Original research

Unionisation and injury risk in construction: a replication study

Lynda S Robson ⓘ , Victoria Landsman ⓘ , Desiree Latour-Villamil, Hyunmi Lee, Cameron Mustard ⓘ

ABSTRACT

Objective To replicate, in a more recent time period, a previous cross-sectional study to estimate the association between unionisation and the risk of workers' compensation injury claims.

Methods The sampling frame was workers' compensation company account records in the industrial, commercial and institutional construction sector in the province of Ontario, Canada, 2012–2018. Company unionisation status was determined through linkage with records of unionised contractors. Outcomes were cumulative counts of workers' compensation injury claims, aggregated to company business. Risk ratios were estimated with multivariable negative binomial regression models. Models were also fit separately to lost-time claims stratified by company size.

Results Business unionisation was associated with a lower lost-time claim incidence (crude risk ratio, CRR=0.69, 95% CI 0.65 to 0.74); adjusted risk ratio, ARR=0.75, 95% CI 0.71 to 0.80). In subgroup analyses, the magnitude of the ARR declined as company size decreased and was not statistically significant for the smallest-sized companies of ≤4 full-time equivalent employees. Unionisation was associated (positively) with the incidence of no-lost-time claims in a crude model, but not in an adjusted one (CRR=1.80, 95% CI 1.71 to 1.89; ARR=1.04, 95% CI 0.98 to 1.09).

Conclusions Company unionisation was associated with a lower risk of lost-time workers' compensation injury claims, corroborating a similar study from an earlier time period. The protective effect of unionisation declined as company size decreased. In contrast to the previous study, a positive relationship between company unionisation and no-lost-time claim incidence was not found, due in part to a methodological refinement.

Key messages

What is already known about this subject?
► There are mixed findings regarding the association of unionisation and worker injury.
► Little research has been carried out in construction.
► A study in industrial, commercial and institutional (ICI) construction, 2006–2012, found a favourable association between business unionisation and lost-time workers' compensation injury claim incidence and an unfavourable one between unionisation and no-lost-time (medical-aid-only) claim incidence.

What are the new findings?
► Corroborating the earlier study in ICI construction, a favourable association between business unionisation and lost-time injury claim incidence was found for 2012–2018.
► This association was stronger in larger companies and was not found at all in companies with ≤4 full-time equivalent employees.
► In contrast to the earlier study, no association was found between unionisation and no-lost-time claim incidence, with the difference attributable in part to a methodological refinement.

How might this impact on policy or clinical practice in the foreseeable future?
► The apparent protective effect of unionisation should be considered by those making decisions about 'right-to-work' legislation affecting unions; public health practitioners seeking partners in occupational health and safety; and by decision-makers seeking indicators of better company safety performance.

INTRODUCTION
Unions have played an important role in developing occupational health and safety (OHS) protections. Unions have advocated for legislative advances[1][2] and for OHS provisions within collective agreements.[3][4] Unionisation has been associated with more stringent enforcement by authorities,[5][6] more effective joint-health-and-safety committees,[7] the presence of an OHS management system[8] and dissemination of OHS information[9]; and are known to conduct OHS research, provide OHS training and develop OHS interventions.[10] A clear understanding of the influences of unionisation on worker health and safety, especially in the context of declining unionisation in many jurisdictions, is important.[11–13]

Research investigating the relationship between unionisation and workplace injuries dates back decades, but findings have not been consistent with those anticipated from the above. Donado[14] reviewed 25 studies published up until 2009. They were based in the USA primarily; conducted in mining, manufacturing or across all sectors; and analysed at the level of individual, workplace or state. These studies typically found the expected

BMJ

protective relationship of unionisation with fatal injuries, whereas with non-fatal injuries, the relationship was usually found to be unfavourable. Reduced fatalities have continued to be favourably associated with unionisation in the studies published since the Donado review.[12 13 15 16] Findings based on non-fatal injuries have been inconsistent, with some showing a favourable relationship[14 17 18] and others an unfavourable one.[15 19]

