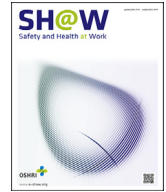




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Original Article

The Interplay Between Supervisor Safety Support and Occupational Health and Safety Vulnerability on Work Injury

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ABSTRACT

Background: Workers exposed to hazards without adequate protections are at greater risk of injury and illness. Supervisor activities have also been associated with injury risk. We examined the interplay between supervisor safety support and occupational health and safety (OHS) vulnerability on workplace injury and illness.

Methods: A survey was administered to 2,390 workers employed for more than 15 hrs/week in workplaces with at least five employees who had a direct supervisor. We examined the combined effects of hazard exposure with inadequate protection (OHS vulnerability) and supervisor support on workplace injury and illness, using additive interactions in log-binomial regression models.

Results: OHS vulnerability and lack of supervisor support independently increased the likelihood of physical injuries at work. Crude and adjusted models showed that the risk of physical injury was at least 3.5 times higher among those experiencing both OHS vulnerability and a lack of supervisor support than individuals without OHS vulnerability and with a supportive direct supervisor. Workers who experienced vulnerability were at less risk if they had a supervisor who was supportive.

Conclusion: In workplaces where workers experience one or more types of OHS vulnerability, having a supportive supervisor may play an important role in reducing the risk of injury and protecting workers.

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1. Introduction

Defining occupational health and safety (OHS) vulnerability has traditionally focused on identifying sociodemographic factors or occupation-/industry-specific groups where work injuries are more common [1–4]. However, it is increasingly recognized that this approach does not take into account the dynamic nature of vulnerability or address modifiable factors that might increase or reduce risk of work injury [5,6]. In the context of OHS, a more contemporary definition of vulnerable workers is “those who have a greater exposure than most workers to conditions hazardous to health or safety and who lack the power to alter those conditions” [7]. Recent efforts have further refined this definition to define OHS vulnerability as situations in which workers are exposed to hazards in combination with inadequate protection to protect them from these hazards, with protections including OHS policies and

procedures, awareness of OHS rights and responsibilities, or a workplace culture that encourages worker participation in safety [5].

In addition to hazards and protections mentioned previously, the safety practices of the direct supervisor may also impact a worker’s risk of injury. Because of their immediate day-to-day presence and direct relationship with workers, supervisors wield significant influence over the safety-related behaviors of workers [8–13]. Supervisory safety support is defined as “the extent to which supervisors encourage safe working practices among their subordinates” ([14], p. 485) and includes elements such as safety prioritization, provision of tools and safety equipment, response to safety concerns, and rewards for safe behavior [14–17]. Increased supervisor safety support is associated with decreased levels of workplace injury [14,15,18–20] and other negative safety outcomes [12,21–23].

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The safety behaviors of supervisors may have greater influence on workers' safety perceptions than the formal OHS policies and procedures [24], and as such, they might more accurately inform workers' awareness and empowerment to participate in injury prevention. Supervisor safety practices may differ from actual organizational policies [17,24,25] both of which may contribute independently to safety outcomes. It is possible that in workplaces where workers experience OHS vulnerability, having a supervisor who is aware of the hazards and risks in the workplace and/or who actively protects workers from negative health outcomes may reduce the risk of injury. The role of workplace factors (e.g., policies and procedures, training programs, and worker empowerment) [26–29] and supervisory leadership [14,15,18–20] on injury are well established. Yet, to date, few articles have examined the relative contribution of both workplace and supervisor factors on injury experience [9,17,30,31]. The objective of this study is to address this research gap by examining the impact of supervisor support and OHS vulnerability on workplace injury.

2. Literature review

2.1. Dimensions of OHS vulnerability

To define situations in which workers are at increased risk of injury, we used the conceptual model of OHS vulnerability by Smith et al [5]. Within this framework, OHS vulnerability is defined as situations when workers are exposed to hazards in combination with inadequate protections in place to protect them from these hazards. Smith et al suggested that these protections include workplace-level OHS protections and policies, worker OHS awareness, and worker empowerment to participate in injury prevention and voice concerns about OHS issues. In the following paragraphs, we have briefly outlined each of the dimensions of vulnerability under the OHS vulnerability framework [5].

