0.15, 1.27)	0.96	(0.68, 1.34)	1.34	(0.90, 1.98)
2001-15	0.91	(0.84, 0.99)	1.29	(0.41, 4.06)	1.33	(1.00, 1.76)	0.87	(0.60, 1.27)
Firm years		7,320		1,997		2,780		4,774
Firms		582		234		274		451

Appendix 11 GEE negative binomial regression results by funded and non-funded certifying partners, lost time and disabling injuries

	Lost time injuries				Disabling injuries			
	Funded		Non-Funded		Funded		Non-Funded	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.98	(0.94, 1.03)	1.02	(0.98, 1.06)	1.05	(1.00, 1.09)	1.08	(1.04, 1.12)
2001-15	0.86	(0.83, 0.89)	0.86	(0.83, 0.88)	0.97	(0.94, 1.01)	0.97	(0.94, 1.00)
Firm years		244,159		273,083		244,159		273,083
Firms		22,997		25,715		22,997		25,715

Appendix 12 GEE negative binomial regression results by sector and certifying partner, lost time injuries

	All sectors				
	AASP		ASC		
	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.16	(1.07, 1.25)	1.17	(1.02, 1.33)	
2000-2015	0.84	(0.79, 0.91)	0.83	(0.74, 0.93)	
Firm years		138,936		124,191	
Firms		13,234		11,794	

	Construction						
	AASP		ACSA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	0.99	(0.85, 1.15)	0.94	(0.87, 1.01)	0.67	(0.57, 0.78)	
2000-2015	1.03	(0.88, 1.22)	0.89	(0.84, 0.95)	0.97	(0.84, 1.12)	
Firm years		51,439		90,222		56,382	
Firms		5,021		8,528		5,445	

	Transportation								
	AASP		ACSA		AMTA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.09	(0.87, 1.38)	0.79	(0.64, 0.97)	1.18	(1.00, 1.38)	0.66	(0.55, 0.77)	
2000-2015	0.77	(0.59, 0.99)	0.93	(0.75, 1.15)	0.77	(0.66, 0.90)	0.96	(0.81, 1.13)	
Firm years		24,966		26,378		35,022		28,254	
Firms		2,420		2,547		3,421		2,722	

	Mining						
	AASP		ACSA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.15	(0.80, 1.65)	1.08	(0.83, 1.41)	1.07	(0.90, 1.26)	
2000-2015	0.91	(0.64, 1.30)	0.90	(0.68, 1.18)	1.09	(0.93, 1.28)	
Firm years		13,408		13,710		21,050	
Firms		1,473		1,488		2,217	

	Manufacturing							
	AASP		ACSA		ESC		MHSA	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.05	(0.88, 1.24)	0.93	(0.82, 1.05)	0.71	(0.57, 0.89)	1.09	(0.98, 1.21)
2000-2015	0.85	(0.72, 1.02)	0.77	(0.69, 0.87)	0.82	(0.66, 1.00)	0.69	(0.63, 0.76)
Firm years		14,245		17,313		14,703		16,882
Firms		1,221		1,488		1,268		1,430

	Trade					
	AASP		ACSA		ESC	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	1.30	(1.13, 1.50)	1.09	(0.85, 1.40)	0.58	(0.45, 0.75)
2000-2015	0.76	(0.68, 0.86)	0.70	(0.60, 0.82)	0.96	(0.77, 1.19)
Firm years		16,119		15,037		16,248
Firms		1,385		1,295		1,425

	Agriculture	
	AFPA	
	IRR	95% CI
COR firm Intervention	0.73	(0.53, 0.99)
2000-2015	1.27	(0.92, 1.75)
Firm years		4,724
Firms		475

Appendix 13 GEE negative binomial regression results by sector and certifying partner, disabling injuries

	All sectors				
	AASP		ASC		
	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.20	(1.11, 1.29)	1.23	(1.09, 1.40)	
2000-2015	0.95	(0.89, 1.02)	0.96	(0.86, 1.06)	
Firm years	138,936		124,191		
Firms	13,234		11,794		

	Construction						
	AASP		ACSA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	0.96	(0.83, 1.12)	1.00	(0.94, 1.07)	0.71	(0.61, 0.82)	
2000-2015	1.16	(1.00, 1.34)	1.01	(0.96, 1.06)	1.07	(0.94, 1.21)	
Firm years	51,439		90,222		56,382		
Firms	5,021		8,528		5,445		

