

## What occupational health and safety management system components predict firm work injury rates in the BC construction industry?

### Background

The British Columbia Construction Safety Alliance (BCCSA) Certificate of Recognition (COR®) is a voluntary audit-based incentive program. As part of the program, the occupational health and safety management system (OHSMS) performance of participating firms is assessed by an auditor using the BCCSA COR® audit tool (Table 1). Firms that successfully meet a set industry standard receive recognition and a workers' compensation premium rebate.

While audit based incentive programs are widely used, rigorous evaluations of their effectiveness, including the ability of audit scores to predict firm injury, are limited. Such evaluations are necessary to drive audit-program improvements and to ensure appropriate representation of safety constructs most important for firm injury prevention.

An earlier version of this work conducted in 2019, using BCCSA COR® audits conducted from 2012 to 2017, examined which elements and sub-elements were most predictive of firm work injury. The results found that specific elements were strongly related to firm injury and that a combination of 21 sub-elements collectively best predicted firm injury. A key recommendation from this work was to replicate the findings using additional, more recent and larger data samples to validate and update the findings.

Based on research presented in:  
McLeod CB, Jones AM. (2023). [British Columbia Construction Safety Alliance COR® Audit Tool: Predictive Validity Update. Final Report to WorkSafeBC and British Columbia Construction Safety Alliance.](#) Vancouver, BC: Partnership for Work, Health and Safety, University of British Columbia.

**Table 1 |** Element number and description, and number of sub-elements, on the BCCSA COR® audit tool

Element	# of sub-elements
1. Company health and safety policy	9
2. Workplace hazard assessment and control	11
3. Safe work practices	6
4. Safe job procedures	6
5. Company rules	5
6. Personal protective equipment	9
7. Preventative maintenance	7
8. Training and communication	15
9. Inspections	10
10. Investigations and reporting	10
11. Emergency preparedness	10
12. Records and statistics	8
13. Legislation	4
14. Joint Occupational Health and Safety	5

The current work is an update and extension of the work conducted in 2019. It addresses the recommendation outlined above through additional years of follow up as well as an improved analytic technique that includes resampling and validation methods to better identify which sub-elements collectively best predict firm injury.



## Approach

We used an observational study design. Firm audit scores were linked to workers' compensation data. Passed certification and recertification audits of construction firms conducted by an external auditor from 2012 to 2019 were extracted (N=1,426). Associations of the overall audit, audit element, and sub-element scores with the injury outcomes was examined using regression models. For the sub-elements, a parsimonious set of best predictors was identified using resampling, automated variable selection, and validation testing.

## What we found

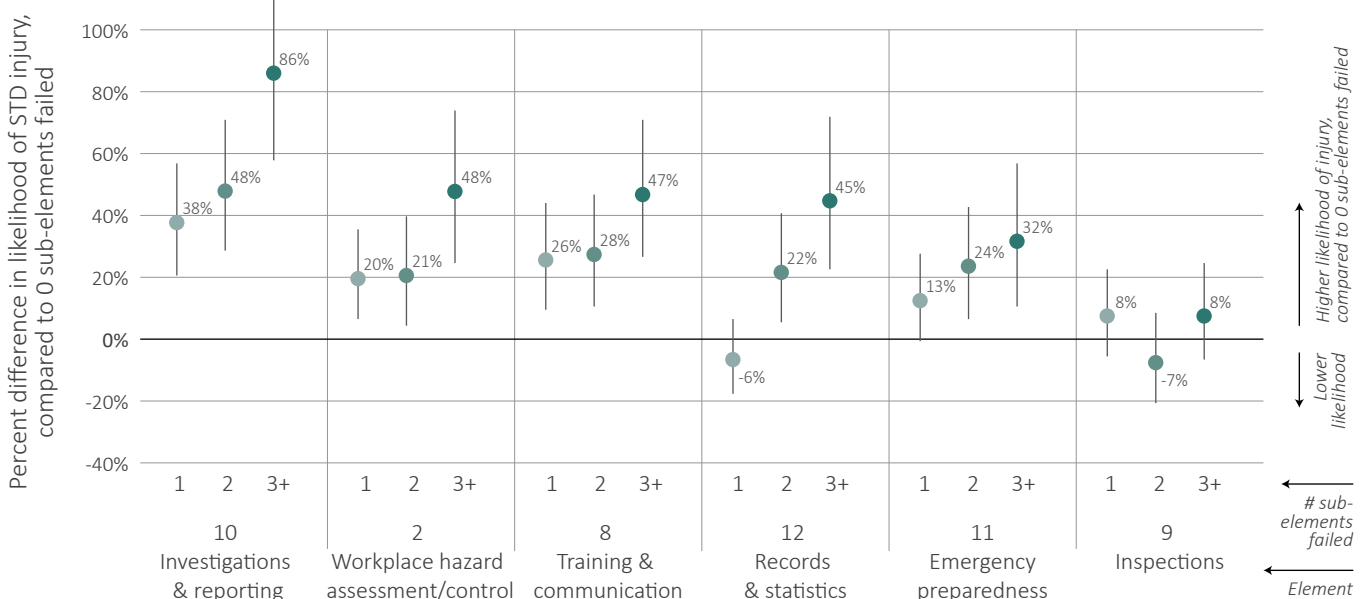
A higher overall audit score was a strong predictor of a lower firm work injury rate. Firms scoring in the lowest overall audit score quartile had a short term disability (STD) injury rate that was 56% (95% confidence interval (CI): 36 to 78%) higher than similar firms in the highest quartile (Fig. 1). These findings were replicated in analyses restricted to audits for small firms (less than 50 full time equivalents (FTEs)), large firms (50 or more FTEs), and specialty contractors.

