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Characteristics of work-related fatal and hospitalised injuries not captured in workers' compensation data

M Koehoorn,¹ L Tamburic,¹ F Xu,¹ H Alamgir,² P A Demers,³ C B McLeod¹

¹School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada
²Occupational Health, School of Public Health, The University of Texas Health Science Center, San Antonio, Texas, USA
³Ontario Cancer Research Centre, Cancer Care Ontario, Toronto, Ontario, Canada

Correspondence to

Professor M Koehoorn, School of Population and Public Health, University of British Columbia, 2206 East Mall, Vancouver, British Columbia, Canada V6T 1Z3; mieke.koehoorn@ubc.ca

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ABSTRACT

Objectives (1) To identify work-related fatal and non-fatal hospitalised injuries using multiple data sources, (2) to compare case-ascertainment from external data sources with accepted workers' compensation claims and (3) to investigate the characteristics of work-related fatal and hospitalised injuries not captured by workers' compensation.

Methods Work-related fatal injuries were ascertained from vital statistics, coroners and hospital discharge databases using payment and diagnosis codes and injury and work descriptions; and work-related (non-fatal) injuries were ascertained from the hospital discharge database using admission, diagnosis and payment codes. Injuries for British Columbia residents aged 15–64 years from 1991 to 2009 ascertained from the above external data sources were compared to accepted workers' compensation claims using per cent captured, validity analyses and logistic regression.

Results The majority of work-related fatal injuries identified in the coroners data (83%) and the majority of work-related hospitalised injuries (95%) were captured as an accepted workers' compensation claim. A work-related coroner report was a positive predictor (88%), and the responsibility of payment field in the hospital discharge record a sensitive indicator (94%), for a workers' compensation claim. Injuries not captured by workers' compensation were associated with female gender, type of work (natural resources and other unspecified work) and injury diagnosis (eg, airway-related, dislocations and undetermined/unknown injury).

Conclusions Some work-related injuries captured by external data sources were not found in workers' compensation data in British Columbia. This may be the result of capturing injuries or workers that are ineligible for workers' compensation, or the result of injuries that go unreported to the compensation system. Hospital discharge records and coroner reports may provide opportunities to identify workers (or family members) with an unreported work-related injury and to provide them with information for submitting a workers' compensation claim.

INTRODUCTION

Workers' compensation claims are currently used for population surveillance of work-related injuries and illness in Canada, and in other high-income countries. These data have also been used by occupational researchers to identify research populations,¹ to investigate relationships between workplace risks and health outcomes and to identify high-risk groups for intervention,^{2–5} to evaluate

What this paper adds

- ▶ Previous research indicates that work-related injuries and diseases are under-reported and that a reliance on workers' compensation data undermines the recognition of the full public health burden of these injuries and fatalities.
- ▶ In the current study, the majority of work-related fatalities and serious injuries were found in workers' compensation data, but coroners' reports and hospitalisation records were able to identify additional work-related fatalities and injuries.
- ▶ Injuries not captured by workers' compensation were associated with female gender, type of work (natural resources and other unspecified work) and injury diagnosis (airway-related, dislocations and undetermined/unknown injury).
- ▶ The findings support the use of multiple data sources to capture the full burden of occupational injuries and fatalities for public health surveillance and research purposes, but data stewards are recommended to maximise the use of work and occupational coding in their respective databases and to share information on work-related injuries and fatalities for public good.

compensation policies and programmes⁶ and to conduct surveillance.^{7–9}

Several studies indicate that work-related injuries and diseases are under-reported^{8 10–15} and some researchers suggest that a reliance on workers' compensation data has undermined the recognition of occupational injuries and fatalities as a public health priority.¹⁶ Under-reporting to compensation systems has been attributed to a number of causes or 'filters' including an unawareness of work attribution, unawareness of compensation benefits or procedures, a desire not to lose a job or fear of reprisal and a belief that some symptoms or injuries are a 'normal' consequence of work.^{17 18} It was hypothesised in the current study that many of the preceding reasons would not affect the reporting of fatalities and serious injuries that are readily diagnosed; involve a traumatic incident at a worksite; necessitate the involvement of numerous parties such as paramedics, coroners, traffic investigators and physicians;^{14 19} and are covered under a no-fault system with a high percentage of