To explain an unfavourable association between unionisation and non-fatal injuries, most studies in the Donado review[14] suggested differential reporting between unionised and non-unionised workplaces. The premise is a unionised setting, relative to one non-unionised, encourages more worker reporting of injuries because fear of employer reprisal is less. The presence of a union may also help ensure enterprises are reporting injuries to authorities. While Donado's own analysis,[14] based on self-reported work-related injury/illness provides evidence to the contrary, the work of Morantz[16] is consistent with the hypothesis. Her study found fatal injuries and severe traumatic injuries in US coal mines had a favourable relationship with unionisation, while two other types of injury outcomes—all other injuries and total non-fatal injuries—showed an unfavourable one. Her study illustrates the value of measuring injury outcomes of varying levels of severity, since more serious injuries should be less subject to differential reporting between unionised and non-unionised workplaces.

The cross-sectional analysis of Amick et al,[20] examining industrial, commercial and institutional (ICI) construction over 2006–2012 in Ontario, Canada, had similar findings to that of Morantz[16]: a favourable relationship between unionisation and workers' compensation injury claims requiring time away from work and an unfavourable one between unionisation and medical-aid-only injury claims. The Amick et al[20] study was the first in construction for some time[21 22] and involved more sophisticated statistical analyses than in those earlier studies. To the authors' knowledge, no other similar study has been conducted in the construction sector since then. However, Schofield et al[23] found unionisation was associated with a higher incidence of lost-time (LT) injury claims when it was included as a covariate in a construction-based study.

This study updates Amick et al,[20] using data from 2012 to 2018, with the same objective of estimating the association between business unionisation and the risk of various types of workers' compensation injury claims. This study extends the original work by examining how the association between the incidence of LT claims and contractor unionisation status varies by company size.

METHODS

More detail about the methods can be found in a recent grey literature report.[24]

Data sources

Workers' compensation records

Deidentified worker injury/illness claim records and company account records from 2012 to 2018 were obtained from Ontario's Workplace Safety and Insurance Board (WSIB). The WSIB is a provincial agency administering a single-payer no-fault workers' compensation scheme, under which all workers in the construction sector are covered, including, since 2013, those self-employed. Workers are insured for work-related physical injuries, illnesses and diseases. Occupational disease claims were excluded from this study.

Worker injury/illness claim record information included the incident date, the company account number and the classification unit to which the worker belonged. Classification unit was WSIB terminology corresponding to industrial sub-sector. Claims were of two types: allowed LT claims, for which time was lost from work, and allowed no-LT (NLT) claims for which there was medical aid only. Rejected and abandoned claims were not included. LT claims (only) were coded for nature of injury, part of body and nature of event. Since 95% of these claims were assigned a 'nature of injury' code corresponding to traumatic injury (as opposed to illness), this paper will refer to them as injury claims.

Company account information included annual information on legal company name, trade name (optional), address, postal code, phone number, classification unit type and the number of full-time equivalent employees (FTEs), which was computed from payroll dollars. Some companies had more than one line of business, each classified into a different classification unit; for these, business-level FTE information was obtained too.

Unionised contractor records

Twenty-four lists of companies holding a collective agreement with a building trade union and working in ICI construction ('unionised contractors') were obtained from 11 unions and 13 employer associations, thereby representing all types of ICI building trades. Under a collective agreement, a company must hire unionised workers if conducting work using the trade covered by the agreement. Labour relations in the Ontario ICI sector are regulated, with collective bargaining occurring simultaneously every 3 years. Access to these lists was facilitated by the Ontario Construction Secretariat, a joint management-labour non-profit organisation representing the interests of unions and unionised contractors in the ICI sector. Across all lists, there were 25 772 records.

Study sample

An initial sample of WSIB company account records included all companies whose largest line of business (based on payroll), for at least one of the years between 2012 and 2018, was classified into one of 39 classification units involving ICI construction trades (eg, Electrical Work), thereby aligning with the sector coverage of the 24 lists of unionised contractors. These 107 939 companies were composed of 123 224 lines of business (referred to as 'businesses' henceforth) and 515 205 business-years over 2012–2018. Exclusion criteria were then applied: (1) business-year if associated classification unit was not one of the 39 ICI classification units; (2) business-year if annual FTE information was missing and (3) business if cumulative annual FTEs for 2012–2018 was ≤1. The final sample used in analysis consisted of 60 425 businesses nested in 58 837 companies (figure 1).

