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Original article

Asthma Among Manitoba Workers: Results from the Manitoba Occupational Disease Surveillance System

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ABSTRACT

Background: This study characterized the risk of new-onset asthma among workers in Manitoba, Canada.
Methods: Accepted time loss claims from the Workers' Compensation Board of Manitoba from 2006 to 2019, containing workers' occupations and industries, were linked with administrative health data from 1996 to 2020. After restricting the cohort to the first claim per person in an occupation and applying age and coverage exclusions, the cohort comprised 142,588 person–occupation combinations. Asthma cases were identified if workers had at least two medical records for asthma (International Classification of Diseases, Ninth Revision, 493) within a 12-month period, within the 2 years before 3 years after cohort entry. New-onset asthma was identified using a 3-year washout period. Asthma hazard ratios by occupation and industry were estimated using Cox proportional hazard models, adjusted for age, and stratified by sex.
Results: Increased asthma risk was observed among workers with known asthmagen exposure, including male veterinary and animal health technologists and technicians (hazard ratio 3.97, 95% CI 1.78–8.86), male fish processing workers (3.40, 1.53–7.57), and male machining tool operators (2.91, 1.72–4.92). Increases were also observed for occupations with unknown or suspected allergens, including gas station attendants, drivers, mail/postal and related workers, public works and maintenance laborers, mine laborers and crane operators, and some indoor worker groups. Decreased risks were observed among nurses and residential and commercial installer and servicers.
Conclusion: This database linkage study successfully identified occupations and industries with known sensitizing agents or irritants, and several occupation and industries not typically associated with work-related asthma, warranting further investigation.

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1. Introduction

Asthma is the most common respiratory disease and the sixth most prevalent chronic disease in Canada [1]; in 2017, an estimated 11.7% of Canadians had asthma [2]. Occupational asthma can occur when workers are exposed to sensitizing agents or to high concentrations of inhaled irritants [3]. Over 400 compounds can cause occupational asthma, with common ones including animal allergens, plant products, fish and crustaceans, diisocyanates, wood dusts, and metal salts [4]. Between 10% and 25% of adult-onset asthma is estimated to be occupational [5].

Asthma imparts large costs to the health care system and can lead to loss of productivity and time from work for workers and functional impairment, leading to reduced quality of life [6]. A study of compensation claims found that occupational asthma from sensitization in Quebec leads to median loss of income of approximately $62,000 for men and $25,000 for women, with a median duration of compensation of 54.1 and 30.2 months, respectively [7]. Another study in British Columbia found that workers with work-related asthma were less likely to have their asthma under control than those with nonwork-related asthma and that these workers had significantly reduced productivity due to presenteeism compared with individuals with nonwork-related and uncontrolled asthma [8].

The workplace presents an opportunity for asthmagen exposure reduction and asthma prevention [9], but current population-based health surveillance systems in Canada [2] do not contain the relevant occupation and industry data to examine occupational disease. To address this gap, Cherry et al linked workers' compensation claims data, containing information on workers' occupations and industries, to physician billing data to assess the incidence of asthma by occupation and industry [10]. These methods were further piloted in British Columbia [11] and fully expanded in Ontario in the creation of the Occupational Disease Surveillance System (ODSS), where more than 20 disease outcomes, including asthma, have been explored [12–14].

The linkage methods previously developed in these studies were adopted to examine the rates and risks of asthma in Manitoba by occupation, industry, and sex to identify groups of workers with increased asthma risk and to test the methods for surveillance purposes in Manitoba to inform future surveillance efforts.

2. Materials and methods

The methods build on those piloted in Alberta [10] and British Columbia [11] and further established in Ontario [12,13]. Ethical approval was obtained from the University of Manitoba Ethics Board and the HIPC committee of Manitoba Health HIPC#2020/21-13.

2.1. Worker cohort development

Workers, with their occupations and industries, were identified using accepted time loss claims from the Workers' Compensation Board (WCB) of Manitoba from January 1, 2006, to December 31, 2019. During this time, approximately 69–79% of Manitoba workers were covered by the WCB [15]. Most industries are covered, but some, including law, accounting and other professional service firms, and recreational centers, are not [16]. Occupations were coded using the National Occupational Classification 2016, Version 1.0 [17], while industries were coded using the WCB's internal system. Both coding systems use hierarchical schemes.