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workforce coverage. Although, it should be noted that issues of eligibility of work-related injuries and illnesses and adjudication of work-relatedness persist in compensation systems.²⁰

Under-reporting of fatalities may be due to a lack of awareness by family members of death or pension benefits for a deceased worker, or a lack of reinforcements for reporting fatalities to the workers' compensation system (ie, no perceived benefits and the death has been recorded by other agencies). The reasons for not reporting a severe, hospitalised injury are less clear. A lack of knowledge about compensation or an ability to file a claim during a period of health-related distress may be an explanation. Others^{18–21} hypothesise that employers may benefit by attempting to 'shift' work-related injuries from the workers' compensation system to other insurance systems, although the ability to do so for injuries necessitating wage loss benefits would be limited in the current jurisdiction of British Columbia. In jurisdictions such as the USA, workers' compensation claims under-represent occupational injuries and illness because many workers are not covered by workers' compensation. This is less of an issue in British Columbia where 94.6%²² of the workforce has coverage. Finally, eligibility and adjudication of work-relatedness²⁰ may mean that some injuries and fatalities are not captured by workers' compensation providing an argument for the use of other databases to capture all cases.

A surveillance system or research data resource relies on accurate and thorough documentation, including information on limitations such as case ascertainment. Understanding data issues helps researchers and policymakers place research and surveillance findings within the context of potential biases as well as provide recommendations for improving case ascertainment, including better data collection procedures and the use of multiple data sources beyond compensation claims. Further, evidence of under-compensation can help to improve procedures for eligible workers and their families who may not be accessing benefits.

The objectives of this research were to (1) estimate the number of work-related fatal and hospitalised (non-fatal) injuries (eg, fractures, amputations, head and spinal injuries, internal injuries, burns/electrocutions) in British Columbia using multiple data sources, (2) to compare case-ascertainment from external data sources with accepted workers' compensation claims and (3) to investigate the sociodemographic, work and injury characteristics of work-related injuries not captured as accepted workers' compensation claims.

METHODS

Data sources

This was a retrospective, linked database study using workers' compensation claims, hospital discharge records, vital statistics records and coroners' investigation reports to identify work-related fatal and hospitalised injuries. The four databases were considered population-based for British Columbia, given a universal healthcare system, the coverage of the workers' compensation system (almost 95% of workforce), and the provincial mandates of the Coroner's Office (all unnatural, sudden, unexpected, unexplained or unattended deaths) and the Vital Statistics Agency (legislated to record all deaths). The 5% of the workforce not covered by the workers' compensation system represent federal employees (transportation workers, federal police force, military) covered by other insurance plans and self-employed workers who opt out of the provincial compensation system. Data access, extraction and linkage services were provided by Population Data BC and use of the data for research purposes was governed by an agreement between the data

stewards and the researchers.^{23–24} Linkage procedures by Population Data BC adhere to legislation governing privacy and confidentiality and are a combination of deterministic (universal personal health identifier) and probabilistic (mathematical techniques to match date of birth, sex, full name) methods to provide the best linkage rates (accurate and reliable) across data sources based on 20 years of experience linking data for research purposes. Personal identifiers were removed from the data files provided to the researchers and replaced with an anonymous study identifier. Race and ethnicity are not data collected by WorksafeBC, Vital Statistics Agency, Ministry of Health or the Provincial Coroners' Office.

Case ascertainment—work-related fatal injuries

Cases included all work-related fatal injuries identified across the four data sources, with a death date between 1991 and 2009 for workers' aged 15–64 years, and who were residents of the Canadian province of British Columbia at the time of death as established via the Ministry of Health Registry.²⁵ The residency and age criteria were applied to match eligibility for workers' compensation. Cases of occupational disease (eg, mesothelioma, lung cancer) identified using international classification of disease codes (ICD9²⁶ and ICD10²⁷) were excluded for the purposes of this study.

