Respiratory-related workers' compensation claims from private employers — Ohio, 2001–2018

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A B S T R A C T

Background: Diseases and conditions related to the respiratory system contribute to work-related morbidity, mortality, and disability. Details on the causes and nature of work-related respiratory disease and the specific industries in which they occur are limited. This study identifies respiratory-related claims in the Ohio Bureau of Workers' Compensation (OHBWC) system and describes claim and worker characteristics to inform public health surveillance. *Methods:* We developed a list of respiratory-related International Classification of Diseases Clinical Modification (ICD-CM) diagnosis codes and searched over 2 million claims filed between 2001 and 2018 in the OHBWC system for at least one of these codes. The claim characteristics, rates of claims by employer industry classification, and causes of claims from narrative text were determined for these respiratory-related claims. *Results:* Among the 23,015 respiratory-related claims (5.8 per 10,000 full-time equivalents [FTE]), 54.6% had at least one ICD-CM code for Allergic Reactions and 30.6% had at least one code for Toxic Effects of Substances Chiefly Non-medicinal as to Source. Claim causes from narrative text included Chemical Exposure (30.3%), Activity Suggesting Exposure (24.4%), and Vapors, Gases, Dusts, or Fumes (VGDF) Exposure (19.3%). The highest overall rates of respiratory-related claims among private employers were for the agriculture, forestry & fishing (11.4 per 10,000), public safety (ambulance services) (11.3), and manufacturing (10.7) industry sectors. *Conclusions:* Respiratory-related claims in the OHBWC system were often acute in nature and included allergic reactions. Narratives from these claims provide insight into the work-related exposures and events causing claims or the disease and symptom factors surrounding claims.

1. Introduction

Chronic or acute diseases and conditions related to the respiratory system have various etiologies, such as exposure to dusts, chemicals, or other toxic substances and events causing injuries to respiratory system structures. Diseases and conditions related to the respiratory system may be connected to work and are considered work-related "if an event or exposure in the work environment either caused or contributed to the resulting condition or significantly aggravated a pre-existing injury or illness (Occupational Safety and Health Administration, 2023)." Pneumoconiosis, chronic obstructive pulmonary disease (COPD), asthma, rhinitis, sinusitis, and other respiratory conditions caused by work exposures are often the focus of occupational studies (Blanc & Torén, 2007; Doll & Peto, 1981; Henneberger et al., 1999; Mannino, 2000). While inhalation exposures can cause respiratory responses, skin

exposures to substances can also play a role in the development of respiratory conditions such as sensitization, asthma, and occupational allergies. For example, contact dermatitis can be a predictor of a larger allergic immune reaction impacting the respiratory system, often in the manifestation of occupational asthma, if a worker is sensitive or allergic to the exposure (Diepgen & Coenraads, 1999).

Unlike respiratory diseases and conditions caused by acute exposures or events (e.g., exposure to an infectious or parasitic disease or an event impacting pulmonary circulation) in the work environment, it can be difficult to determine work-relatedness of respiratory conditions caused by long-term exposures. This is especially true for chronic diseases, as they often require careful documentation of workplace exposures and symptom onset, which may be hindered by long latency periods or subclinical disease. Clinician under-recognition of work-relatedness is a significant barrier to diagnosing such respiratory conditions (Reinisch

et al., 2001). While data sources containing detailed information on clinician-diagnosed, work-related respiratory conditions are limited, workers' compensation (WC) claims provide a unique case-based data source for work-related respiratory conditions. WC claims were previously used to help identify exposures at work for a mold-related respiratory disease outbreak, respiratory disease associated with exposure to hop dust, and silicosis among stone countertop fabrication workers (Morse et al., 2005; Reeb-Whitaker & Bonauto, 2014; Rose et al., 2019).

WC systems are the largest databases of workers' injuries in the United States. WC systems are state-based and there are many differences in regulations, reporting, and compensability across states. Ohio is one of four states with an exclusively state-run WC system where the state acts as the sole insurance carrier for WC coverage (the other exclusively state-run WC systems are in North Dakota, Washington, and Wyoming). The X has a formal agreement with Ohio Bureau of Workers' Compensation (OHBWC) to use deidentified WC claims data to identify high risk industries, reduce worker risk for work-related injuries, inform prevention efforts, and aide in occupational health surveillance. While numerous occupational injury studies were published using OHBWC data, respiratory-related claims in this informative dataset have not been identified or described (Meyers et al., 2018; Wurzelbacher et al., 2016). The objectives of this analysis were to: (1) identify claims for respiratory-related diseases or conditions in the OHBWC system from 2001 to 2018; (2) describe these claims and the workers they impacted; and (3) identify factors causing or surrounding the claim from narrative text. Identifying unrecognized findings regarding the nature and characteristics of work-related respiratory conditions will help improve the health and safety of workers and aide in occupational health surveillance.