2.1.1. Workplace hazards

Workplace hazards are generally defined as working conditions that could potentially cause injury and/or illness to workers. Workplace hazards can include exposure to hazardous substances, unsafe working conditions and equipment, potentially injurious duties (e.g., working in an awkward posture and lifting heavy items), and psychological hazards such as being bullied or harassed at work [5,32]. Previous research has established a relationship between hazardous work and work-related injuries [33]. Furthermore, in a meta-analysis of the relationship between job demands and safety outcomes, Nahrgang et al [34] found that workplace hazards and risks were negatively associated with worker participation in safety compliance.

OHS vulnerability framework focuses on three key protections that can help alleviate the impact of hazard exposure on injury risk: workplace policies and procedures, OHS awareness, and empowerment. Workers may experience differing levels of vulnerability depending on their access to these protections. For example, if Worker A and Worker B have similar levels to exposure to hazards, but Worker A enjoys the benefit of safety policies and procedures that help mitigate that risk, Worker A would be less vulnerable to injury [5].

2.1.2. Workplace-level policies and procedures

OHS policies and practices are put in place to protect workers from hazard exposure and workplace risks. These include safety training, compliance with safety standards, responsiveness to health and safety issues and procedures related to safety communication, and identification and prevention of hazards [5,32].

2.1.3. Worker OHS awareness

Worker OHS awareness refers to the extent to which workers are aware of workplace hazards and worker and employer OHS rights and responsibilities at work. It also refers to a worker's knowledge of an organization's safety policies and procedures and how to safely use protective equipment [5,35]. Safety knowledge can be acquired through formal and informal health and safety training in the workplace [36]. Research suggests that safety knowledge of workers is positively related to safety compliance and participation [35].

2.1.4. Worker empowerment

Worker empowerment to participate in injury prevention refers to a worker's ability to participate in health and safety, speak to employers/ask questions about perceived workplace hazards, and refuse unsafe duties. Shannon et al [28], in their review of studies on the relationship between workplace factors and injuries, found that worker empowerment was related to lower injury rates.

Smith et al [5] suggested that these four aforementioned dimensions of OHS vulnerability are related but conceptually dissimilar. In addition to an independent association between exposure to any of these four dimensions and increased prevalence of injury, Lay et al [6] also found that workplace hazards and insufficient access to safety resources (i.e., policies and procedures, understanding of rights, and worker empowerment) combined to increase the risk of injury beyond their individual effects.

2.2. Supervisor safety support

It is widely acknowledged in OHS literature that front-line supervisors influence workers' safety-related behaviors and their compliance with safety rules [13]. A supervisor who is aware of hazards in the workplace and who understands safety risks can play a critical role in creating a safe work environment. Supervisor knowledge of OHS is seen to be an important driver of improved safety conditions and reduced injuries [7]. In addition, supervisors who are actively committed to safety and who proactively identify problems before they arise can have a meaningful impact on injury prevention and other positive safety outcomes [17]. Feedback from supervisors can provide unique insights into an organization's safety priorities. In a recent study, Huang et al [37] found that safety communication from supervisors to their workers—and the perceptions around how adequate those lines of communications are—was positively related to safety performance and negatively related to injury rates.

In workplaces where workers report OHS vulnerability, supervisors with an awareness of the hazards and risks in the workplace and who actively protect workers from negative health outcomes can reduce the risk of injury. Moreover, supervisors who actively prioritize and promote safety help pave the way for a communicative and supportive safety environment. For example, a supervisor who encourages workers to wear personal safety equipment can be a valuable resource for workers who face OHS vulnerability. By extension, we expect that direct supervisors who are aware of workplace hazards and who actively protect their workers will have a positive effect on workplace injury prevention. Psychosocial models of occupational stress and well-being, such as Job Demand-Control-Support model [38,39] and Job Demands-Resources model [40], suggest that the negative impact of high job demands can be alleviated by job control (e.g., decision authority) and support provided by the workplace environment. We adopt a similar approach to understand how—within the context of occupational health and safety—hazard exposure can be mitigated by access to workplace protections (e.g., safety policies and worker empowerment) and supervisor safety support. An understanding of how job

demands and resources interact to influence the risk of injury can help to identify the contextual factors that should be addressed in the workplace. To date, Smith et al [5] have limited their consideration of workplace factors impacting worker vulnerability to the four dimensions of OHS vulnerability. The present study aims to expand the understanding of how other workplace factors, specifically supervisor safety support, interact with OHS vulnerability in relation to increasing the risk of work injury. We hypothesize that both OHS vulnerability and supervisor support will be independently related to work injury. We also hypothesize that when people experience both OHS vulnerability and lack of supervisor support, this combination will be more strongly associated with work injury than would be expected based on the sum of the effects of each of these factors in isolation.