Record linkage to identify unionised companies

Using five sequential steps, WSIB company account records were linked (matched) to unionised contractor records at the company level using company name, postal code and phone number. The steps used a combination of deterministic and probabilistic methods, including SAS functions SPEDIS and COMPGED, which compare text strings, the R software package text2vec,[25] which enabled text mining, and manual review.

If a WSIB company record was matched, it was classified as unionised. Matches were considered strong and included in the main analysis if at least two of three variables were matched. Matches were considered weak and included only in a sensitivity
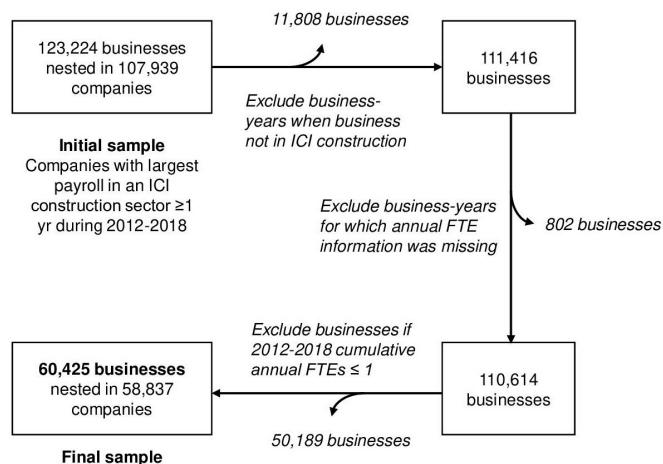
Figure 1 Sample construction. FTEs, full-time equivalent employees; ICI, industrial, commercial and institutional.

analysis if only name was matched. Of the sample of 60 425 businesses, 5267 were classified as unionised through strong matches and 6224 were classified as unionised based on strong and weak matches together.

Manual check of record linkage

After record linkage and deduplication, 15 813 unionised contractor records remained unmatched. A manual review of 200 of these unmatched records found seven matched with seven WSIB company records in the initial sample not previously matched, corresponding to five businesses in the final sample. This led to an estimate that $15\,813/200 \times 5 = 395$ businesses in the final sample had been misclassified; and therefore up to 94% (ie, $5267/(5267 + 395)$) of the potential matches to businesses had been found through the five linkage steps. Additional cross-checking of remaining unmatched records with non-sample WSIB employer records, a business registry, and the Internet suggested that no more than 8% were active construction companies (whether in ICI unknown).

Statistical analysis

All statistical analyses were performed with SAS V.9.4 with business (not company) as the unit of analysis.

Outcome variables

Outcome variables were cumulative counts of claims, 2012–2018: LT claims, NLT claims and total LT and NLT claims. A severe injury subcategory of LT claims was created, corresponding to injuries that jeopardised life, caused blindness or resulted in a loss of consciousness or a major amputation, burn or fracture.

Main independent variable

Unionisation was a dichotomous variable, which took value 1 if a WSIB company record had been matched to a unionised contractor record and 0 otherwise.

Additional independent variables

Company size was a five-level categorical variable (≤1, 2–4, 5–19, 20–49 and 50+) based on average annual FTEs at the company level over the years found in the sample for the company. Chosen category cut-off points reflect the regulatory environment.

Classification unit category (39 levels) was included to control for the different risks associated with different types of work.

Company complexity was a five-level categorical variable (1, 2, 3, 4 and 5+) corresponding to the number of businesses in the companies, since more complex organisations may have better resources for managing OHS.

Geographical region was a six-level variable created from the first letter of the postal code (K, L, M, N, P, 'other province or country') to control for regional variation in OHS culture, knowledge and regulatory enforcement.

Negative binomial regression models

To estimate the association between claim counts and unionisation, negative binomial (NB) regression models were fit to each of the four outcomes with log (FTE) as the offset (FTE in the offset were cumulative FTE at the business level). Crude models included unionisation as the only predictor. Adjusted models also included company size, classification unit, company complexity and geographical region variables. All crude and adjusted models with the full sample showed a dispersion coefficient consistent with an NB model. Model fit was considered satisfactory following visual inspection of rootograms.[26] Alternative approaches to modelling were explored, including using zero-inflated NB and zero-inflated Poisson models; using company size as continuous rather than categorical; and accounting for the nesting of businesses in companies. All had little impact on the unionisation effect estimate. Three sensitivity analyses were conducted to explore potential sources of bias associated with the matching processes or misalignment of the WSIB and unionised contractor sector coverage.