2. Methods

2.1. Data source

OHBWC policies cover 99% of all private and public industry employers in Ohio, which includes about two-thirds of the state's workforce. Approximately 80% of the OHBWC-insured workforce are private industry employers (Meyers et al., 2018; Wurzelbacher et al., 2016). Eligible employers demonstrating the ability to meet several financial and administrative criteria may opt out of OHBWC coverage and choose to self-insure. Limited information on claims for self-insured employers are included in the OHBWC system. This study was restricted to WC claims filed during 2001–2018 from OHBWC-insured, private industry employers with single-location or multiple-location (establishments). Public employers represented 1.9% of OHBWC policies and complete denominator information was unavailable for OHBWC-insured public employers (e.g., state agencies and public taxing districts) (Wurzelbacher et al., 2016). This activity was reviewed by the Y, deemed research not involving human subjects, and conducted in a manner consistent with applicable federal law and Y policy.

2.2. Claim characteristics

Claims included information on injured worker characteristics (i.e., sex, age group), employer information (i.e., employer workforce size, employer North American Industry Classification System [NAICS] codes and corresponding National Institute for Occupational Safety and Health [NIOSH] National Occupational Research Agenda [NORA] sector classifications), claim type (medical-only claim [medical care expenses only or <8 days away from work] or lost-time claim [≥8 days away from work]), and a brief free-text narrative describing how the illness or injury occurred (National Institute for Occupational Safety and Health (NIOSH), 2023). Free-text narratives were reported by the injured worker, a surrogate, or a medical provider. OHBWC claims also included International Classification of Diseases Clinical Modification (ICD-CM) diagnosis codes (Ninth and Tenth Revisions). On October 1, 2015, the U.

S. transitioned from the Ninth Revision (ICD-9-CM) to the Tenth Revision (ICD-10-CM) of the ICD-CM. This study spans 2001–2018 and data include both ICD-CM revisions.

2.2.1. Disease categories

A respiratory disease epidemiologist compiled a list of respiratory-related ICD-9-CM and ICD-10-CM diagnosis codes based on the ICD-CM categories. A second respiratory disease epidemiologist reviewed the diagnosis codes and helped create the final list of respiratory-related diagnosis codes (Supplement Table 1). Respiratory-related diagnosis codes were grouped into eight broad disease categories (Supplement Table 1) following the existing ICD-CM categories. These categories included: (1) Infectious and Parasitic Diseases (e.g., pulmonary tuberculosis, histoplasmosis); (2) Lung, Respiratory, or Intrathoracic Neoplasms (e.g., malignant neoplasm of pleura); (3) Diseases of the Circulatory System (e.g., acute pulmonary heart disease); (4) Diseases of the Respiratory System (e.g., asthma, chronic obstructive pulmonary disease); (5) Pneumoconioses and Lung Diseases Due to External Agents (e.g., silicosis, hypersensitivity pneumonitis); (6) Respiratory Symptoms, Signs, and Ill-defined Conditions (e.g., symptoms involving respiratory system and other chest symptoms); and (7) Allergic Reactions (e.g., contact dermatitis due to detergents, oils and greases, solvents, and other agents; anaphylactic reaction). The eighth disease category, Toxic Effects of Substances Chiefly Non-medicinal as to Source, includes diagnosis codes for exposures known to cause respiratory system outcomes such as alcohol, solvents, carbon monoxide, and other gases, fumes, or vapors. Some workers had more than one respiratory-related claim. Also, claims could include more than one ICD-CM diagnosis code and respiratory-related diagnosis codes were counted in all applicable disease categories (but only once when multiple codes were in the same category). State-level claims for coal workers' pneumoconiosis (black lung) are administered under a separate system in Ohio and were excluded from this analysis.