**Figure 1 |** Difference in likelihood of short term disability (STD) and serious injury for high, middle, and lowest scoring firms compared to the highest scoring firms

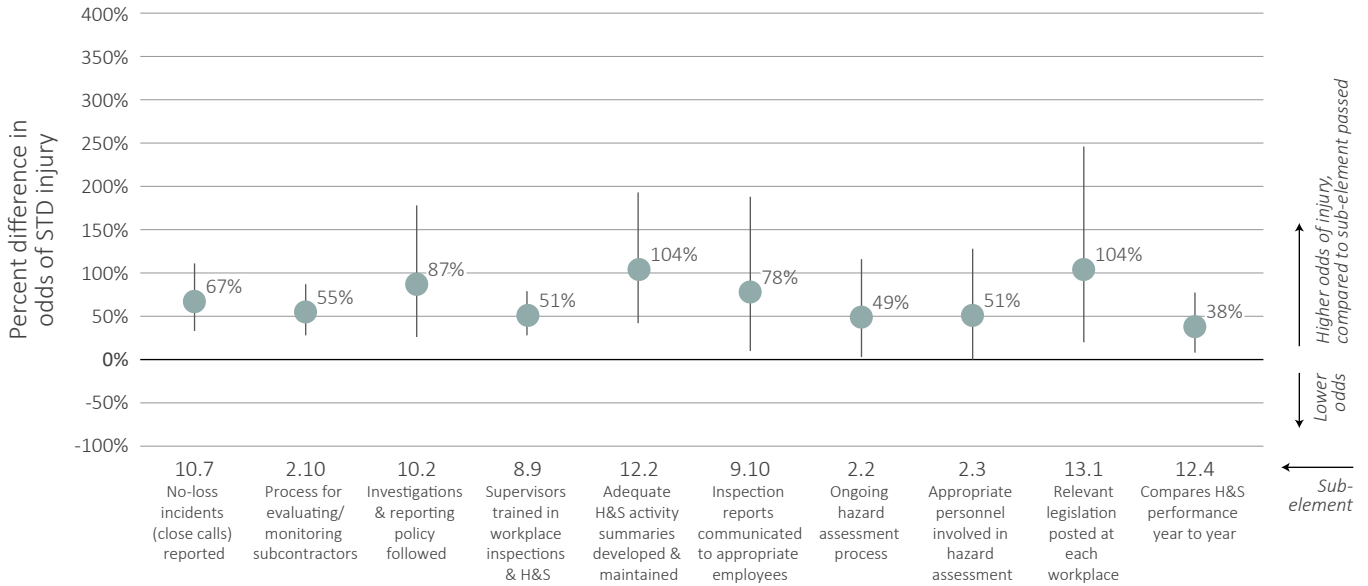


Only six of the 14 audit elements had sufficient score variability to discriminate between high and low performing firms. Of these, five were predictive of STD (Fig. 2). Element 10 (Investigations and reporting) was most strongly associated with STD. Firms that failed three or more sub-elements from Element 10 had an 86% higher STD injury rate than similar firms that failed zero sub-elements from Element 10.