Workers, with their occupation and industry of employment at the time of an accepted time loss claim, were linked using personal health identification number (PHIN, a unique nine-digit numeric identifier assigned by Manitoba Health to every person registered for health insurance in Manitoba), name, birthdate, address, and sex by Manitoba Health to a pseudoPHIN. The pseudoPHIN and compensation data were then sent to the Manitoba Centre for Health Policy (MCHP) for linkage with the administrative data by pseudoPHIN [18]. Health data included medical and hospital records from 1996 to 2020. Excluding compensated workers with missing occupation codes (n = 2,342), the linkage rate was 95.5% (n = 202,029). After restricting the cohort to workers' first compensation claim for each occupation, given multiple claims, and applying age and coverage exclusions (Fig. 1), the final cohort,

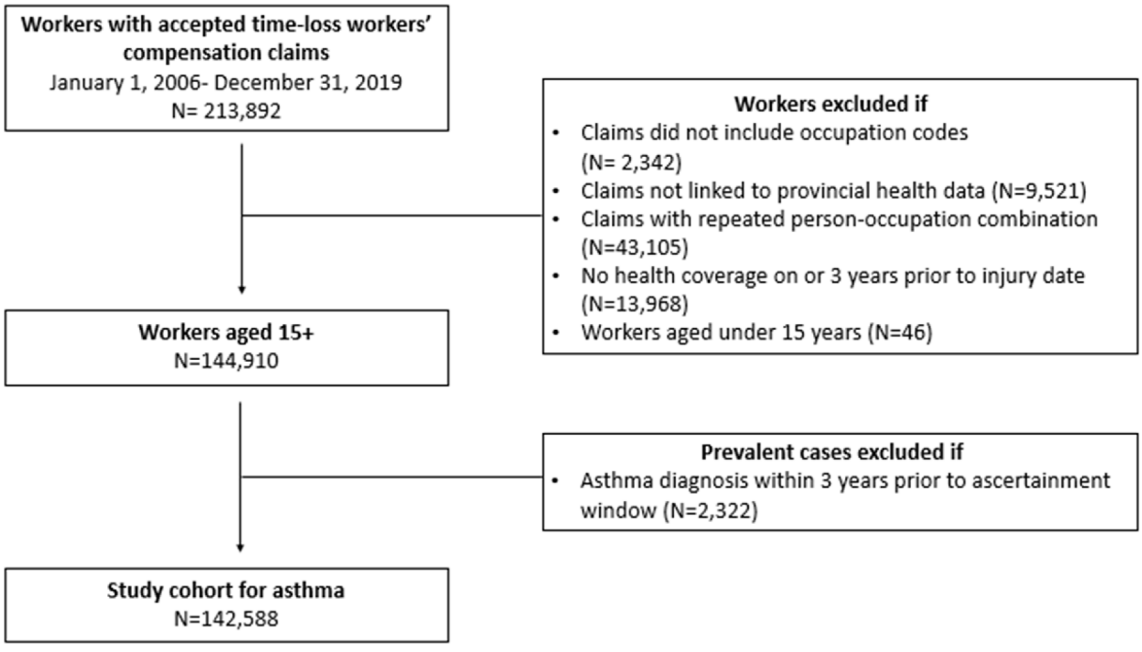

Fig. 1. Development of Manitoba Occupational Disease Surveillance System (MODSS) cohort for evaluation of asthma in Manitoba workers.

which composed the Manitoba Occupational Disease Surveillance System (MODSS) asthma cohort, contained 142,588 person–occupation combinations.

2.2. Asthma case ascertainment

From cohort entry (i.e., compensation claim date of injury), workers were followed to identify incident cases of asthma. Asthma cases were defined for a worker as having at least two medical or hospital claims for asthma (International Classification of Diseases, Ninth Revision, 493) within a 12-month period, within the 2 years preceding to 3 years after cohort entry. Accepted compensation claims for asthma were not used to ascertain new-onset asthma; however, workers with accepted asthma claims that met the case definition were included in the analyses. A 3-year washout period was used to identify new-onset asthma from preexisting asthma. The case definition was based on a validated definition used by the Ontario ODSS [12]; however, the follow-up period was expanded from 3 years after cohort entry, as used in the Ontario ODSS, to 2 years before 3 years after cohort entry, given the smaller sample size in Manitoba.