2.2.2. Narrative text review

Keyword category development: Occupational Injury and Illness Classification System (OIICS) event or exposure codes (describing the manner in which an illness or injury was produced) were only available for OHBWC claims starting in 2007 and often lacked sufficient detail about specific exposures (Bureau of Labor Statistics, 2023). For example, 78% of claims from 2007 to 2018 were coded to the 1-digit OIICS (version 2.01) "exposure to harmful substances or environments" code. More detailed 2-digit OIICS sub-category coding for 98% of these "exposure to harmful substances or environments" claims only specified "exposure to other harmful substances (Bureau of Labor Statistics, 2023)." Therefore, to consistently identify factors in the narrative text discussing how the claim occurred, we developed a structured narrative text review process rather than manually code narratives from the 23,015 respiratory-related claims, which was not feasible due to resource constraints. In this narrative text review process, we: (1) identified common, meaningful keywords, (2) grouped related keywords into categories, and (3) performed keyword searches to assign keyword categories to narrative text.

One epidemiologist with over 10 years of research experience in occupational respiratory health developed a comprehensive list of keywords (including two-word phrases) identified from the literature and from the OHBWC claim narrative text (Reeb-Whitaker & LaSee, 2019). The frequency output of keywords from narrative text was examined to identify common keywords (i.e., occurring at least 10 times). An iterative search and manual review process identified uncommon yet meaningful keywords and allowed for refinement or modification of keyword terms. The reviewer grouped keywords into categories unique to this study and more detailed than the OIICS event or exposure codes. Keywords related to an etiological exposure or event were grouped into 10 Exposure/Event categories (Vapors, Gases, Dusts, or Fumes [VGDF] Exposure, Chemical Exposure, Agriculture Exposure, Other Exposure,

Activity Suggesting Exposure, Inhalation Exposure, Smoke Exposure, Dermal Exposure, Fire Event, and Trauma Event [such as slips, trips, falls, contact with objects and equipment]) using technical knowledge of occupational exposures and events. The Activity Suggesting Exposure category included keywords that are verbs and tasks (such as braze, grind, sand blasting, welding) and are known to result in exposures. Narrative text was unstructured, and the complexity and detail of text varied by claim. Narrative text without any etiological Exposure/Event keywords often included keywords related to disease or symptom factors surrounding the claim, so we grouped these keywords into three Disease/Symptom categories (Respiratory Disease/Symptom, Dermal Disease/Symptom, and Other Disease/Symptom). Examples of keywords from all 13 narrative keyword categories are included in Supplement Table 2.

Keyword category assignments: Three rounds of keyword searches were performed to assign keyword categories to text. In the first round, Exposure/Event keyword categories were assigned to narratives using a text search algorithm. In the second round, narratives not assigned to an Exposure/Event category were searched for a Disease/Symptom category. A claim narrative could be assigned more than one Exposure/Event category or Disease/Symptom category but was only searched for Disease/Symptom keywords if Exposure/Event keywords were not present. In the third round, the remaining unassigned narratives were manually read to assign a category. A category was created for claim narratives not assigned to an Exposure/Event or Disease/Symptom category due to missing or incomplete information regarding how the claim occurred. The narrative text review process is summarized in Fig. 1.

2.3. Rate calculation methods and study analysis

Rates of WC claims per 10,000 employees were calculated by industry among private employers insured by the OHBWC. The numerator for rates was the number of respiratory-related claims. OHBWC claims from employers with missing NAICS codes or without reported employees (n = 333 claims) were excluded from rate calculations, resulting in 22,682 claims comprising the numerator for the overall rate calculation (Wurzelbacher et al., 2016). To obtain the denominator, OHBWC claims were linked to Ohio unemployment insurance data to determine employer industry and number of employees. Full-time equivalent (FTE) was estimated for each industry using Bureau of Labor Statistics (BLS) Labor and Productivity and Costs survey data on hours worked per employee, as described elsewhere (Wurzelbacher et al., 2021). Cumulative claim rates were calculated as the sum of claim counts divided by the sum of FTE for 2001–2018. SAS version 9.4 (SAS Institute, Cary, NC) was used to conduct all analyses.