**Figure 2 |** Impact of 0, 1, 2, or 3+ failed sub-elements on the STD injury rate, for the most predictive elements



**Figure 3 | Top ten sub-elements that collectively best predict STD injury**



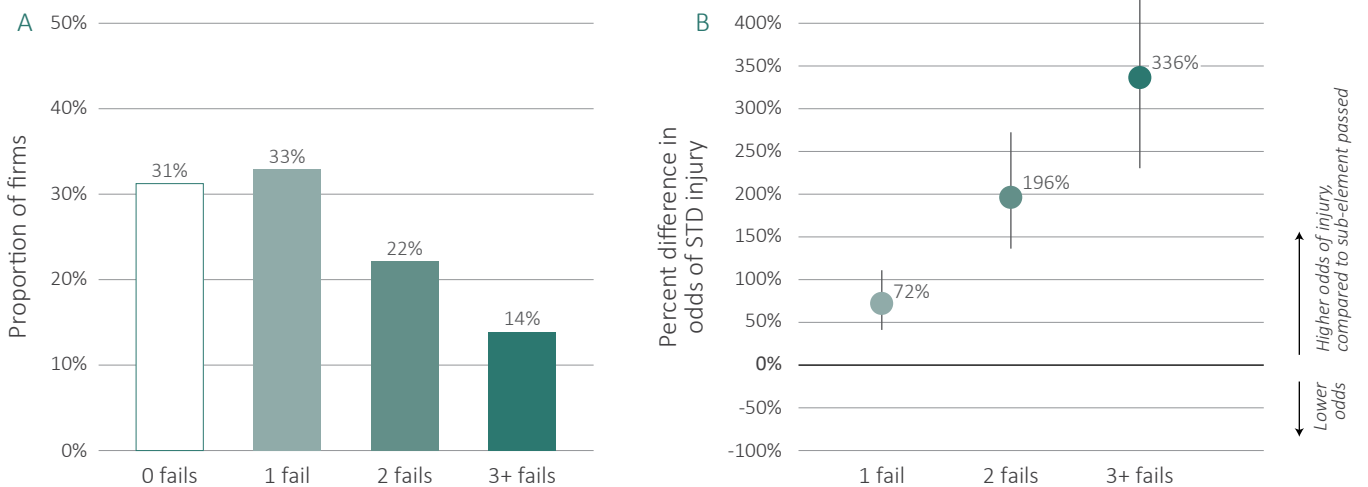
A combination of ten audit sub-elements largely drawn from the five predictive elements was found to best predict STD injury. In the final multi-variable model, failure of any one of these sub-elements was independently predictive of higher odds of STD (Fig. 3).

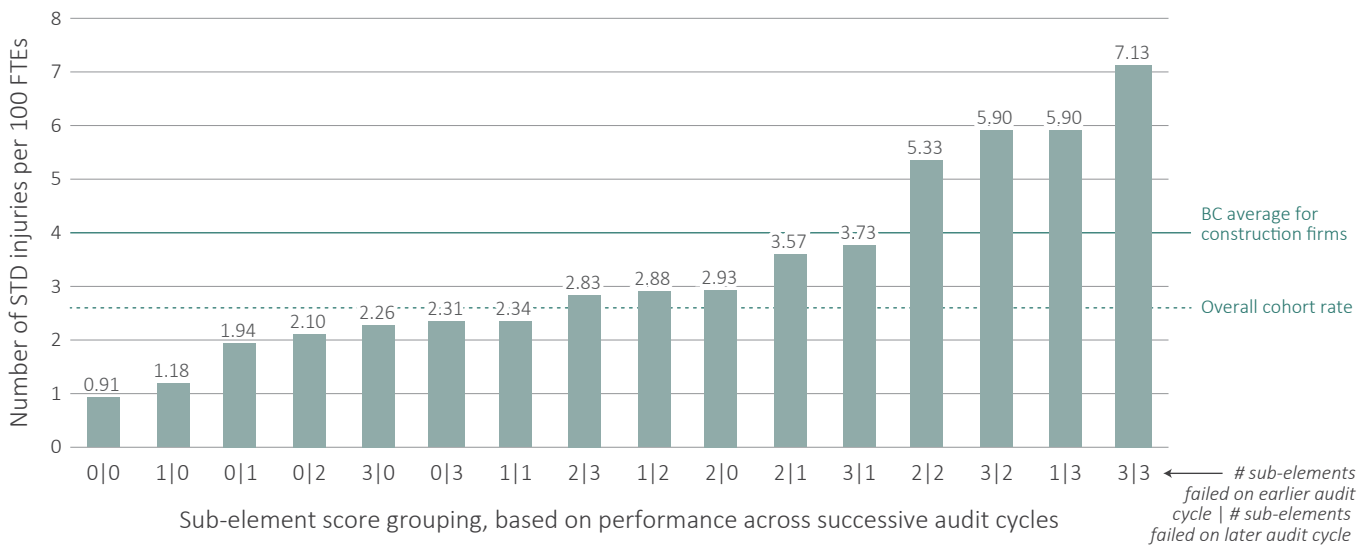
Thirty-one percent of audits failed zero of the top ten sub-elements, while 33%, 22% and 14% failed one, two, or three or more respectively (Fig. 4A). A strong dose response relationship was observed between the number of sub-elements failed (out of the top ten) and the