NB models were also fit separately to LT claims stratified by company size: ≤4, 5–19, 20–49 and 50+ FTEs. To allow model convergence in all subgroups, observations belonging to three smaller classification unit categories were first removed from all subgroups, reducing the total sample size to 60 337.

RESULTS

Description of the sample

Characteristics of the 60 425 businesses included in the analysis are summarised in table 1 and online supplemental appendix A. Comparing unionised and non-unionised businesses, large differences are seen in company size and complexity. More modest differences are seen with regard to industrial sector (online supplemental appendix A), though non-unionised firms had greater representation in painting and decorating, carpeting and flooring, terrazzo and tile work and roof shingling. Geographical distributions of the two groups were similar.

Table 2 examines the distribution of FTEs and claims by unionisation status. Although 8.7% of businesses were classified as unionised, 45% of FTEs were employed by them; and 31% of LT claims and 52% of NLT claims were attributed to them. The ratio of NLT claims to LT claims was 5.9 for unionised businesses and 2.5 for non-unionised.

Association of unionisation and injury claim incidence

Table 3 presents the main findings from a series of regression analyses. Substantial differences are seen between crude and adjusted risk ratio (ARR) estimates in the outcomes involving NLT claims. Unionisation was associated with a 25% lower risk of LT claims after adjustment. In contrast, for NLT claims, unionisation was associated with a statistically non-significant 4% elevation in risk.

Table 1 Characteristics of the sample of Ontario ICI construction businesses by unionisation status

	Unionised (n=5267)		Non-unionised (n 55 158)		
	n	%	n	%	P value
Annual full-time equivalent employees					<0.0001
≤1	894	17.0	32 646	59.2	
2–4	1034	19.6	13 636	24.7	
5–19	1640	31.1	7134	12.9	
20–49	823	15.6	1283	2.3	
50+	876	16.6	459	0.8	
Complexity (no of businesses in company)					<0.0001
1	3061	58.1	47 035	85.3	
2	1196	22.7	5977	10.8	
3	437	8.3	1353	2.5	
4	263	5.0	425	0.8	
5 or more	310	5.9	368	0.7	
Geographical region (first letter of postal code)					<0.0001
K	710	13.5	8059	14.6	
L	2197	41.7	23 282	42.2	
M	673	12.8	7690	13.9	
N	862	16.4	11 333	20.6	
P	485	9.2	3173	5.8	
Other	340	6.5	1621	2.9	

P values based on Pearson's χ^2 test for differences. The distribution of industrial subsector (classification unit) for unionised and non-unionised businesses is presented in online supplemental appendix A.
ICI, industrial, commercial and institutional.

The severe injury category of LT claims, with an ARR of 0.84 (95% CI 0.73 to 0.96), was found to have similar results to the category of all LT injury claims.

Association of unionisation of LT injury claim incidence by company size

The association between unionisation and LT injury claim incidence by company size was of interest because of the well-recognised differences in OHS capacity between large and small/medium-sized companies. As well, size was the most influential covariate in the regression analyses. After dividing the study sample of businesses into four groups, according to company size, analyses were carried out separately for each.

Table 2 Total numbers of businesses, FTEs and claims by unionisation status, 2012–2018

	Unionised		Non-unionised	
	No	Row %	No	Row %
No of businesses	5267	8.7	55 158	91.3
Annual FTEs, cumulative	772 797	44.6	958 186	55.4
Lost-time claims	5873	31.0	13 089	69.0
Severe lost-time claims	547	34.3	1047	65.7
No-lost-time claims	34 904	51.7	32 589	48.3
Total lost-time and no-lost-time claims	40 777	47.2	45 678	52.8

FTEs, full-time equivalent employees.