2.3. Statistical analysis

Workers were followed until diagnosis, emigration from Manitoba, death, or end of the follow-up period. Rates of asthma were calculated by occupation, industry, and sex. Asthma risk was estimated using Cox proportional hazard models, where the risk of asthma within one industry and/or occupation group was compared with the rest of the cohort [19]. Hazard ratios and 95% confidence intervals were calculated for each occupation and industry group, adjusted for age and sex. Sex-stratified analyses were reported for the groups that met the reporting threshold of more than five cases of asthma (as set by the MCHP). Cells that would allow the calculation of a cell with less than six individuals were also redacted (indicated by "-"). The number of asthma cases, as identified using the study's case definition, was compared with asthma cases captured in the workers' compensation claims. Associations for industries or occupations that had a significant finding ($p < 0.05$) for overall, males, or females, were displayed here. All analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

The MODSS cohort for asthma surveillance comprised 142,588 workers across 484 occupations. Most workers were men (65%) and between the ages of 40–64 years (49%). A total of 1,803 and 1,632 new-onset asthma cases were identified in males and females, respectively (Table 1). Asthma incidence within the cohort overall was 2.41%, with higher rates for females (3.27%) than males (1.95%). From the cohort of 142,588 workers, 82 workers' compensation claims contained "asthma" in the International Classification of Diseases code, occupational disease type, or injury nature, of which 22 were captured by the study's asthma case definition using medical or hospital records. The remaining 60 were not captured by MODSS; of which 15 were in business, finance, and administration occupations (primarily among office support occupations), 14 in occupations in education, law and social, community and government services (primarily among paraprofessional occupations), and between 6 and 9 were in each of health occupations, sales and service occupations, and trades, transport and equipment operators and related occupations.

3.1. Industry

Reduced asthma risks were observed for workers in construction, building construction, and plastic manufacturing (Table 2). Reduced asthma risk was observed for females only in facilities services, an industry with increased asthma risk for males.

Elevated risks were observed among workers in service and in education industries. Female workers also saw an increased risk in other service and manufacturing medication industries. Among males only, elevated asthma risks were found in health care and in social services industries.

3.2. Occupation

Within the manufacturing occupations, increased asthma risks were observed among machining tool operators, male laborers in fish processing, and other laborers in processing, manufacturing, and utilities (Supplemental Table 1).

Increased asthma risks were observed in education, law and social, community, and government services occupations. At more detailed occupation codes, higher risks were observed for male community and social service workers and also for female home support workers, housekeepers and related occupations, and elementary and secondary school teacher assistants.

Increased asthma risk in sales and service occupations was observed for males. This was driven by increased risk among service station attendants, light duty cleaners, bakers, and janitors, caretakers, and building superintendents. An elevated risk was also observed among female janitors, caretakers, and building superintendents, although this was not significant.

Trades, transport and equipment operators, and related occupations had a decreased asthma risk, as did a few occupational subgroups, including residential and commercial installers and servicers and other transport equipment operators and related maintenance workers. Elevated risks were also observed for crane operators and for male public works and maintenance laborers.

Table 1
Rates of asthma by age and sex in the Manitoba Occupational Disease Surveillance System.

Age at injury	Males			Females		
	Number of workers	Asthma cases	Rate of asthma (%)	Number of workers	Asthma cases	Rate of asthma (%)
15–17	1,122	19	1.69	596	22	3.69
18–24	16,601	300	1.81	6,222	224	3.60
25–39	31,196	604	1.94	14,434	479	3.32
40–64	2,080	839	1.99	27,848	876	3.15
65+	1,632	41	2.51	857	31	3.62
Total	92,631	1,803	1.95	49,957	1,632	3.27

Table 2
Risk of asthma among the Manitoba Occupational Disease Surveillance System cohort, by sex and industry.