All fatal claims in the workers' compensation database²⁸ coded for injury (ICD9 800–999) were included. These fatal injury claims were further limited to those that occurred in the province and expected to be found in other provincial data sources.

Coroners' reports coded as accidental or undetermined fatalities²⁹ (versus intentional or natural) and coded as an occupational activity at the time of death were reviewed (activity category and type, and cause and means of death fields) and included as a case if identified as work-related by two investigators.

All hospital discharge records³⁰ coded for injury (ICD9 800–999 or ICD10 S00–T99) and with death as the exit code were considered work-related cases if workers' compensation was listed as the payer and/or the ICD9 E-codes or ICD10 V-Z codes for external cause of morbidity and supplemental information indicated work-relatedness (table 1), according to previously developed algorithms for diagnostic coding in hospital records.³¹

All vital statistics death records³² coded for injury (ICD9 800–999 or ICD10 V00–Y99) were considered work-related cases using diagnosis algorithms as noted above.³¹ Diagnoses not coded beyond three digits were included if there was a partial match to the work-related algorithm and two of the investigators coded the death as work-related based on a record review of the cause, manner, activity of death, occupation and industry of employment fields.

A total of 51 fatalities were coded as undetermined by one of the two investigators. A third investigator reviewed the undetermined reports of which 19 were coded as work-related and included in the analysis.

Case ascertainment—work-related hospitalised injuries

All hospital discharge records with an admission date between 1991 and 2009 and coded for injury (ICD9 800–999 or ICD10 S00–T99) as the principle diagnosis for admission were used to identify work-related (non-fatal) injuries. Hospital records with death as the exit code were excluded for the purposes of this analysis. To be considered a case, both the responsibility for payment field had to indicate workers' compensation and the

Table 1 International Classification of Disease (ICD9 E Codes and ICD10 V-Z) codes for identifying work-relatedness

Accident or injury description	ICD code	Indicator of work-relatedness
Railway	E800–E807	4th digit: 0=railway employee
Motor vehicle traffic, motor vehicle non-traffic, other road vehicles	E810–E829	Included if responsibility for payment was workers' compensation
Water transport	E830–E838	4th digit: 2=crew or 6=dockers and stevedores
Air and space transport	E840–E845	4th digit: 2=crew or 6=ground crew
Powered vehicles used within buildings and premises of industrial or commercial establishment	E846	Any digit
Vehicles, not elsewhere classified	E847–849	Included if responsibility for payment was workers' compensation
Poisoning	E860–869	5th digit: 1=farm, 2=mine or quarry or 3=industrial places and premises
Other accidents (by fall, fire or flame, natural or environmental factors, submersion or suffocation)	E880–928	5th digit: 1=farm, 2=mine or quarry or 3=industrial places and premises
Transport (heavy transport vehicle, bus, water transport)	V60–69 V70–79 V90–94	V60, V70–73, V75–77 4th digit: 0=driver V61–68, V74, V78 digit: 0=driver, 5=driver V69, V79 digit: 0=driver, 4=driver V90–94 4th digit: 0=merchant ship, 2=fishing boat
Other land transport (industrial premises, agricultural, construction)	V83–85	Any digit
Other external causes (eg, exposure to mechanical forces, forces of nature, fire/flame/smoke)	W00–W99 X00–X59 Y10–Y34	4th digit: 5=trade or service area, 6=industrial or construction area, 7=farm
Codes with occupational or work in descriptor (eg, work-related condition, occupational exposure to risk factors, examination following work accident)	Z42 Z57 Z100 Z563–Z567 Z570–Z579	Any digit

ICD9 E-codes or ICD10 V-Z codes had to indicate work-relatedness (table 1) using algorithms described above.³¹ The responsibility for payment field in the hospital record is based on the disclosure of work-relatedness at time of admission. This field can be updated on review at time of discharge. The payment field provides an indicator of work-relatedness by the worker and/or hospital staff, but not by the workers' compensation system.