3. Results

3.1. Demographics and claim type

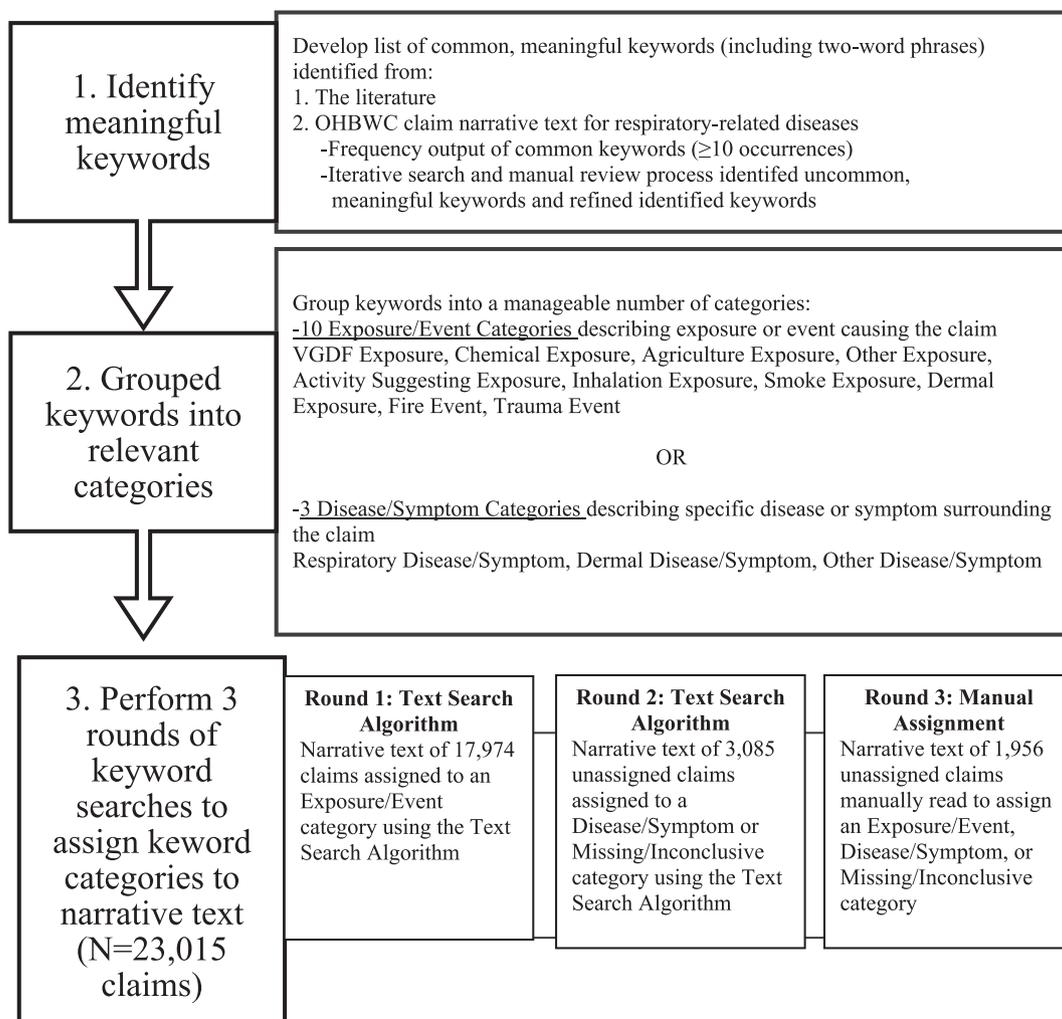During 2001 to 2018, there were about 2,080,000 total OHBWC

Fig. 1. Summary of narrative text review process.

claims filed. Of these total claims, 23,015 claims from private employers were respiratory-related and represented 22,071 unique workers (Table 1). Over two-thirds of the 23,015 claims were from male workers (67.1%) and from workers 14–44 years of age (68.6%). By employer size, the largest proportion of claims were from workers with employers with 100 to <1000 FTE (42.4%), followed by >0 to <50 FTE (37.0%). Most claims (85.7%) were medical-only claims, particularly in the Allergic Reactions and Toxic Effects of Substances Chiefly Non-medicinal as to Source disease categories. Lost-time claims were highest in the categories Lung, Respiratory, or Intrathoracic Neoplasms (97.4%), Diseases of the Circulatory System (96.7%), and Infectious and Parasitic Diseases (71.6%) and there were 181 claims resulting in fatalities (data not shown). Of claims among younger workers 14–44 years of age, 90.0% were medical-only claims while 76.2% of claims among workers 45 years of age and older were medical-only claims.

3.2. Disease categories

Claims could include more than one ICD-CM diagnosis code, and the 23,015 respiratory-related claims had a total of 41,149 ICD-CM codes for any disease (not only respiratory-related diseases). Among these 23,015 claims, 78.7% (n = 18,119) had only one ICD-CM code, 11.3% had two ICD-CM codes for any disease, 5.3% had 3–5 codes, and 4.7% had 6–39 codes (data not shown). Since claims with more than one code were counted in all applicable disease categories (but only once if more than one code was in the same disease category), the 24,897 ICD-CM respiratory-related codes on the 23,015 claims were represented as 23,689 disease categories (Tables 2 and 3). The count and percent of respiratory-related codes in each disease category are presented in Table 2 and over half (53.0%) were in the Allergic Reactions disease category.