Table 3 Association of unionisation and workers' compensation injury claim incidence, 2012–2018

Workers' compensation claim type	Crude risk ratio (95% CI)	Adjusted risk ratio (95% CI)
Lost time	**0.69** (0.65 to 0.74)	**0.75** (0.71 to 0.80)
Severe lost time	**0.71** (0.63 to 0.80)	**0.84** (0.73 to 0.96)
No lost time	**1.80** (1.71 to 1.89)	1.04 (0.98 to 1.09)
Total lost time and no lost time	**1.40** (1.34 to 1.46)	**0.95** (0.91 to 0.99)

Regression analyses were conducted separately for each outcome, as described in the Methods section. They included 5267 unionised and 55 158 non-unionised businesses. Risk ratio is the risk of injury claims in unionised businesses divided by the risk in non-unionised. All risk ratios were derived from analyses with unionisation as the main independent variable. Adjusted risk ratios were from analyses that also included company size, company complexity, type of business activity and geographical region as covariates. Statistically significant risk ratios are shown in boldface. More detailed results can be found in Appendix F in Robson *et al*.[24]

Results in table 4 show that the ARRs differed markedly. While the two intermediate-sized categories showed results very similar to the overall findings, those for companies with 50+ FTEs showed unionisation was associated with a 44% lower adjusted risk of a LT claim. At the other extreme were companies with ≤4 FTEs, which showed no difference in risk.

Results of sensitivity analyses

To test the robustness of the union effect, several sensitivity analyses were conducted. The first involved an expansion of the group of WSIB companies classified as unionised to include both strong and weak matches. The effect on estimates were slight: the ARR for LT injury claims increased to 0.77 (95% CI 0.72 to 0.81) and the one for NLT injury claims increased to 1.05 (95% CI 1.00 to 1.10). A second analysis, restricting the sample to companies with only one business, resulted in a modest increase in the ARR for LT claims to 0.82 (95% CI 0.75 to 0.89). A third analysis, restricting the sample to seven classification units exclusively active in the ICI sector, resulted in a modest decrease in the ARR for LT claims to 0.71 (95% CI 0.60 to 0.84).

DISCUSSION
Principal findings and comparison with earlier study

This study replicates the finding of Amick *et al*[20] that company unionisation is associated with a lower risk of LT injury claims in the Ontario ICI construction sector. In this study, company unionisation was associated with a 25% lower incidence of LT injury claims. Applied to table 1, this suggests unionisation may have prevented 2000 LT injuries over 2012–2018. Also repeated from before was the finding that unionisation was associated with a lower risk of LT claims related to injuries of a severe nature—this time with greater confidence because it was based on a fully adjusted regression model rather than a partially adjusted one.

This study did not repeat the earlier finding that unionisation was associated with a higher incidence of NLT claims. This between-study difference is partly related to improved control of confounding by company size. If the three company size categories from the earlier study would have been applied to the 2012–2018 data, a positive relationship would again have been found (ARR=1.16, 95% CI 1.10 to 1.22).

The magnitude of union effect on LT claim incidence in this study 0.75 (95% CI 0.71 to 0.80) is greater than the one reported in Amick *et al*.[20] (ARR=0.86, 95% CI 0.82 to 0.98).

Table 4 Effect of unionisation on workers' compensation lost-time injury claim incidence, 2012–2018, by company size

Average annual FTEs	No of businesses		Crude risk ratio (95% CI)	Adjusted risk ratio (95% CI)
	Unionised	Non-unionised		
≤4	1921	46 265	0.91 (0.78 to 1.06)	0.98 (0.84 to 1.15)
5–19	1628	7112	**0.75** (0.68 to 0.83)	**0.75** (0.69 to 0.83)
20–49	816	1276	**0.79** (0.70 to 0.89)	**0.76** (0.67 to 0.86)
50+	863	456	**0.64** (0.55 to 0.74)	**0.56** (0.48 to 0.66)

Regression analyses were conducted separately for each outcome, as described in the Methods section. Risk ratio is the risk of injury claims in unionised businesses divided by the risk in non-unionised. All risk ratios were derived from analyses with unionisation as the main independent variable. Adjusted risk ratios were from analyses including in addition company complexity, type of business activity and geographical region as covariates. Statistically significant risk ratios are shown in boldface. More detailed results can be found in Appendix G in Robson *et al*.[24]
FTE, full-time equivalent employees.