Work-related hospitalised injuries were further limited to acute injury diagnoses in order to exclude hospitalisations associated with complications, surgeries and treatments subsequent to the incident injury, and therefore not expected to match to the claim injury date. Acute injuries were defined as fractures, dislocations, intracranial injury, internal injury, amputations, injury to blood vessels, crushing injuries, burns and injuries to nerves/spinal cords. Acute injuries were further limited to those with at least one overnight hospital stay and therefore expected to result in a short-term disability (ie, at least 1 day off work) workers' compensation claim.

Analysis

An anonymous study identifier enabled work-related fatal and hospitalised injury cases to be merged across data sources at the individual-level. Case ascertainment of work-related fatal injuries was described by each data source and by joint data sources, compared to the workers' compensation data (% match). Work-related fatal injuries not found as an accepted workers' compensation claim were described by age, gender, geographic location, work and injury characteristics; and the odds of not being captured by a workers' compensation claim were modelled using logistic regression.

For the analysis of the ascertainment of work-related hospitalised injuries, a match was further defined by an injury claim date within plus or minus 7 days of the hospital admission date (% match). A sensitivity analysis investigated matches within plus or minus 30 days. Work-related hospitalised injuries not found as

an accepted workers' compensation claim were described by age, gender, geographic location and injury characteristics (occupation and industry are not coded fields in the hospital record); and the odds of not being captured by a workers' compensation claim was modelled using logistic regression.

Positive predictive value and sensitivity were calculated to investigate the validity of ascertaining work-related injuries for surveillance and research purposes using external databases. Positive predictive value³³ is a measure of the probability that a person has the outcome (an accepted workers' compensation claim for a fatal injury) given that they test positive by another means (in this study, a coroner's report for occupational fatalities). Sensitivity³³ is a measure of the probability of correctly identifying a true case (an accepted workers' compensation injury claim) by another means (in this study, having a responsibility for payment field coded for workers' compensation in the hospital record).

RESULTS

Work-related fatal injuries

A total of 1677 work-related fatal injuries were identified across the four data sources. Of these, 1264 were captured as an accepted workers' compensation claim (75.4%). Work-related fatal injuries identified in coroners' records were most likely to be captured as a workers' compensation claim (773 of 880 or 87.8%), and more so if identified jointly with a vital statistics record (479 of 522 or 91.7%) or a hospitalisation record (114 of 123 or 92.7%; table 2). No pattern emerged for capture by year. Six work-related fatalities identified by all three external data sources were not captured by a workers' compensation claim. Although the six fatalities were all males, they were from different age groups (35–64 years), regions of the province, and industries (construction, forestry, fishing/hunting, the film and motion picture industry and general freight hauling).

The investigation of the characteristics of work-related fatal injuries not captured by workers' compensation was limited to coroners' cases as the most valid case definition (high

Table 2 Description of work-related fatal injuries identified by data source, matched to a workers' compensation claim, 1991 to 2009 (presented in order of capture rate)

Work-related fatal injury by data source	Workers' compensation claim		Total
	No	Yes	
Joint (C, V and H)	6 (6.8%)	82 (93.2%)	88
Joint (C and H)	9 (7.3%)	114 (92.7%)	123
Joint (C and V)	43 (8.2%)	479 (91.8%)	522
Coroners single source	107 (12.2%)	773 (87.8%)	880
Joint (V and H)	17 (15.7%)	91 (84.3%)	108
Hospitalisation single source	66 (31.9%)	141 (68.1%)	207
Pooled (C, V or H)	413 (32.1%)	875 (67.9%)	1288
Vital statistics single source	303 (35.0%)	563 (65.0%)	866
All work-related fatal cases*	413 (24.6%)	1264 (75.4%)	1677

*Represents unique fatal cases, de-duplicated across data sources. C, coroner's reports; H, hospital discharge records; V, vital statistics.