3.3. Narrative keyword categories

In the first keyword search round, 17,974 claim narratives were assigned Exposure/Event categories using the text search algorithm. Of the residual claims not assigned to an Exposure/Event category, the second keyword search round assigned 3,085 narratives to a Disease/Symptom or Missing/Inconclusive category. The remaining 1,956

narratives without an assignment were read and manually assigned to a narrative keyword category (Fig. 1). Among the respiratory-related claims, 82.7% (n = 19,023) had a narrative describing an Exposure/Event category (including Chemical Exposure [30.3%], Activity Suggesting Exposure [24.4%], or VGDF Exposure [19.3%]); 14.6% (n = 3,355) had a narrative describing a Disease/Symptom category (including Dermal [9.8%], Other [3.8%], or Respiratory [3.1%] Disease/Symptom); and 2.8% (n = 637) had missing or inconclusive narrative text (Table 2).

3.4. Narrative keyword categories by disease category

Allergic reactions: Narrative text suggested 74.2% of the 12,565 claims with at least one Allergic Reactions diagnosis had an Exposure/Event category. The three Exposure/Event categories causing the highest proportion of Allergic Reactions included Chemical Exposure (30.5%), Dermal Exposure (28.8%), and Activity Suggesting Exposure (18.3%). Narrative text for 17.6% of Allergic Reactions reported the Disease/Symptom keyword category of Dermal Disease/Symptom (Table 2). Of all Allergic Reactions, 82.2% included the ICD-9-CM diagnosis code contact dermatitis and other eczema (692). Poison ivy and exposures to similar plants were common in the narrative text of these claims (Table 2).

Toxic effects of substances chiefly non-medicinal as to source: Of the 7,044 claims with at least one Toxic Effects of Substances Chiefly Non-medicinal as to Source diagnosis, the most common Exposure/Event categories were VGDF Exposure (44.5%), Activity Suggesting Exposure (37.9%), and Chemical Exposure (36.4%) (Table 2). Specific Toxic Effects of Substances Chiefly Non-medicinal as to Source diagnosis codes included toxic effects of other gases, fumes, or vapors (55.8%, ICD-9-CM 987) and toxic effect of carbon monoxide (14%; ICD-9-CM 986) (Table 2).

Diseases of the respiratory system: Narrative text for 2,206 claims with at least one Diseases of the Respiratory System diagnosis indicated 91.8% resulted from an Exposure/Event. Specifically, narrative text suggested 58.2% of Diseases of the Respiratory System were from a Trauma Event, 16.2% were from VGDF Exposure, and 16.0% were from Chemical Exposure (Table 2). Examples of narrative text keywords are "fell," "slipped," "motor vehicle crash," and "inhalation of fumes." The top three most common diagnosis codes on these claims included other diseases of the lung (17.0%, ICD-9-CM 518), asthma (9.7%, ICD-9-CM 493), and pleurisy (8.8%, ICD-9-CM 511) (Table 2). Approximately two-thirds of claims with a Diseases of the Respiratory System diagnosis (64.9%) were lost-time claims resulting in ≥8 days away from work (data not shown).

Pneumoconiosis and lung diseases due to external agents: The top three Exposure/Event categories causing 1,186 claims with at least one Pneumoconiosis and Lung Diseases Due to External Agents diagnosis were VGDF Exposure (38.7%), Activity Suggesting Exposure (35.8%), and Chemical Exposure (35.5%). Pneumoconiosis and Lung Diseases Due to External Agents claims included the ICD-9-CM diagnosis code for respiratory conditions due to chemical fumes and vapors (57.9%; ICD-9-CM 506) and respiratory conditions due to other and unspecified external agents (12.8%; ICD-9-CM 508).

Diseases of the circulatory system: Most (92.6%) of the 361 claims with at least one Diseases of the Circulatory System diagnosis code were assigned to a Trauma Event keyword category. The most common Diseases of the Circulatory System diagnosis codes were acute pulmonary heart disease (78.5%; ICD-9-CM 415) or pulmonary embolism (20.1%; ICD-9-CM I26). Almost all Diseases of the Circulatory System claims were lost-time claims (96.7%), and examples of narrative text keywords for the Trauma Event were "runover," "slipped," "fell," "lifting," or "struck by car."