odds of STD injury. Compared to firms that failed zero of the ten sub-elements, firms that failed three or more had 336% (95% CI: 230 to 476%) higher odds of STD (Fig. 4B).

Firms’ performance on these ten sub-elements over time was a strong indicator of firm safety, even more so than performance on a single audit cycle. Firms that consistently failed three or more of the top ten sub-elements across subsequent audit cycles (labelled as group “3|3” in Fig. 5), had the highest group STD injury

**Figure 4 | Failure of 0, 1, 2, or 3+ of the top ten sub-elements: (A) Proportion of firms and (B) odds of STD injury**



**Figure 5 |** STD injury rate pooled across successive audit cycles grouped by performance on the top ten best sub-elements

rate (7.1 injuries per 100 FTEs). Likewise, firms that consistently passed all of the top ten sub-elements across subsequent audit cycles (labelled as group “0|0” in Fig. 5), demonstrated the lowest group STD injury rate (0.9 injuries per 100 FTEs). The worst performing group (“3|3”) had a group injury rate that was 7.8 times higher than the best performing group “0|0”, 2.8 times higher than the cohort average, and 1.8 times higher than the provincial average for construction firms.

The current findings for the overall audit score and individual element scores are similar to those reported in 2019. One minor difference being that in 2019, Element 9 (Inspections) was weakly predictive of STD whereas here, it was not predictive. In 2019, a set of 21 sub-elements that collectively best predicted STD was identified, whereas here, we identified a smaller set of ten sub-elements. This difference is likely due to methodological decisions made during the current project that lean towards a more parsimonious set of predictors (e.g. exclusion of sub-elements that are very rarely failed, use of resampling to prevent over-fitting of the data, and the decision to recognize a point of diminishing return during the model validation phase).

## What this means

The findings support use of the predictive elements and sub-elements (or their related occupational health and safety constructs) for assessing firm safety performance, as target areas for prevention or monitoring activities, and inclusion in OHSMS theoretical frameworks. The ten sub-elements identified may function well as a part of a sentinel or risk identification approach. Non-predictive elements and sub-elements may be due to question design or audit practices and the importance of these in preventing work injury cannot be ruled out.

For the BC construction industry, this research supports the idea that a more parsimonious audit tool could sufficiently capture differences in firm injury risk among construction firms. Target areas for improvement include changes to question design or audit practices for elements and sub-elements not currently predictive as well as overall simplification of the BCCSA audit tool. Findings from this research can inform other industry-based OHSMS programs, or firm level health and safety interventions, particularly those in construction, as well as theoretical frameworks. Ultimately, further research and efforts in this area, especially in high risk industries

like construction, can help build effective OHSMS to keep workers healthy and safe.

## Disclosure statement

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All inferences, opinions, and conclusions drawn in this brief are those of the authors, and do not reflect the opinions or policies of the BCCSA or WorkSafeBC.

## About us

The Partnership for Work, Health and Safety (PWHS) is an innovative research unit that combines rigorous work and health research with effective knowledge translation.

PWHS brings together policy-makers, researchers and data resources from national and international organizations to address current and emerging issues of work-related health in Canada. Our research is aimed at improving understanding of the causes and consequences of injuries and illness, identifying high-risk industries and occupations, and investigating the effectiveness of interventions that improve worker health, prevent occupational illness and injury, and reduce work-related disability.

Our collaboration, based on best practices of knowledge transfer, enables researchers and decision-makers to work together to identify relevant questions, understand data, and produce useful information to effectively inform policy and practice.

## More information

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