3. Methods and materials

3.1. Data

Survey data for this study were collected as part of a larger study examining occupational vulnerability in two Canadian provinces [5]. The survey was administered in April 2015 and September 2015 by a third-party survey provider. Individuals were eligible to participate if they were over 18 years old and were employed for at least 15 hours a week at an organization with more than five employees. The majority (approximately 90%) of study participants were recruited from an existing EKOS Research Associates panel of 90,000 individuals from Ontario and British Columbia who have agreed to complete surveys from time to time. A minority (approximately 10%) of participants were recruited using random digit dialing (RDD) approach that was also conducted by EKOS Research Associates. The advantage of the panel data is that it includes cell phone-only households, which are not commonly included in RDD sample frames. It is also considerably more cost-effective to recruit survey respondents through the household panel than the other sampling approaches.

4. Measures

4.1. Outcome: work-related physical injury or illness

Two outcomes were examined in this study: work-related physical injury or illness and work-related physical injury or illness requiring time off work or medical attention. Individuals were considered to have a work-related physical injury if they replied “yes” to the question “In the past 12 months, have you sustained a physical injury or illness due to your work?” Those who reported a physical injury or illness were also asked whether their injury required time off work or medical attention. Participants who replied “yes” are compared with those who were not injured and those whose injury did not require medical attention or time off. Our rationale for including both types of injury (those who require time off work and injuries in general) is in recognition that some groups of workers (e.g., those in precarious work situations) may be less likely to take time off work after a workplace injury [41].

4.2. Exposure 1: OHS vulnerability

OHS vulnerability was measured using a 27-item survey tool that includes four dimensions of vulnerability: (1) exposure to hazards (9 questions); (2) access to protective policies and procedures (7 questions); (3) awareness of OHS rights and responsibilities (6 questions); and (4) empowerment to act on these rights (5 questions). Development and validation of the tool is

explained in detail elsewhere [5]. Briefly, the development of the OHS vulnerability measure included development of a conceptual framework and systematic review of the peer-reviewed and grey literature, as well as focus group discussions with stakeholders (workers, employers, policy makers, and employee and employer representatives) to identify potential items to measure dimensions of OHS vulnerability [5]. The final item list of the OHS vulnerability measure was developed based on theoretical considerations and psychometric properties. Exploratory factor analyses suggested that each of the three protection dimensions within the measure (policies and procedures, awareness, and empowerment) were separate but related factors [5]. This measure has demonstrated good internal construct validity [5] and concurrent construct validity with demographic, occupational, and workplace groups where vulnerability is thought to be more prevalent [42].

To measure hazard exposure, individuals were asked to report hazard exposure on a seven-point scale (never to everyday) for nine common workplace hazards (repetitive motions, noise exposure, lifting or carrying heavy items, working with hazardous substances, working in awkward posture, performing unfamiliar tasks, working at heights, prolonged standing, and being bullied or harassed at work). Workers were classified as exposed to hazards if they reported weekly or more frequent exposure to at least two of nine hazards or if they reported at least weekly exposure to lifting or carrying 20 kg at least twice a day, work at heights greater than two meters, bullying or harassment, or work with hazardous substances.

The remaining dimensions of vulnerability—policies and procedures, awareness, and empowerment—were each measured using a series of statements. For each dimension, individuals who disagreed (strongly disagree or disagree) with at least one related statement were considered to have inadequate access to that preventative resource. Adequacy of policy and procedures was measured using seven statements such as “There is an active and effective health and safety committee” or “Systems are in place to identify, prevent, and deal with hazards at work.” Six statements evaluated the adequacy of awareness. For example, “I am clear about my rights and responsibilities in relation to workplace health and safety.” Empowerment is measured using five statements, such as “I know that I can stop work if I think something is unsafe and management will not give me a hard time.”