Respiratory symptoms, signs, and ill-defined conditions: Of the 182 claims with at least one Respiratory Symptoms, Signs, and Ill-defined Conditions diagnosis code, keywords indicated the cause for 40.7%

Table 1
Count and percent of respiratory-related claims by claim type among OHBWC private employers, 2001–2018.

Characteristic	Claims n (%)		
	All 23,015	Lost-time 3,286 (14.3)	Medical-only 19,729 (85.7)
Sex			
Female	7,319 (31.8)	791 (24.1)	6,528 (33.1)
Male	15,433 (67.1)	2,487 (75.7)	12,946 (65.6)
Unknown	263 (1.1)	8 (0.2)	255 (1.3)
Age Group (years)			
14–19	1,392 (6.0)	61 (1.9)	1,331 (6.7)
20–24	3,505 (15.2)	167 (5.1)	3,338 (16.9)
25–34	5,758 (25.0)	532 (16.2)	5,226 (26.5)
35–44	5,139 (22.3)	817 (24.8)	4,322 (21.9)
45–54	4,471 (19.4)	906 (27.6)	3,565 (18.1)
55–64	2,250 (9.8)	571 (17.4)	1,679 (8.5)
65 and over	461 (2.0)	232 (7.1)	229 (1.2)
Unknown	39 (0.2)	0 (0)	39 (0.2)
Employer workforce size			
>0 to <50 est. FTE	8,527 (37.0)	1,591 (48.4)	6,936 (35.2)
≥50 to <100 est. FTE	4,068 (17.7)	542 (16.5)	3,526 (17.9)
≥100 to <1000 est. FTE	9,749 (42.4)	1,059 (32.2)	8,690 (44.0)
≥1000 est. FTE	513 (2.2)	72 (2.2)	441 (2.2)
Unknown (0 est. FTE)	158 (0.7)	22 (0.7)	136 (0.7)

Table 2
Narrative keyword categories for claims (n = 23,015) by claim type and for disease categories[a] (n = 23,689) among OHBWC private employers, 2001–2018.

	Claims n (%)			Disease Category n (%)				
	All 23,015	Lost-time 3,286 (14.3)	Medical-only 19,729 (85.7)	Allergic Reactions n = 12,565 (53.0)	Toxic Effects of Substances Chiefly Non-medicinal as to Source n = 7,044 (29.7)	Diseases of the Respiratory System n = 2,206 (9.3)	Pneumoconioses and Lung Diseases Due to External Agents n = 1,186 (5.0)	Diseases of the Circulatory System n = 361 (1.5)
Narrative Keyword Categories								
Exposure/ Event[b]	19,023 (82.7)	2,937 (89.4)	16,086 (81.5)	9,319 (74.2)	6,567 (93.2)	2,026 (91.8)	1,102 (92.9)	341 (94.5)
Chemical Exposure	6,982 (30.3)	740 (22.5)	6,242 (31.6)	3,834 (30.5)	2,565 (36.4)	353 (16.0)	421 (35.5)	11 (3.0)
Activity Suggesting Exposure	5,621 (24.4)	499 (15.2)	5,122 (26.0)	2,300 (18.3)	2,672 (37.9)	349 (15.8)	424 (35.8)	10 (2.8)
VGDF[c] Exposure	4,444 (19.3)	568 (17.3)	3,876 (19.6)	599 (4.8)	3,133 (44.5)	357 (16.2)	459 (38.7)	4 (1.1)
Dermal Exposure	3,722 (16.2)	130 (4.0)	3,592 (18.2)	3,622 (28.8)	97 (1.4)	14 (0.6)	2 (0.2)	1 (0.3)
Trauma Event	3,475 (15.1)	1,569 (47.8)	1,906 (9.7)	1,153 (9.2)	614 (8.7)	1,284 (58.2)	115 (9.7)	334 (92.5)
Fire Event	1,135 (4.9)	93 (2.8)	1,042 (5.3)	46 (0.4)	835 (11.9)	82 (3.7)	223 (18.8)	3 (0.8)
Inhalation Exposure	894 (3.9)	91 (2.8)	803 (4.1)	207 (1.6)	539 (7.7)	89 (4.0)	103 (8.7)	1 (0.3)
Smoke Exposure	887 (3.9)	47 (1.4)	840 (4.3)	9 (0.1)	675 (9.6)	54 (2.5)	186 (15.7)	0
Other Exposure	554 (2.4)	82 (2.5)	472 (2.4)	331 (2.6)	115 (1.6)	85 (3.9)	24 (2.0)	3 (0.8)
Agriculture Exposure	459 (2.0)	76 (2.3)	383 (1.9)	284 (2.3)	73 (1.0)	56 (2.5)	20 (1.7)	7 (1.9)
Disease/ Symptom[b]	3,355 (14.6)	287 (8.7)	3,068 (15.6)	2,755 (21.9)	395 (5.6)	133 (6.0)	69 (5.8)	12 (3.3)
Dermal	2,245 (9.8)	133 (4.1)	2,112 (10.7)	2,214 (17.6)	29 (0.4)	13 (0.6)	3 (0.3)	1 (0.3)
Other	875 (3.8)	99 (3.0)	776 (3.9)	494 (3.9)	294 (4.2)	59 (2.7)	19 (1.6)	11 (3.0)
Respiratory	717 (3.1)	93 (2.8)	624 (3.2)	449 (3.6)	131 (1.9)	77 (3.5)	55 (4.6)	3 (0.8)
Missing/ Inconclusive	637 (2.8)	62 (1.9)	575 (2.9)	491 (3.9)	82 (1.2)	47 (2.1)	15 (1.3)	8 (2.2)
Narrative text keyword examples	—	Tripped, cleaners, lead, crushed	Coughing, fumes, poison ivy, smoke	Fiberglass, poison ivy, chemical, rash, resin, insect bite	Carbon monoxide, carbon dioxide, spill, smoke, paint	Fell/fall, slipped, motor vehicle crash, inhalation of fumes	Exploded, mold, asbestos, smoke inhalation, ammonia leak	Runover, slipped, fell, lifting, struck by car