(This remains true when the old data set is reanalysed using the new five-category size variable, yielding an estimate of 0.92 (95% CI 0.87 to 0.97).) We are cautious in interpreting this as a true change over time, in part because there was an influx in 2013–2015 of companies newly registered with WSIB, due to change in the insurer's coverage requirements.

This research extends the Amick *et al*[20] study by reporting the union effect found for four company size categories. Results indicate the union effect on LT injury claim incidence was greater among the largest companies (50+ FTEs) compared with companies with 5–19 or 20–49 FTEs. No union effect was observed among the smallest companies (≤4 FTEs). These very small organisations are particularly vulnerable to OHS challenges, because of their lack of OHS and operational expertise and their invisibility to authorities. In Ontario, their OHS regulatory requirements differ markedly from companies in the next largest category, 5–19 FTEs, with the latter needing to post OHS policies and have a health and safety representative. As well, projects with less than four workers on site do not need to have a supervisor present.

Study strengths and limitations

A strength of this study was the availability of a single source of workers' compensation administrative data for a jurisdiction, including several variables for control of potential confounders. Covariates included company size, a fine-grained categorisation of industrial sector, an indicator of company complexity and geographical region. The sample size yielded relatively precise estimates of union effects for the ICI sector as a whole and for sub-groups based on company size.

However, we were not able to measure any compositional effects arising from demographic differences between unionised and non-unionised companies. Of particular interest would have been job tenure, since tenure in the job/company of less than a year has been associated with higher injury risk in multivariable models including a unionisation variable[17 19 27]; and average job tenure is longer when Canadian construction workers are unionised.[28 29] We were also not able to measure the availability of short-term disability plans and other benefits, which could provide an alternative to workers' compensation coverage, and which might have been more available in unionised workplaces. Data from another province suggest that about one-quarter of workers absent from work more than a day due to work injury receive wage continuation from their employer or workplace sick leave plan.[30]

The classification of WSIB-registered companies as unionised relied on 24 lists of contractors provided by unions and employer associations. These lists were comprehensive in their coverage of the trades found in the ICI sector. However, for some of the smaller subsectors, only employer association lists were available, which were considered less likely than union lists to be complete. Correct classification of companies in WSIB records as unionised or not also relied on the ability to link the records of unionised contractors with the WSIB records. A manual search of WSIB records suggested up to 94% of the linkable records had been linked. Linkage success was further confirmed by determining 45% of the workforce (FTEs) was unionised in the main analysis (table 1) and 48% unionised in the sensitivity analysis; these are higher than the estimate of 32% for the Ontario construction sector as a whole,[31] which is known to be less unionised than the ICI sector.

A common concern when using workers' compensation data is its underestimation of the true incidence of work-related injuries due to under-reporting. This potential source of bias would likely result in an underestimation of the true union effect, since unionisation is associated with a greater likelihood of reporting workers' compensation claims.[32 33] It is also suggested by the larger NLT/LT claim ratio observed for unionised companies (5.9 vs 2.5) noted earlier. On the other hand, there could be an overestimation of the union effect arising from the way WSIB imputes an employer's annual FTEs (by dividing reported payroll by the average wage of injured workers from the respective sector), coupled with the 'wage premium' in unionised wages.[29 34] While this bias may have had an influence with a magnitude similar to the overall estimate of the protective effect of unionisation, it does not explain all of the observed effects associated with unionisation: using data from Statistics Canada's Labour Force Survey, we found that wages are 30%–50% higher for unionised trade workers relative to non-unionised, but this wage premium tends to decrease as company size increases (see Appendix I in Robson *et al*.)[24] in sharp contrast with the pattern observed in table 4 in which the union effect increases markedly with company size.

Finally, results from the study are limited to the ICI sector as a whole. They cannot be generalised to each ICI sub-sector nor to non-ICI construction sectors.

Contribution to the literature

This study contributes to the limited literature on the relationship between unionisation and non-fatal workplace injuries in the construction sector. It has corroborated the finding of Amick *et al*[20] that unionised businesses are at lower risk of LT injury claims than non-unionised. This finding is robust to sensitivity testing, as well as to variation in the time period under study, methodological variation and research team composition. This study has extended the previous study by conducting company size-stratified subgroup analyses, finding important reductions in the protective effect of unionisation as company size declined. Future research

to document and explain the union safety effect may benefit from considering this observation when formulating hypotheses and planning studies.