specificity). Descriptively, the 107 coroner fatalities not captured (12.2%) were more likely female; of older age; to involve natural resources (eg, fishing, farming) or 'other' work; to involve an airway, exposure or undetermined/unknown injury and from the northern (more rural and remote) region of the province (table 3). In multivariable logistic regression (table 3), the odds of a work-related injury death not captured by the workers' compensation system remained elevated for females, older workers and workers from smaller urban or more rural/remote regions, although the 95% CIs included '1' indicating variability around these demographic and geographic variables. The odds were also elevated for type of injury with a twofold increase associated with airway-related and undetermined/unknown injuries compared to blunt injuries, and for type of work with a threefold to fourfold increase associated with natural resources (eg, fishing, farming) and 'other' or unspecified work compared to forestry and mining work. The 95% CIs excluded '1' for the type of work and injury variables with the exception of the estimate for undetermined/unknown injuries.

Table 3 Descriptive statistics and adjusted ORs for characteristics of work-related fatalities (coroner's reports) not captured by workers' compensation, 1991–2009

Coroners' fatality	Workers' compensation claim		Unadjusted OR (95% CI) No claim	Adjusted OR (95% CI) No claim
	Not captured	Total		
Total	107 (12.2%)	880		
Gender				
Male	101 (11.9%)	847	1.00	1.00
Female	6 (18.2%)	33	1.64 (0.66 to 4.07)	1.32 (0.50 to 3.49)
Age group (years)				
15–24	8 (10.5%)	76	1.00	1.00
25–34	21 (11.7%)	180	1.12 (0.47 to 2.66)	1.27 (0.52 to 3.13)
35–44	26 (11.0%)	236	1.05 (0.46 to 2.43)	1.12 (0.46 to 2.68)
45–54	29 (13.3%)	218	1.30 (0.57 to 2.99)	1.42 (0.60 to 3.39)
55–64	23 (13.5%)	170	1.33 (0.57 to 3.13)	1.40 (0.57 to 3.44)
Type of work*				
Forestry and mining	18 (6.4%)	283	1.00	1.00
Commercial fishing	17 (22.4%)	76	4.24 (2.06 to 8.72)	3.71 (1.45 to 9.49)
Farming	7 (21.9%)	32	4.12 (1.57 to 10.8)	4.01 (1.43 to 11.2)
Unspecified work placet	31 (20.7%)	150	3.84 (2.06 to 7.13)	3.60 (1.87 to 6.96)
Other place of work‡	15 (17.1%)	88	3.03 (1.45 to 6.29)	3.03 (1.39 to 6.57)
Construction	9 (9.1%)	99	1.47 (0.64 to 3.39)	1.68 (0.70 to 4.00)
Industrial sectors	10 (6.6%)	152	1.04 (0.47 to 2.31)	0.99 (0.44 to 2.26)
Type of injury*				
Blunt injuries	31 (10.9%)	285	1.00	1.00
Undetermined/unknown§	7 (28.0%)	25	3.19 (1.23 to 8.24)	2.32 (0.83 to 6.47)
Airway injuries¶	11 (25.0%)	44	2.73 (1.26 to 5.94)	2.39 (1.04 to 5.49)
Exposures**	16 (20.0%)	80	2.05 (1.06 to 3.97)	1.61 (0.80 to 3.23)
Drowning	13 (16.3%)	80	1.59 (0.79 to 3.21)	0.93 (0.37 to 2.34)
Head and neck injuries	17 (8.3%)	204	0.75 (0.40 to 1.39)	0.84 (0.44 to 1.59)
Crushing/torso injuries	12 (7.4%)	162	0.66 (0.33 to 1.32)	0.69 (0.34 to 1.41)
Geographical location††				
Vancouver Coastal	9 (9.6%)	94	1.00	1.00
Interior	23 (11.4%)	202	1.21 (0.54 to 2.73)	1.30 (0.56 to 3.05)
Fraser	31 (12.5%)	249	1.34 (0.61 to 2.94)	1.16 (0.51 to 2.63)
Vancouver Island	23 (12.5%)	184	1.35 (0.60 to 3.05)	1.38 (0.59 to 3.24)
Northern	21 (13.9%)	151	1.53 (0.67 to 3.49)	1.80 (0.76 to 4.28)

*As coded by the coroners' office.