[a] A claim could have multiple respiratory-related diagnosis codes which were counted in all applicable disease categories but only once if codes were in the same disease category.

[b] A claim narrative could be assigned to more than one Exposure/Event category or Disease/Symptom category but was only searched for Disease/Symptom keywords if Exposure/Event keywords were not present.

[c] Vapors, Gases, Dusts, or Fumes (VGDF).

was Trauma Event and Chemical Exposure for 22.5%. Diagnosis codes for most of these claims were for symptoms involving respiratory system and other chest symptoms (88.7%, ICD-9-CM 786) (data not shown).

Lung, respiratory, or intrathoracic neoplasms: There were 78 claims with a Lung, Respiratory, or Intrathoracic Neoplasm diagnosis codes, and narrative text suggested the cause of 97.4% was VGDF exposure (usually to asbestos). Example narrative keywords for Lung, Respiratory, or Intrathoracic Neoplasm claims included "asbestos" and "mesothelioma," diagnosis codes for these claims were for malignant neoplasm of the pleura (31.3%, ICD-9-CM 163), mesothelioma (30.0%, ICD-10-CM C45), and malignant neoplasm of bronchus and lung (21.3%, ICD-10-CM C34), and claims were primarily lost-time claims (97.4%) (data not shown).

Infectious and parasitic: Of the 67 claims with an Infectious and Parasitic Diseases diagnosis codes, narrative text indicated the cause for 43.3% was Agriculture Exposure and Activity Suggesting Exposure for 22.4%. Narrative text for 31.3% included a Disease/Symptom keyword category. Narrative text keyword examples for Infectious and Parasitic Disease claims included "droppings," "feces," "soil," and "histoplasmosis," diagnosis codes for these claims were for histoplasmosis (52.9%,

ICD-9-CM 115) or pulmonary tuberculosis (15.7%, ICD-9-CM 011), and 71.6% were lost-time claims (data not shown).

3.5. Claims by industry

The highest proportions of respiratory-related claims occurred among the services (34.4%), manufacturing (31.1%), healthcare & social assistance (10.3%), wholesale & retail trade (9.5%), and construction (9.0%) sectors (Table 3). By disease category, over half of Allergic Reactions claims, Toxic Effects of Substances Chiefly Non-medicinal as to Source claims, and Pneumoconiosis and Lung Diseases Due to External Agents claims occurred in the services or the manufacturing sectors. While claims often occurred in the services and manufacturing sectors, claims with a Diseases of the Respiratory System diagnosis also occurred in the construction sector (18.2%); claims with a Disease of the Circulatory System diagnosis occurred in the wholesale & retail trade (12.5%), construction (19.9%), and transportation (10.5%) sectors; and Lung, Respiratory, or Intrathoracic Neoplasms claims occurred among workers exposed to asbestos in the construction sector (50.0%). Claims with Respiratory Symptoms, Signs, and Ill-defined Conditions occurred

Table 3
NORA Industry sector for claims (n = 23,015) by claim type and for disease categories[a] (n = 23,689) among OHBWC private employers, 2001–2018.