In this study, we use the definition of OHS vulnerability as exposure to workplace hazards, in combination with inadequate access to workplace protections. The first part of the definition points to hazard exposure, and the second part of the definition points to the three modifiable factors—workplace policies and procedures, OHS awareness, and OHS empowerment—that, when properly accessed, mitigate the injury risk due to hazard exposure. Hence, combined categories of exposure to hazards (exposure to two or more hazards on a weekly basis) were used in conjunction with inadequate access to protections (at least one negative response to statements in each of the three dimensions). Three specific—policy and procedure vulnerability (workplace hazards and inadequate protective policies and procedures); awareness vulnerability (workplace hazards and inadequate awareness); and empowerment vulnerability (workplace hazards and inadequate empowerment)—and one overall type of vulnerability—overall vulnerability (workplace hazards and at least one type of inadequate protection)—were defined.

4.3. Exposure 2: supervisor support

Supervisor support was measured with two questions developed in consultation with the stakeholders who participated in the creation of the original survey designed to capture the dimensions

of OHS vulnerability. Stakeholders were interested in understanding whether supervisor activities might be related to injury in the workplace. Respondents were considered to have an aware supervisor if they responded “strongly agree” or “agree” to the statement, “My direct supervisor is aware of the hazards involved in performing my job.” When respondents “strongly agreed” or “agreed” with the statement “My direct supervisor does everything that is reasonable to protect me from being injured at work,” they were classified as having an engaged supervisor. Individuals who disagreed (strongly disagree or disagree) with having either an aware or engaged supervisor were considered to have no supervisor support.

4.4. Covariates

Additional sociodemographic variables were included in the analysis including gender (male or female), age (<35 years, 35–44 years, 45–54 years, and 55 + years), type of employment relationship (permanent vs. temporary), workplace size (5–19 employees, 20–99 employees, 100–499 employees, and 500 + employees), and industry (primary industries, e.g., mining, forestry, and construction; manufacturing/trade and transport; information, finance, and administration; education; health care and social assistance; arts, recreation, accommodation, and retail trade; public administration; and other service industries). Workplace size and age were included as categorical variables as they were reported in this way. All these variables were included as confounders in analytic models.

4.5. Analysis

Analysis in this study proceeded in three steps. To begin, injury outcomes were explored across all study variables. Second, the distribution of injury outcomes was analyzed across groups defined by coexposure to supervisor support and all measures of OHS vulnerability. To examine the relative contribution of supervisor support and OHS vulnerability on injury, we used an additive interaction approach [43]. The additive interaction approach compares the injury risk among workers experiencing both negative supervisor and workplace-/individual-level factors and the injury risk of those experiencing one of these factors, but not the other, with that of workers who experience neither of these factors. The additive interaction between supervisor support and OHS vulnerability was examined by sorting the sample into four groups: (1) those who are not vulnerable and have a supportive supervisor; (2) those who are not vulnerable but do not have supervisor support; (3) those who are vulnerable and have a supportive supervisor; and (4) those who are vulnerable and do not have supervisor support. This four-class categorization was completed for each type of OHS vulnerability (policy and procedure, awareness, empowerment, and overall).

The objective of this approach is to understand if each of these factors (in our case, supervisor and workplace/individual factors) independently contributes to injury and if the combination of both factors results in a synergistic effect, which is greater than what would be expected from the additive risk of both factors. To explore the additive impacts of supervisor and workplace-/individual-level factors, we used log-binomial models. In these models, individuals experiencing OHS vulnerability, lack of supervisor support, or both were compared to those who report having a supportive supervisor and no vulnerability. All models were adjusted for age, gender, employment relationship, workplace size, and industry. To examine the additive interaction, synergy index (SI) values and corresponding 95% confidence intervals (CIs) were calculated [44,45]. An SI value of greater than one suggests a synergistic relationship between exposures, an SI of one suggests an additive relationship

between exposures, and an SI below one suggests that the combined effect of both exposures is less than the additive effects (a subadditive relationship). Analyses were weighted to reflect the gender, age, and province distribution of the workforce at each of the two time points when surveys were conducted. All analyses were completed using SAS 9.4 (SAS Institute, Cary, NC, USA).