Industry	Overall			Males			Females		
	Number	Asthma cases	HR (95% CI)	Number	Asthma cases	HR (95% CI)	Number	Asthma cases	HR (95% CI)
Construction	**18,589**	**326**	**0.86 (0.77–0.97)***	**18,032**	**311**	**0.88 (0.78–1.00)***	**557**	**15**	**0.82 (0.49–1.36)**
Building construction	15,401	262	0.84 (0.74–0.96)**	14,959	250	0.85 (0.75–0.98)*	442	12	0.82 (0.47–1.46)
Health care	**22,024**	**658**	**0.96 (0.87–1.05)**	**3,406**	**85**	**1.30 (1.05–1.62)***	**18,618**	**573**	**0.91 (0.83–1.01)**
Health care	22,024	658	0.96 (0.87–1.05)	3,406	85	1.30 (1.05–1.62)*	18,618	573	0.91 (0.83–1.01)
Social services	1,894	67	1.26 (0.99–1.61)	542	17	1.66 (1.03–2.67)*	1,352	50	1.16 (0.87–1.54)
Manufacturing	**26,509**	**571**	**0.98 (0.90–1.08)**	**22,308**	**429**	**0.96 (0.87–1.08)**	**4,201**	**142**	**1.03 (0.86–1.22)**
Manufacturing medication	415	16	1.47 (0.90–2.40)	—	—	—	218	15	2.14 (1.29–3.56)**
Plastic manufacturing	1,466	18	0.55 (0.34–0.87)*	1,174	—	0.51 (0.29–0.91)*	292	—	0.63 (0.28–1.39)
Natural resources	**3,541**	**80**	**1.07 (0.85–1.33)**	**3,038**	**61**	**1.04 (0.80–1.34)**	**503**	**19**	**1.15 (0.73–1.81)**
Public administration	**14,743**	**372**	**1.06 (0.95–1.18)**	**9,692**	**198**	**1.04 (0.89–1.20)**	**5,051**	**174**	**1.06 (0.91–1.25)**
Service	**20,830**	**603**	**1.10 (1.01–1.21)***	**8,722**	**188**	**1.14 (0.98–1.33)**	**12,108**	**415**	**1.07 (0.96–1.20)**
Educational institutions	4,609	155	1.24 (1.05–1.45)*	1,717	36	1.04 (0.75–1.45)	2,892	119	1.34 (1.11–1.61)**
Facilities services	2,296	58	1.00 (0.77–1.29)	1,233	36	1.51 (1.09–2.10)*	1,063	22	0.64 (0.42–0.97)*
Other service	822	26	1.26 (0.86–1.86)	410	6	0.77 (0.34–1.71)	412	20	1.56 (1.01–2.43)*
Trade	**22,548**	**542**	**1.02 (0.93–1.12)**	**15,449**	**298**	**1.00 (0.89–1.14)**	**7,099**	**244**	**1.05 (0.92–1.21)**
Transportation	**13,793**	**282**	**0.95 (0.84–1.08)**	**11,974**	**232**	**0.98 (0.85–1.12)**	**1,819**	**50**	**0.83 (0.63–1.10)**

CI, confidence interval; OR, odds ratio.
Bolded font indicates major industry groups, and regular font indicates industry subgroups.
Associations with p values of less than 0.05, 0.01, and 0.001 were reported, signified by (*), (**), and (***), respectively.
Dark gray cells indicate significantly increased risk, while light gray cells indicate significantly reduced risk at $p < 0.05$ or 95% CI not including 1.

There was also an increased risk for female transport truck drivers and female bus drivers, subway operators, and other transit operators.

Among health occupations, reduced asthma risks were observed among female registered nurses and registered psychiatric nurses, technical occupations in health, and licensed practical nurses. However, increased asthma risks were observed among male veterinary animal technologists and technicians and male medical technologists and technicians, as well as for medical technologists and technicians, overall.

Within the business, finance, and administration occupations, elevated risks were observed for receptionists and switchboard operators, survey interviewers, and statistical clerks, as well as male mail, postal, and related works.

Male specialized middle management occupations (National Occupational Classification 01) had a strong and significantly increased asthma risk, as did managers in social, community, and correctional services (overall). Reduced risks were observed for middle management occupations in retail and wholesale trade and customer service and also technical occupations related to natural and applied sciences. While the broad group of natural resources, agriculture and related production occupations did not see any significant associations, the more detailed occupation group of mine laborers did see a significantly increased risk.

4. Discussion

This study assessed the risk of asthma in Manitoba by occupation, industry, and sex to identify occupations and industries that may have unrecognized cases of occupational asthma.

Consistent with previous findings, we found an increased risk of asthma among certain, well-established occupation groups with known exposures to asthmagens. Some of the strongest associations were observed for male veterinary and animal health technologists and technicians, who can be exposed to animal-specific asthmagens (e.g. proteins via secretions, fur, epithelia, particularly for laboratory animals) [4,20], as well as for male fish processing workers, who are exposed to fish proteins, mold in wet, humid environments, and bacterial toxins [21].