	Transportation								
	AASP		ACSA		AMTA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.11	(0.90, 1.37)	0.87	(0.72, 1.06)	1.17	(1.01, 1.36)	0.74	(0.63, 0.86)	
2000-2015	0.88	(0.70, 1.11)	1.01	(0.83, 1.22)	0.85	(0.74, 0.97)	1.01	(0.86, 1.19)	
Firm years	24,966		26,378		35,022		28,254		
Firms	2,420		2,547		3,421		2,722		

	Mining						
	AASP		ACSA		ESC		
	IRR	95% CI	IRR	95% CI	IRR	95% CI	
COR firm Intervention	1.04	(0.75, 1.43)	1.22	(0.96, 1.55)	1.19	(0.98, 1.44)	
2000-2015	1.03	(0.74, 1.41)	1.06	(0.86, 1.30)	1.17	(0.97, 1.40)	
Firm years	13,408		13,170		21,050		
Firms	1,473		1,488		2,217		

	Manufacturing										
	AASP			ACSA			ESC			MHSA	
	IRR	95% CI		IRR	95% CI		IRR	95% CI		IRR	95% CI
COR firm Intervention	1.22	(1.04, 1.42)		1.08	(0.96, 1.22)		0.80	(0.65, 0.98)		1.18	(1.07, 1.31)
2000-2015	0.95	(0.83, 1.09)		0.90	(0.81, 1.00)		0.99	(0.83, 1.18)		0.85	(0.78, 0.92)
Firm years		14,245			17,313		14,703			16,882	
Firms		1,221			1,488		1,268			1,430	

	Trade								
	AASP			ACSA			ESC		
	IRR	95% CI		IRR	95% CI		IRR	95% CI
COR firm Intervention	1.38	(1.20, 1.59)		1.17	(0.93, 1.46)		0.64	(0.51, 0.81)
2000-2015	0.85	(0.76, 0.96)		0.84	(0.73, 0.97)		1.09	(0.90, 1.33)
Firm years		16,119			15,037		16,248	
Firms		1,385			1,295		1,425	

	Agriculture	
	AFPA	
	IRR	95% CI
COR firm Intervention	0.71	(0.53, 0.97)
2000-2015	1.42	(1.05, 1.92)
Firm years		4,724
Firms		475

Appendix 14 GEE negative binomial regression results by firm size, lost time and disabling injuries

	Lost time injuries				Disabling injuries			
	0-19 FTEs		20+ FTEs		0-19 FTEs		20+ FTEs	
	IRR	95% CI	IRR	95% CI	IRR	95% CI	IRR	95% CI
COR firm Intervention	0.88	(0.83, 0.93)	1.08	(1.02, 1.15)	0.94	(0.89, 0.99)	1.17	(1.10, 1.24)
2001-15	0.91	(0.86, 0.95)	0.84	(0.81, 0.87)	0.99	(0.95, 1.04)	0.96	(0.93, 0.99)
Firm years	202,863		73,581		202,863		73,581	
Firms	19,812		6,173		19,812		6,173	

Final Report: Is COR associated with lower firm-level injury rates?

Appendix 15 GEE negative binomial regression results by period and COR years, lost time and disabling injuries

	Lost time injuries		Disabling injuries	
	IRR	95% CI	IRR	95% CI
COR firm	1.03	(0.99, 1.07)	1.09	(1.05, 1.14)
Intervention				
2001-2005	0.88	(0.84, 0.92)	1.04	(1.00, 1.08)
2006-2010	0.90	(0.86, 0.93)	0.97	(0.94, 1.01)
2011-2015	0.81	(0.77, 0.85)	0.87	(0.83, 0.91)
COR years				
1-3		Ref.		Ref.
4-12	0.96	(0.93, 0.99)	1.01	(0.98, 1.04)
13-15	0.90	(0.83, 0.97)	0.94	(0.88, 1.00)
2001-2005 * 1-3	0.88	(0.84, 0.92)	1.04	(1.00, 1.08)
2006-2010 * 1-3	0.90	(0.86, 0.93)	0.97	(0.94, 1.01)
2006-2010 * 4-12	0.86	(0.83, 0.90)	0.98	(0.94, 1.02)
2011-2015 * 1-3	0.81	(0.77, 0.85)	0.87	(0.83, 0.91)
2011-2015 * 4-12	0.78	(0.74, 0.82)	0.88	(0.84, 0.92)
2011-2015 * 13-15	0.73	(0.67, 0.79)	0.81	(0.76, 0.87)
Firm years		273,083		273,083
Firms		25,715		25,715