5. Results

The original sample included 3,911 responses, most (88.9%) of which were recruited from the panel, and the remaining 11.1% were recruited using RDD. Response rates for these two strategies were 22% and 10.7%, respectively. Because the majority of recruitment was conducted from an existing panel of participants, some individuals completed the survey at both time points. Only the most recent responses were retained, leaving 3,334 observations. We excluded those who did not have a direct supervisor ($n = 389$) and those missing information on the exposure variables ($n = 427$). Individuals who responded “don’t know” to questions regarding supervisor support were classified as not having that support. Respondents were also excluded if they were missing information regarding any of the covariates ($n = 128$). The final analytical sample included 2,390 respondents.

Table 1 displays the distribution of demographic and workplace characteristics and of supervisor support and OHS vulnerability of the sample. Just more than half of the sample was male (50.3%), and more than a third (38.6%) of respondents aged below 35 years. More than one in 10 respondents (11.2%) were in temporary work relationships, and most often, workers were employed in workplaces with between 20 and 499 employees (60.3%). Overall, nearly one in three respondents (31.8%) reported at least one type of OHS vulnerability. There was a relatively equal distribution of industry groups among respondents. The most common type of OHS vulnerability was policy and procedure vulnerability (23.7%). Approximately one in 12 respondents (8.6%) reported a supervisor who was not aware of the hazards involved in performing their job, whereas 13.2% reported a supervisor who does not do everything that is reasonable to protect them from being injured at work.

The prevalence of both injury outcomes across these groups is also presented in Table 1. Prevalence of work-related physical injury or illness in the previous 12 months was 17.8%, and 11.9% of respondents reported an injury requiring time off work or medical attention. Physical injury was more common among individuals who reported supervisors who are not aware than among those with aware supervisors (36.3% vs. 16.1%). Similarly, those who disagreed that their supervisor would act to protect them were more likely to report an injury (43.9%) than those who did not (13.9%). Injuries were also more frequent among groups of workers who were classified as vulnerable (34% to 39.2% across different types of vulnerability) than among those classified as not vulnerable (10.3 to 15.2%). Similar trends were observed for injuries that required time off work or medical attention.

Table 2 describes the distribution of both injury outcomes across groups defined by the cooccurrence of OHS vulnerability (three specific types and one overall) and measure of supervisor support. The prevalence of physical injury or illness or injury requiring time off or medical attention was highest among individuals who reported any type of vulnerability in conjunction with no supervisor support and lowest among workers who are not vulnerable and described having supportive supervisors. For example, of those who experienced policy and procedure vulnerability and have no supervisor support, 50.3% reported a physical injury in the preceding 12 months compared with just 10.3% of those who were not vulnerable and had a supportive supervisor. Respondents who were not classified as vulnerable but reported no supervisor

Table 1
Distribution of the sample, including covariates and outcomes

	N	%	Physical injury/illness			Injury requiring time-off or medical attention		
			N	%	p-value	N	%	p-value
Total			426	17.8		283	11.9	
OHS vulnerability								
Policy and procedure vulnerability	566	23.7	221	39.2	<0.0001	140	24.8	<0.0001
No policy and procedure vulnerability	1824	76.3	205	11.2		143	7.8	
Awareness vulnerability	287	12	108	37.6	<0.0001	67	23.3	<0.0001
No awareness vulnerability	2103	88	318	15.2		216	10.3	
Empowerment vulnerability	533	22.3	207	38.9	<0.0001	136	25.5	<0.0001
No empowerment vulnerability	1857	77.7	219	11.8		147	7.9	
Overall vulnerability	760	31.8	258	34.0	<0.0001	165	21.8	<0.0001
Not vulnerable	1630	68.2	168	10.3		118	7.2	
Supervisor support								
Supervisor aware	2184	91.4	352	16.1	<0.0001	235	10.8	<0.0001
Supervisor not aware	206	8.6	75	36.3		48	23.4	
Supervisor engaged	2076	86.8	288	13.9	<0.0001	184	8.9	<0.0001
Supervisor not engaged	314	13.2	138	43.9		99	31.6	

Table 2
Physical injury and injury requiring time off across groups defined OHS vulnerability and supervisor support (n = 2,390)