The incidence of asthma in the overall cohort (2.4%) was lower than the general Canadian population prevalence of asthma, which is estimated at 11.7% [2]. This is likely because the general population includes nonworkers (children, the retired, and those who are out of the workforce for other reasons, including health reasons) who have higher disease burdens than people able to work. In addition, incident cases were considered over a 5-year window rather than at a single time point or year, and finally, the difference could be due to differences between the MODSS cohort (workers who have had an accepted time loss claim) and the general working population in Manitoba.

An increased risk was observed among light duty cleaners and janitors who are exposed to well-known irritant and sensitizing asthmagens, including detergents, chlorine and acids, solvents, biocides, dusts, and latex gloves [22,23]. For light duty cleaners, these findings were only positive for males; while consistent with the Ontario ODSS study [12], these were contrary to the Alberta study, where increased risk was found among females only [10]. However, the broader literature also shows sex variations in risk [24,25], potentially reflecting differences in tasks and industries worked by sex, with resulting differential exposures. Similarly, an increased risk was observed among home support workers, housekeepers, and related occupations, who may also be exposed to cleaning products, detergents, and dusts, as well as secondhand smoke [26]. Other well-recognized groups with occupational asthma reflected in our results include bakers, who are exposed to a number of asthmagens including cereal flours and enzymes [27], machining tool operators, who are exposed to metalworking fluids [28,29], other medical technologists and technicians, who are exposed to a number of asthmagens, including glutaraldehyde, latex, nitrile, formaldehyde, sulfur dioxide, and acetic acid [30], and other laborers in processing, manufacturing, and utilities, a large group of workers with many potential asthmagen exposures (e.g., wood dust among sanders, toluene diisocyanates among printer helpers).

Gas station attendants, drivers (transport truck drivers; bus drivers, subway operators, and other transit operators), mail, postal and related workers, and public works and maintenance laborers (for males, females, and/or overall workers) showed increased

asthma risks. Similar results have been observed in some studies for these occupations [24,25,31] but less consistently compared with the well-known at-risk occupations. Asthmagens specific to these occupations are less clear. A potential exposure common to these occupations is traffic-related air pollution, which has some but limited evidence of an association with new-onset asthma in adults, and more specifically diesel engine exhaust, a key component of traffic-related air pollution for which evidence of asthma exacerbations in children exists [32]. Increased asthma risk was also observed among groups not well associated with asthma but for which previous findings have found some evidence of an association [31], including mine laborers, who may be exposed to dusts and exhausts, and crane operators, who may be exposed while maintaining or lubricating equipment and to respiratory irritants.

Survey interviewers and statistical clerks, receptionists and switchboard operators, and elementary and secondary school teacher assistants showed increased asthma risk, with the latter two associated with an increased risk among females. While indoor workers may be exposed to a number of asthmagens associated with indoor air, printing, cleaning chemicals, mold, and others [33], the increased risk observed within the receptionist and teaching occupations may also be driven by the overall higher incidence of asthma among adult females [34]. However, the Ontario ODSS did find an elevated risk of asthma among male school teachers [12], suggesting that increased risk among these workers in Manitoba could also be due to hazardous occupational exposures and not just due to increased asthma risk among females generally observed. Similarly, community and social service workers and managers in social, community, and correctional services showed increased risk within MODSS, but not in the broader literature. These workers may be exposed to secondhand smoke [25], as well as asthmagens associated with indoor work environments, listed above, although additional research should be conducted to better ascertain the most relevant exposures.

Contrary to previous findings, which found an increased or no effect on asthma risk [24,25,31], but similar to the Ontario ODSS [12], a decreased risk of asthma was observed among nurses. This may be in part be due to the reduced use of latex gloves in the 1990s and movement toward nitrile gloves [22]. These findings may also be explained by the healthy worker effect [35]; nurses who can be exposed to many different asthmagens [36,37], including high-level disinfectants, may become sensitized to occupational exposures and seek alternate employment. Finally, reduced risk was also observed among residential and commercial installer and servicers, which could be due to lower health care utilization rates among these workers, leading to asthma cases not being captured by MODSS.