This study illustrates the value in examining injuries of differing severity separately, since the associated union effects differ. This was also found by Morantz,[16] who proposed this arises from more minor injuries being more susceptible to a differential reporting bias. Earlier studies analysing all types of non-fatal injuries together, such as most research reviewed by Donado,[14] may therefore have been misleading; such estimates are driven by the more frequent minor injuries. The findings of this study were mixed with regard to the differential reporting bias hypothesis: as expected, the relationship between unionisation and LT injuries was more negative than the one with NLT injury claims; contrary to expected, the negative relationship between unionisation and the severe subcategory LT injury claims was not stronger than the one with all LT injury claims. As well, fatal injuries, 103 of which occurred within the sample during the study period, were examined post hoc in a model controlling for company size only. Results showed no difference between union and non-union, though the estimate was less precise than for the other injury outcomes, ARR=0.97 (95% CI 0.56 to 1.67).

CONCLUSIONS

An association was found between company unionisation status and lowered risk of LT workers' compensation injury claims, corroborating a previous study conducted in the same jurisdiction. The protective effect of unionisation declined as company size decreased. No relationship was found between a company being unionised and the risk of claims involving injuries requiring medical aid only.

Disclaimer The views expressed in this document are those of the authors and do not necessarily reflect those of the Province of Ontario.

Competing interests The contract provided no financial benefit to the authors and allowed for IWH to freely publish the study results. OCS was not involved in the scientific aspects of the study nor in the reporting of its results.

Patient consent for publication Not required.

Ethics approval The methods were approved by the Health Sciences Research Ethics Board of the University of Toronto.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available.

ORCID iDs
Lynda S Robson http://orcid.org/0000-0003-4418-0042
Victoria Landsman http://orcid.org/0000-0001-5238-3857
Cameron Mustard http://orcid.org/0000-0002-0747-8870