	N	%	Prevalence			
			Physical injury		Injury requiring time off or medical attention	
			%	p	%	p
Policy and procedure vulnerability						
Not vulnerable + supervisor support	1694	70.9	10.3	<0.0001	7.2	<0.0001
Not vulnerable + no supervisor support	130	5.5	22.8		16.1	
Vulnerable + supervisor support	316	13.2	30.4		16.7	
Vulnerable + no supervisor support	249	10.4	50.3		35.1	
Awareness vulnerability						
Not vulnerable + supervisor support	1865	78.0	12.8	<0.0001	8.6	<0.0001
Not vulnerable + no supervisor support	238	10.0	33.6		23.9	
Vulnerable + supervisor support	145	6.1	22.5		10.6	
Vulnerable + no supervisor support	142	5.9	52.9		36.4	
Empowerment vulnerability						
Not vulnerable + supervisor support	1717	71.8	10.8	<0.0001	7.4	<0.0001
Not vulnerable + no supervisor support	140	5.9	24.2		14.9	
Vulnerable + supervisor support	293	12.3	29.3		16.4	
Vulnerable + no supervisor support	240	10.0	50.5		36.6	
Overall vulnerability						
Not vulnerable + supervisor support	1517	63.5	9.7	<0.0001	6.8	<0.0001
Not vulnerable + no supervisor support	113	4.7	19.1		13.0	
Vulnerable + supervisor support	493	20.6	25.3		14.6	
Vulnerable + no supervisor support	267	11.2	50.0		35.1	

support had a lower injury prevalence than individuals who were vulnerable but had a supportive supervisor.

A similar pattern was seen among other types of vulnerability, with the highest rate of injury observed among respondents who were vulnerable without supervisor support and the lowest rate observed for respondents who were not vulnerable and had a supportive supervisor.

Table 3 displays the results of crude and adjusted prevalence ratios and 95% CIs for each of the combinations of OHS vulnerability (four measures) and supervisor support. Models are adjusted for age, gender, employment relationship, workplace size, and industry. The table also includes the adjusted and unadjusted SI estimates and CI, evaluating the additive interaction between OHS vulnerability and supervisor support for both adjusted and unadjusted models.

Crude and adjusted models show a pattern whereby individuals who reported no supervisor support in conjunction

with any type of OHS vulnerability were significantly more likely to experience workplace physical injuries. For example, those who reported empowerment vulnerability and no supervisor support were more than four times (relative risk (RR): 4.48; 95% CI: 3.72–5.40) more likely to report a work-related physical injury than workers who were not vulnerable and had a supportive supervisor.

For most adjusted models, the SI values were greater than 1.00, although the effect was only statistically significant in models related to overall vulnerability. This suggests that the combination of worker-level vulnerability and lack of supervisor support is at least additive on risk of injury and in some cases (for overall vulnerability and supervisor support) is super additive. In other words, the combination of overall vulnerability and lack of supervisor support on injury risk is greater than what would be predicted based on the independent effects of each of these factors.

Table 3

Crude and adjusted log-binomial models examining relationship between supervisor support, OHS vulnerability and physical injury, and injury requiring time off or medical attention. Weighted for age, gender, and province ($n = 2390$)