When comparing the number of asthma cases identified by the MODSS with those captured by WCB claims, many MODSS cases in occupations with excess asthma cases were not captured by the WCB, indicating that there is a potential underrepresentation of asthma in WCB claims. Similarly, the broader literature that finds underclaiming and underreporting of workers' injuries and illnesses to workers' compensation boards [38,39]. To encourage reporting, efforts to educate workers about occupational asthma, and also workers' ability to apply for compensation, may be needed. We also found that some WCB claims are not being captured by the provincial health system. This would occur if an individual's treating physician diagnosed the worker with occupational asthma, submitted the claim to the WCB and not the provincial health care plan, and the WCB accepted it. As the case would not appear in the provincial health data, this would lower the observed asthma rate in some occupations. Unfortunately, due to data suppression restrictions, the distribution of the accepted claims that were not identified in the administrative health data by detailed occupation is not available. However, these claims primarily occurred in occupations in business, finance, and administration, as well as education, law and social, community, and government services.

Limitations of this study include the inability to control for potentially important confounders, such as smoking, family history of respiratory disease, allergic disease, and other environmental exposures. In addition, to be considered by MODSS, workers must be captured by the health care system. Thus, asthma risk among by occupation may be impacted by differential health care utilization (i.e., if a worker does not present to a physician with asthma symptoms, they would not be identified as an asthma case in MODSS). Furthermore, occupation misclassification is a possibility. Workers' occupations and industries are recorded with the submission of a WCB claim; these workers are then followed to identify new-onset asthma. However, workers' occupations may change from the time of cohort entry to case identification. To reduce misclassification, the case definition was limited to asthma cases occurring within 5 years of cohort entry (2 years prior, 3 years post). While the Manitoba WCB claims system includes most of the workforce, some industries such as law and accounting are excluded; therefore, our results cannot be generalized to the risks in those jobs; however, these are office-type jobs with limited known asthmagen exposures. Furthermore, MODSS is limited to workers who have accepted time loss WCB claims. Thus, some well-known occupations at risk of asthma may be excluded if the occupation's rate of compensation is low. Misclassification of asthma with other chronic obstructive lung diseases is also possible; however, previous research has shown that this is less problematic for asthma than for other COPD-like illnesses [40]. Finally, the generalizability of our findings to other provinces in Canada or internationally likely varies based on the workers included in other compensation systems, the adjudication processes of different systems, and the industry composition in other jurisdictions. For example, Manitoba has a smaller manufacturing industry than provinces such as Ontario or Quebec, but a larger agricultural industry, which may change the risk of asthma across working populations and jurisdictions. The impact of these limitations is likely to at least somewhat underestimate the true burden of occupational asthma in Manitoba, especially due to the missingness of workers without any time loss claims, and to a lesser extent, those who are not included in the compensation system in the first place.

Despite these limitations, the study results are reflected for the most part in the literature, indicating that MODSS is accurately identifying occupations with increased risk. Some occupations not typically associated with asthma were identified and warrant further investigation. By applying previously developed methods to link workers' compensation data to administrative health database in Manitoba, and finding meaningful results consistent with the broader literature, we found that these methods are applicable to jurisdictions with smaller populations.

There are important implications for workers, employers, and policy makers alike that result from this study. We identified elevated risks of occupational asthma among female home support workers, housekeepers, teacher assistants, and truck and bus drivers. Among male workers, increased risk was observed in mine laborers, gas station attendants, light duty cleaners, janitors, animal workers, and bakers. We also found lower risks for female nurses (perhaps reflective of a healthy worker effect), as well as among residential and commercial installers and servicers, and broadly speaking in those working in the trades and cultural and recreation professions (however, specific occupations in these categories did have an increased risk). Overall, this research helps to identify occupations and industries with increased risk of asthma and can be

used to prioritize and target future research and surveillance efforts at the employer, industry, and policymaker levels. This is of fundamental importance, given the paucity of occupation and/or industry information that is linked to health data in Canada. Importantly, this study demonstrated that occupational disease surveillance systems of this nature are feasible outside of large population centers, and other provinces should consider creating their own systems such that national occupational disease surveillance is possible in Canada.

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CRediT authorship contribution statement

Elizabeth Rydz: Investigation, Methodology, Project administration, Writing – original draft. **Randy Walld:** Data curation, Formal analysis, Methodology, Software, Writing – review & editing. **Mieke W. Koehoorn:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **Christopher B. McLeod:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **Paul A. Demers:** Conceptualization, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Cheryl E. Peters:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing. **Allen Kraut:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing – original draft, Writing – review & editing.

Conflicts of interest

The authors have no competing interests to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2024.07.002.

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