Appendix 16 GEE negative binomial regression results of audit score by COR and certifying partner, lost time injuries

	All		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.02	(0.911, 1.147)	1.162	(0.865, 1.561)	0.877	(0.719, 1.068)
90-94	1.15	(1.027, 1.284)	1.303	(0.967, 1.754)	0.924	(0.758, 1.127)
85-89	1.16	(1.032, 1.295)	1.283	(0.951, 1.730)	1.034	(0.846, 1.265)
80-84	1.29	(1.150, 1.456)	1.43	(1.058, 1.931)	0.877	(0.666, 1.156)
Firm years		44,750		22,159		22,230
Firms		9,152		4,595		5,049

	ACSA		ESC		AASP	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.02	(0.870, 1.197)	1.017	(0.686, 1.510)	1.106	(0.805, 1.520)
90-94	1.19	(1.025, 1.381)	1.207	(0.830, 1.754)	1.184	(0.865, 1.620)
85-89	1.228	(1.052, 1.433)	1.256	(0.860, 1.834)	1.279	(0.927, 1.764)
80-84	1.398	(1.183, 1.652)	1.548	(1.067, 2.246)	1.401	(1.006, 1.951)
Firm years		19,079		10,535		7,117
Firms		4,078		2,187		1,731

	AMTA		MHSA		ASC	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.09	(0.750, 1.584)	0.932	(0.266, 3.258)	1.331	(0.397, 4.465)
90-94	1.098	(0.748, 1.611)	0.82	(0.231, 2.907)	1.841	(0.587, 5.777)
85-89	0.915	(0.622, 1.347)	0.821	(0.231, 2.917)	1.765	(0.557, 5.593)
80-84	1.088	(0.727, 1.630)	1.055	(0.293, 3.794)	2.013	(0.634, 6.395)
Firm years		4,175		1,294		1,118
Firms		927		253		249

Appendix 17 GEE negative binomial regression results by COR type and certifying partner, disabling injuries

	All		COR		SECOR	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.07	(0.967, 1.183)	1.05	(0.859, 1.284)	0.908	(0.747, 1.104)
90-94	1.17	(1.066, 1.293)	1.154	(0.942, 1.415)	0.93	(0.777, 1.114)
85-89	1.17	(1.064, 1.297)	1.135	(0.925, 1.393)	1.015	(0.841, 1.224)
80-84	1.27	(1.143, 1.406)	1.23	(1.000, 1.513)	0.804	(0.625, 1.036)
Firm years		44,750		22,159		22,230
Firms		9,152		4,595		5,049

	ACSA		ESC		AASP	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.048	(0.912, 1.205)	1.09	(0.790, 1.503)	1.189	(0.898, 1.573)
90-94	1.204	(1.056, 1.374)	1.166	(0.857, 1.587)	1.24	(0.940, 1.636)
85-89	1.212	(1.058, 1.388)	1.217	(0.891, 1.661)	1.299	(0.973, 1.733)
80-84	1.361	(1.175, 1.576)	1.385	(1.018, 1.885)	1.345	(1.000, 1.809)
Firm years		19,079		10,535		7,117
Firms		4,078		2,187		1,731

	AMTA		MHSA		ASC	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
100		Ref.		Ref.		Ref.
95-99	1.046	(0.760, 1.440)	1.176	(0.460, 3.005)	1.272	(0.492, 3.289)
90-94	1.106	(0.797, 1.533)	1.047	(0.405, 2.712)	1.668	(0.672, 4.140)
85-89	0.977	(0.703, 1.360)	1.05	(0.404, 2.727)	1.629	(0.652, 4.068)
80-84	1.049	(0.740, 1.485)	1.238	(0.473, 3.239)	1.845	(0.727, 4.682)
Firm years		4,175		1,294		1,118
Firms		927		253		249