†Category used by coroners' office with no further details.

‡Category used by coroners' includes electrical/powerlines, excavating/paving/grading, movie industry, yardwork, railway sites, business and education.

§Undetermined, unnatural, missing.

¶Obstruction/suffocation/smothering, aspiration, strangulation, asphyxia.

**Heat, cold, electrical, lightening.

††Defined by health authorities governing delivery of health services in the province.

Work-related hospitalised (non-fatal) injuries

In total, 8314 work-related injuries were identified in hospitalisation records of which 7925 (95.3%) were captured as an accepted workers' compensation claim. Descriptively, the 389 work-related hospitalised injuries (4.7%) not captured were more likely to be females from Vancouver Coastal (large, urban region) with a principle diagnosis for dislocations, intracranial or internal injuries, burns or nerve/spinal cord injury (table 4). No pattern emerged by year. In multivariable logistic regression (table 4), the odds of a work-related hospitalised injury not captured by a workers' compensation claim remained significantly higher for females and for those with dislocations, and significantly lower for workers from the interior region (rural, remote).

In the analysis of work-related hospitalised injuries matched to workers' compensation claims within plus or minus 30 days (results not shown), case ascertainment increased to 97%, but the characteristics associated with non-capture by an accepted workers' compensation claim remained the same as described above.

Validity of external data sources for work-related injuries and fatalities

A coroner's report for a work-related fatal injury was a positive predictor for an accepted workers' compensation fatal claim (88%). The responsibility of payment field coded for workers' compensation in the hospital discharge record was a sensitive indicator for an accepted workers' compensation injury claim (94%).

DISCUSSION

Some work-related injuries captured by external data sources were not found in workers' compensation data in British Columbia. This may be the result of external data sources capturing injuries or workers not covered for workers' compensation in the province, but also the result of injuries that go unreported to the workers' compensation system. Hospital discharge records, in particular the responsibility of payment field, and occupational coroner reports may provide the best opportunities to identify workers (or their family members) with an unreported work-related hospitalised or fatal injury and to provide information for submitting a workers' compensation claim.

Under-reporting is not a new problem in health-related surveillance systems and has been documented for compensable work-related injuries,^{10–12 34} diseases^{7 13} and fatalities.^{15 16} Although previous studies indicate that not all work-related injuries and diseases are captured by workers' compensation,^{13 14} it was hypothesised this would not persist for fatalities and serious (hospitalised) injuries in the current context. Although the majority of cases were ascertained in workers' compensation data, it was surprising that some work-related fatalities and serious (hospitalised) injuries were still not found in workers' compensation claims data in a jurisdiction with no-fault insurance and the majority of the workforce covered by the compensation system.

Previous studies support the utility of using external databases to identify work-related injuries and fatalities to those found in

Table 4 Descriptive statistics and adjusted ORs for work-related hospitalised injuries not captured by the workers' compensation system, 1991–2009