REFERENCES

1 Schurman SJ, Weil D, Landsbergis P. The role of unions and collective bargaining in preventing work-related disability. In: Thomason T, Burton JF, Hyatt DE, eds. *New approaches to disability in the workplace*. Madison, WI: Industrial Relations Research Association, 1998: 121–54.
2 Wallace M. Dying for coal: the struggle for health and safety conditions in American coal mining, 1930-82. *Soc Forces* 1987;66:336–64.
3 Hagedorn J, Paras CA, Greenwich H, et al. The role of labor unions in creating working conditions that promote public health. *Am J Public Health* 2016;106:989–95.
4 Malinowski B, Minkler M, Stock L. Labor unions: a public health institution. *Am J Public Health* 2015;105:261–71.
5 Morantz A. Does unionization strengthen regulatory enforcement – an empirical study of the mine safety and health administration. *N Y Univ J Legis Public Policy* 2011;14:697–728.
6 Sojourner A, Yang J. Effects of Union certification on workplace-safety enforcement: regression-discontinuity evidence. *ILR Review* 2020.
7 Nichols T, Walters D, Tasiran AC. Trade unions, institutional mediation and industrial safety: evidence from the UK. *J Ind Relat* 2007;49:211–25.
8 Arocena P, Núñez I. An empirical analysis of the effectiveness of occupational health and safety management systems in SMEs. *Int Small Bus J* 2010;28:398–419.
9 Okun AH, Watkins JP, Schulte PA. Trade associations and labor organizations as intermediaries for disseminating workplace safety and health information. *Am J Ind Med* 2017;60:766–75.
10 Morantz A. The elusive union safety effect: toward a new empirical research agenda. In: Eaton AE, ed. *Proceedings of the 61st annual meeting of the labor and employment relations association*. San Francisco: California, USA, 2009: 130–46.
11 Visser J. Trade unions in the balance. ILO ACTRAV working paper. International labour organization, 2019. Available: https://ilo.userservices.exlibrisgroup.com/discovery/delivery/41ILO_INST:41ILO_V2/1263269980002676?lang=en
12 Zullo R. RIGHT-TO-WORK laws and fatalities in construction. *WorkingUSA* 2011;14:225–34.
13 Zoorob M. Does 'right to work' imperil the right to health? The effect of labour unions on workplace fatalities. *Occup Environ Med* 2018;75:736–8.
14 Donado A. Why do unionized workers have more nonfatal occupational injuries? *ILR Review* 2015;68:153–83.
15 Economou A, Theodossiou I. Effects of unionization on occupational safety and health. *Labour* 2015;29:127–40.
16 Morantz AD. Coal mine safety: do unions make a difference? *ILR Review* 2013;66:88–116.
17 Altassan KA, Sakr CJ, Galusha D, et al. Risk of injury by unionization: survival analysis of a large industrial cohort. *J Occup Environ Med* 2018;60:827–31.
18 Kim W-Y, Cho H-H. Unions, health and safety committees, and workplace accidents in the Korean manufacturing sector. *Saf Health Work* 2016;7:161–5.
19 Souza K, Cantley LF, Slade MD, et al. Individual-Level and plant-level predictors of acute, traumatic occupational injuries in a manufacturing cohort. *Occup Environ Med* 2014;71:477–83.
20 Amick BC, Hogg-Johnson S, Latour-Villamil D, et al. Protecting construction worker health and safety in Ontario, Canada: identifying a Union safety effect. *J Occup Environ Med* 2015;57:1337–42.
21 Baker B, Scherer RF. Construction project management and safety: do labor unions have an effect? *Project Manage J* 1997;28:6–10.
22 Dedobbeleer N, Champagne F, German P. Safety performance among Union and nonunion workers in the construction industry. *J Occup Med* 1990;32:1099–103.
23 Schofield KE, Alexander BH, Gerberich SG, et al. Workers' compensation loss prevention representative contact and risk of lost-time injury in construction policyholders. *J Safety Res* 2017;62:101–5.
24 Robson L, Landsman V, Latour-Villamil D. Updating a study of the union effect on safety in the ICI construction sector. Report to Ontario Construction Secretariat. Toronto: Institute for Work & Health, 2021. Available: https://www.iwh.on.ca/sites/iwh/files/iwh/reports/iwh_report_union_safety_effect_construction_update_2021.pdf

25 Selivanov D. text2vec. [software], 2016. Available: http://text2vec.org/index.html

26 Kleiber C, Zeileis A. Visualizing count data regressions using Rootograms. *Am Stat* 2016;70:296–303.

27 Kubo J, Cullen MR, Cantley L, *et al*. Piecewise exponential models to assess the influence of job-specific experience on the hazard of acute injury for hourly factory workers. *BMC Med Res Methodol* 2013;13:89.

28 Dobrusin B. Good, safe jobs in Ontario's construction industry under threat. Can Centre Policy Altern (CCPA): The Monitor, 2019. Available: https://monitormag.ca/articles/good-safe-jobs-in-ontarios-construction-industry-under-threat

29 Fang T, Verma A. *Union wage premium. Perspectives on labour and income. Statistics Canada Catalogue No. 75-001-XPE*, 2002: 17–23.

30 Saunders R, O'Grady J, Cardoso S. Nature and extent of claim suppression in B.C.'s workers' compensation system. IWH Issue Briefing. Toronto, ON: Institute for Work & Health, 2021. Available: https://www.iwh.on.ca/summaries/issue-briefing/claim-suppression-in-bc-workers-compensation-system[Accessed 29 Jun 2021].

31 Statistics Canada. Table 14-10-0070-01: Union coverage by industry, annual (X 1,000), 2020. Available: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410007001

32 Shannon HS, Lowe GS. How many injured workers do not file claims for workers' compensation benefits? *Am J Ind Med* 2002;42:467–73.

33 Stock S, Nicolakakis N, Raïq H, *et al*. Underreporting work absences for nontraumatic work-related musculoskeletal disorders to workers' compensation: results of a 2007-2008 survey of the Québec working population. *Am J Public Health* 2014;104:e94–101.

34 Campolieti M. Matching and inverse propensity weighting estimates of the Union wage premium: evidence from Canada, 1997-2014. *Ind Relat* 2018;57:101–30.