	Physical injury/illness				Injury requiring time off or medical attention			
	Crude		Adjusted		Crude		Adjusted	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Policy and procedure vulnerability								
Not vulnerable + supervisor support	Ref.		Ref.		Ref.		Ref.	
Not vulnerable + no supervisor support	2.20	1.56–3.11	2.23	1.58–3.15	2.23	1.45–3.42	2.24	1.46–3.44
Vulnerable + supervisor support	2.94	2.37–3.66	2.86	2.29–3.58	2.31	1.71–3.12	2.35	1.74–3.19
Vulnerable + no supervisor support	4.86	4.03–5.86	4.69	3.89–5.67	4.87	3.83–6.19	4.82	3.79–6.14
Synergy index	1.23	0.90–1.68	1.19	0.86–1.65	1.52	0.95–2.44	1.47	0.92–2.36
Awareness vulnerability								
Not vulnerable + supervisor support	Ref.		Ref.		Ref.		Ref.	
Not vulnerable + no supervisor support	2.62	2.12–3.25	2.61	2.11–3.23	2.79	2.13–3.66	2.79	2.13–3.65
Vulnerable + supervisor support	1.76	1.27–2.43	1.71	1.23–2.37	1.24	0.75–2.03	1.24	0.76–2.04
Vulnerable + no supervisor support	4.14	3.40–5.03	3.96	3.25–4.83	4.26	3.27–5.54	4.14	3.18–5.38
Synergy index	1.32	0.91–1.90	1.28	0.88–1.86	1.61	0.95–2.70	1.55	0.92–2.60
Empowerment vulnerability								
Not vulnerable + supervisor support	Ref.		Ref.		Ref.		Ref.	
Not vulnerable + no supervisor support	2.24	1.62–3.09	2.25	1.63–3.11	2.02	1.31–3.10	2.04	1.33–3.13
Vulnerable + supervisor support	2.71	2.17–3.93	2.64	2.10–3.31	2.23	1.64–3.03	2.20	1.61–3.00
Vulnerable + no supervisor support	4.68	3.89–5.63	4.48	3.72–5.40	4.95	3.91–6.28	4.83	3.80–6.13
Synergy index	1.25	0.90–1.72	1.20	0.87–1.68	1.76	1.07–2.89	1.71	1.03–2.83
Overall vulnerability								
Not vulnerable + supervisor support	Ref.		Ref.		Ref.		Ref.	
Not vulnerable + no supervisor support	1.98	1.31–2.98	1.99	1.32–2.99	1.91	1.15–3.20	1.92	1.15–3.21
Vulnerable + supervisor support	2.63	2.12–3.26	2.56	2.05–3.19	2.14	1.61–2.84	2.16	1.62–2.88
Vulnerable + no supervisor support	5.18	4.26–6.29	5.01	4.11–6.10	5.16	4.03–6.61	5.12	3.99–6.58
Synergy index	1.60	1.11–2.32	1.58	1.08–2.30	2.03	1.17–3.53	1.98	1.14–3.44

Adjusted models: adjusted for age, gender, employment relationships, workplace size, and industry groups. CI, confidence interval; OHS, occupational health and safety; RR = Relative Risk.

6. Discussion

In this study, we sought to understand the relative contribution of supervisor support and worker-level vulnerability on work-related injury. Independently, OHS vulnerability and lack of supervisor support significantly increased the likelihood of physical injuries at work. OHS vulnerability in conjunction with lack of supervisor support had at least additive effect—and in some cases, the combination of both risk factors produced an increased risk of injury that was statistically greater than what would be predicted by adding the risks associated with each of these factors in isolation. We observed that the risk of injury was greatest among those who experienced OHS vulnerability in conjunction with a direct supervisor who is not supportive of health and safety. After taking into consideration age, gender, employment relationship, workplace size, and industry, the risk of physical injury was as at least 3.5 times higher among those experiencing both OHS vulnerability and a lack of supervisor support than among individuals without OHS vulnerability and with a supportive direct supervisor.

Our results corroborate the findings of previous research that established a link between hazard exposure, workplace protections, management practices, and safety outcomes [26–29,33–35,46–48]. However, this previous work did not focus specifically on the role of the supervisor in exacerbating or ameliorating the relationship between workplace context and injury risk. Although the dimensions studied in this study (OHS vulnerability and supervisor support) are not new, exploring how each of these dimensions act in combination among workers who are injured compared with those who are not represents a novel research contribution in this context. The study findings contribute to the

recent literature that conceptualizes OHS vulnerability through the lens of modifiable workplace factors and defines it as a dynamic construct [5,6,42]. Understanding work-related dimensions of OHS vulnerability can help identify workplace policies and practices that, when improved, can reduce injury risk. Focusing on vulnerability from the perspective of these dimensions can also guide workplaces to prioritize prevention activities that need to be targeted. For example, in a workplace where workers have low awareness of OHS, implementing a training program can reduce injury risk.