Hospitalised injury	Workers' compensation claim		Unadjusted OR (95% CI) No claim	Adjusted OR (95% CI) No claim
	Not captured	Total		
Total	389 (4.7%)	8314		
Gender				
Male	357 (4.5%)	7877	1.00	1.00
Female	31 (7.2%)	433	1.54 (1.04 to 2.30)	1.56 (1.04 to 2.33)
Age group (years)				
15–24	60 (5.4%)	1111	1.00	1.00
25–34	81 (3.9%)	2103	0.73 (0.52 to 1.04)	0.70 (0.49 to 1.00)
35–44	110 (4.6%)	2395	0.85 (0.61 to 1.19)	0.81 (0.58 to 1.13)
45–54	88 (5.0%)	1777	0.91 (0.64 to 1.29)	0.86 (0.60 to 1.22)
55–64	50 (5.4%)	928	1.05 (0.71 to 1.56)	1.01 (0.67 to 1.50)
Injury				
Fracture	224 (4.5%)	5033	1.00	1.00
Dislocation	25 (14.0%)	178	3.61 (2.30 to 5.68)	3.74 (2.37 to 5.90)
Nerves/spinal cord	8 (7.1%)	113	1.72 (0.83 to 3.59)	1.75 (0.84 to 3.66)
Internal	21 (6.1%)	346	1.47 (0.92 to 2.33)	1.52 (0.96 to 2.42)
Burns	25 (5.8%)	431	1.30 (0.83 to 2.02)	1.32 (0.84 to 2.05)
Intracranial	26 (5.6%)	464	1.24 (0.81 to 1.92)	1.29 (0.83 to 1.99)
Open wounds	52 (3.6%)	1450	0.79 (0.57 to 1.08)	0.80 (0.58 to 1.11)
Blood vessel injury	2 (3.2%)	62	0.76 (0.18 to 3.13)	0.78 (0.19 to 3.22)
Crushing	6 (2.5%)	237	0.60 (0.26 to 1.36)	0.61 (0.27 to 1.39)
Geographic location*				
Vancouver Coastal	70 (5.3%)	1322	1.00	1.00
Interior	63 (3.7%)	1717	0.68 (0.48 to 0.97)	0.67 (0.46 to 0.94)
Fraser	119 (4.6%)	2573	0.87 (0.64 to 1.17)	0.86 (0.63 to 1.17)
Vancouver Island	59 (4.7%)	1251	0.89 (0.62 to 1.26)	0.88 (0.61 to 1.27)
Northern	57 (4.4%)	1295	0.81 (0.56 to 1.16)	0.81 (0.56 to 1.16)

*Defined by health authorities governing delivery of health services in the province.

the current study, including coroners' reports in Canada¹⁶ and a trauma registry in Washington State, although the latter varied by injury.³⁵ Building an effective surveillance and reporting system for work-related injuries and fatalities may require a commitment across organisational jurisdictions involved in these incidents to share information. The responsibility of payment field in the hospital record was the better indicator for non-fatal work-related injuries likely due to an increased probability that a worker could convey details of their injury on admission. This is in contrast to the use of the trauma registry in Washington State³⁵ where the work-related field was a better indicator than payer field for identifying work-related injuries, perhaps as a result of the financial incentive to code the payer field correctly in the current study for hospitalisations that are covered by other insurance plans within a public healthcare system. A coroner's report was the better indicator for fatal work-related injuries likely due to the in-depth investigation of the incident and multiple text-based fields capturing injury and activity details.

While the three 'external' databases used in this study all included fields to capture work characteristics, these fields were not complete or standardised for the purposes of identifying work-related injuries and fatalities. As a result, conservative definitions were used to definitely identify work-related injuries and fatalities in the current study that may still under-represent those not captured by workers' compensation. In particular, the investigation of the characteristics of work-related fatalities not captured by workers' compensation was limited to the coroners' data as a result of the lack of specificity of the ICD coding in the vital statistics and hospitalisation data and the under-utilisation of the 4th and 5th digits for place of occurrence and work location respectively especially for ICD 10. Data stewards are encouraged as part of a public utility model of data collection to investigate ways to improve the coding of work characteristics and the work-related nature of the injury and death for public good, including the use of standardised occupational and industry codes, an indicator of whether the injury or death occurred at work/on the job, and the regular use of the full external cause of injury codes (4th and 5th digits of the E codes and V-Z ICD codes). Better coding may prove useful for identifying workers from sociodemographic, occupational and injury groups vulnerable to under-reporting, as seen in the current study.

Gender differences in work-related outcomes and compensation experiences have been documented previously.^{36–43} Gender differences observed for the capture of fatalities by workers' compensation in the present study did not persist in models adjusted for type of work, consistent with emerging evidence that differences as a result of the gendered division of the labour force^{41–42} may not persist or be as strong when type of work is accounted for.⁴⁴ The adjustment for type of work was not possible in the model for work-related hospitalised injuries and the elevated odds for females may be as a result of unmeasured confounding.