This study also provides a novel examination of how OHS vulnerability interacts with supervisor support to shape risk of on-the-job injury. Workers who experienced vulnerability were at less risk if they had a supportive supervisor. This finding suggests that even in workplaces where policies and procedures, worker awareness, or empowerment do not adequately mitigate the impact of workplace hazards, a supportive direct supervisor can reduce the risk of injury. This illustrates the important role of a supervisor committed to safety in protecting workers who may not know about their rights or lack the power to speak up, such as workers who are new to their jobs or recent immigrant workers. Although having a supportive supervisor may not mitigate vulnerability entirely, it can lessen the risk of injury. Interestingly, the protective role of supervisor was also seen among workers who were not vulnerable; supportive supervision can have positive impact on workers in both vulnerable and nonvulnerable work settings. Nahrgang et al, in their meta-analysis of relationship between job demands, resources, and safety outcomes, concluded that “reducing risks and hazards and establishing a supportive environment are among the best ways to improve safety.” [34, p. 16].

Our findings suggest that building supervisor's capacity may comprise an important component of solutions to protect workers, especially in workplaces where it is challenging to reduce hazards or to implement organization-level changes. Past research shows that training interventions that target supervisory leadership (e.g., emphasizing safety in interactions and increasing safety reward) are associated with improved safety climate and safety performance [49–52]. For example, in small businesses in which budget limitations prevent adoption of costly engineering controls or worker training, investing in the safety knowledge and capacity of supervisors can help create a safer environment for workers.

Although supervisor-level safety support may be effective in managing risks, it is important to note that reducing and preventing injuries require organizational commitment to safety. Workplace factors explored in this study can help organizations identify areas where improvement will have the most impact on protecting their staff (e.g., training and work procedures). Commitment to creating a safe workplace at the organizational level can also reinforce supervisor safety practices.

The study results should be interpreted acknowledging several limitations. The cross-sectional, self-report and voluntary nature of the sample used in this study introduces the possibility of recall bias whereby workers who sustain a workplace injury may undertake a more careful and critical appraisal of workplace circumstance and supervisor support than noninjured participants. This may result in an overreporting of OHS vulnerability and lack of supervisor support leading among injured compared to noninjured workers, which would in turn lead to an overestimation of the true relationships between OHS vulnerability and poor supervisor support and injury. However, although using information from multiple sources is optimal to only one source of data collection (e.g., self-report), we feel that the objective wording of the injury questions limits potentially self-reported bias than more subjective questions. Also, the higher-than-expected prevalence of injury in our data set may be due to a selection bias; it is possible that individuals who have experienced a recent injury at work would be more likely to participate in a survey focused on OHS.

Although one of the strengths of this study is the large sample, caution should be used in generalizing the results to the entire labor force (external validity) as our sample did not include individuals who were self-employed or working in very small businesses (less than five employees). In addition, young workers were underrepresented in the age groups. We have addressed this limitation to some extent by weighting out sample across age, gender, and province to resemble estimates from the Labour Force Survey. However, given the low response rate, we cannot be sure that respondents and nonrespondents are similar even within the same strata of gender, age group, and province of residence. The sample however includes workers from a wide range of occupational and industry categories. In relation to the external validity of the results of this study, we also recommend caution in generalizing prevalence estimates for the level of OHS vulnerability, supervisor support, or work injuries to the labor market populations of Ontario and British Columbia. However, given the variation in our sample across our main independent variables and industry groups, we feel that the relationships between independent variables and outcomes are potentially generalizable [53,54].

In addition, future work examining supervisor support would benefit from a more comprehensive measure. However, the single questions used in the survey do provide an initial impression of the role supervisors play in creating a vulnerable workplace and did elicit a diversity of responses regarding the presence or lack of supervisor support. The present study asked only about the support levels of the direct supervisor; future work examining the health and safety support at additional organizational levels would

provide a richer understanding of how internal hierarchy and leadership can shape worker health and safety risk.

7. Conclusion

This study builds on previous research by identifying unique opportunities to develop integrated approaches to reduce injury risk on the job. The role of a supportive direct supervisor is important in the workplace and, as illustrated by this study, can reduce the risk of injury among both vulnerable and nonvulnerable workers. Supervisors play an important role in creating a safe work environment. Having a direct supervisor who is aware of the workplace risks and engaged in reducing them can improve the outcomes of workers even in the most vulnerable conditions. Especially in workplaces where organizational interventions and solutions to reduce workplace injury are challenging, investing time in supervisors can be an important component of an effective injury prevention program.

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Conflicts of interest

All authors have no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.shaw.2018.11.001>.

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