While under-reporting of work-related injuries has been hypothesised for young workers as a vulnerable segment of the workforce, this does not appear to be the case in the present study with under-reporting observed for older workers. It may be that the attribution of work-relatedness is more challenging with older workers, including in the presence of comorbidities. It may also be the case that older (mature, experienced) workers and their families have more resources to draw on for health and income benefits than workers' compensation benefits. This is consistent with a Canadian study of work-related

musculoskeletal injuries where higher income and more seniority was associated with not filing a compensation claim.⁴⁵

Workers' in natural resources were more likely to have a death not captured in workers' compensation data compared to other types of work, consistent with previous findings for work-related injuries in farming and agricultural.^{46–48} In the past, this may have been explained by a lack of coverage, but farming has been covered by the workers' compensation system in British Columbia since 1993, and includes coverage of farm workers on temporary work permits. Yet, under-reporting persists for this type of work, often inclusive of precarious, temporary or seasonal employment arrangements. It is possible that farming fatalities are more likely to be misclassified as work-related using external databases reliant on diagnostic coding for place of occurrence, as observed by others.³⁵ Although, in the current study, coroner's records were limited to investigations coded as 'occupational' and two investigators independently interpreted the activity category and type, and cause and means of death fields, as work-related.

Despite variability around the estimate, workers not readily classified by standard occupational or industrial groupings were also more likely to have a death not captured in workers' compensation data. The 'other' category may represent work more likely to be exempt or excluded from workers' compensation coverage, or unique types of work where there is a lack of recognition of eligibility and work-relatedness. Use of standardised occupational and industrial coding by the various data stewards, as recommended above, would be for public good in maximising the use of routinely collected data for surveillance purposes and to ensure those who are eligible for social benefits receive them.

The significantly elevated odds observed for hospitalised dislocation injuries not captured by the workers' compensation system may be a methodological issue. Despite limiting the analysis to emergency and urgent admissions, dislocations in particular may be associated with surgical procedures subsequent to the incident event for which we were unable to find a match to a claim. The elevated odds observed for airway-related fatalities not captured by compensation, relative to other type of fatalities, remains less clear given coroner cases excluded fatalities due to intentional or natural causes not otherwise covered by the compensation system. Although not statistically significant, the elevated odds for fatalities coded as undetermined or unknown would suggest challenges with adjudicating eligibility and/or work-relatedness for compensation purposes.

The investigators acknowledge some misclassification of work-related fatal and hospitalised injuries using the study algorithms in data sources mandated for administrative purposes other than workers' compensation. However, the definitions were conservative requiring two indicators of work-relatedness in the hospital records and consensus from at least two investigators on work-relatedness in the coroners reports already coded as occupational by the coroner. It is also possible that a certain proportion of identified fatal or hospitalised injuries not captured by accepted workers' compensation claims represented disallowed (ie, injury is not covered under the compensation act) or rejected claims (ie, either the worker or employer is not covered under the act). WorkSafeBC statistics⁴⁹ indicate that disallowed claims represented 7.6% of all claims in 2012 and rejected claims less than 1%. Better case ascertainment methods or access to disallowed/rejected claims may improve the overall rate of capture with workers' compensation claims, but we do not believe it would alter the main conclusions of the study that some serious work-related injuries and fatalities go unrecognised or unreported in workers' compensation claims data.

The research findings support the continued education and awareness efforts by stakeholder groups such as labour organisations, health and safety associations and the workers' compensation system, to reach potentially vulnerable groups (or their families) with regards to workers' compensation. These vulnerable groups include female workers and workers in the natural resource sectors (agriculture, fishing, farming) and those in non-traditional occupations or with injuries/incidents that are not readily classified. However, given a persistent issue of under-reporting, the research findings also support investigating other opportunities to use existing administrative reporting and data collection processes external to the workers' compensation system to reach workers (or their families) with injuries or fatalities identified as work-related for information about applying for workers' compensation benefits. Finally, the study findings support the use of multiple data sources, in this context hospital and coroner records, to capture the full burden of occupational injuries and fatalities for public health surveillance and research purposes.

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