	Claims n (%)			Rate per 10,000 FTE		Disease Category[a] n (%)							
	All 23,015	Lost-time 3,286 (14.3)	Medical-only 19,729 (85.7(	All claims[c]	Lost-time	Allergic Reactions n = 12,565	Toxic Effects of Substances Chiefly Non-medicinal as to Source n = 7,044	Diseases of the Respiratory System n = 2,206	Pneumoconioses and Lung Diseases Due to External Agents n = 1,186	Diseases of the Circulatory System n = 361	Respiratory Symptoms, Signs, and Ill-defined Conditions n = 182	Lung, Respiratory, or Intrathoracic Neoplasms n = 78	Infectious and Parasitic n = 67
Total				5.8	0.8								
NORA Industry Sector[b]													
Services	7,909 (34.4)	818 (24.9)	7,091 (35.9)	5.0	0.5	4,692 (37.3)	2,310 (32.8)	632 (28.7)	333 (28.1)	88 (24.4)	42 (23.1)	14 (18.0)	13 (19.4)
Manufacturing	7,154 (31.1)	954 (29.0)	6,200 (31.4)	10.7	1.4	4,262 (33.9)	2,055 (29.2)	470 (21.3)	423 (35.7)	75 (20.8)	47 (25.8)	14 (18.0)	5 (7.5)
Healthcare & Social Assistance	2,374 (10.3)	256 (7.8)	2,118 (10.7)	4.5	0.5	1,187 (9.5)	817 (11.6)	226 (10.2)	122 (10.3)	33 (9.1)	30 (16.5)	1 (1.3)	16 (23.9)
Wholesale & Retail Trade	2,189 (9.5)	382 (11.6)	1,807 (9.2)	3.3	0.6	1,006 (8.0)	790 (11.2)	258 (11.7)	116 (9.8)	45 (12.5)	22 (12.1)	6 (7.7)	5 (7.5)
Construction	2,079 (9.0)	573 (17.4)	1,506 (7.6)	6.7	1.8	900 (7.2)	590 (8.4)	401 (18.2)	114 (9.6)	72 (19.9)	30 (16.5)	39 (50.0)	25 (37.3)
Transportation, Warehousing & Utilities	822 (3.6)	231 (7.0)	591 (3.0)	5.7	1.6	260 (2.1)	337 (4.8)	164 (7.4)	46 (3.9)	38 (10.5)	9 (5.0)	4 (5.1)	1 (1.5)
Agriculture, Forestry & Fishing	288 (1.3)	26 (0.8)	262 (1.3)	11.4	1.1	196 (1.6)	60 (0.9)	19 (0.9)	12 (1.0)	3 (0.8)	1 (0.6)	0	2 (3.0)
Public Safety[d]	92 (0.4)	8 (0.2)	84 (0.4)	11.3	1.0	28 (0.2)	47 (0.7)	11 (0.5)	7 (0.6)	2 (0.6)	1 (0.6)	0	0
Oil & Gas Extraction	54 (0.2)	15 (0.5)	39 (0.2)	7.7	2.1	17 (0.2)	25 (0.4)	10 (0.5)	1 (0.1)	2 (0.6)	0	0	0
Mining	43 (0.2)	21 (0.7)	22 (0.1)	5.2	2.5	9 (0.1)	11 (0.2)	13 (0.6)	11 (0.9)	3 (0.8)	0	0	0
Multiple Sectors	11 (0.1)	2 (0.1)	9 (0.1)	1.7	0.3	8 (0.1)	2 (0.1)	2 (0.1)	1 (0.1)	0	0	0	0

[a] A claim could have multiple respiratory-related diagnosis codes which were counted in all applicable disease categories but only once if codes were in the same disease category.

[b] National Occupational Research Agenda (NORA) Industry Sectors (NIOSH, 2023).

[c] 22,682 claims out of 23,015 were included in the numerator for the overall rate calculation.[d] A more detailed exploration of private employers within the public safety sector showed all 92 claims were from workers employed in the ambulance services industry.

in manufacturing (25.8%), services (23.1%), healthcare & social assistance (16.5%), and construction (16.5%) sectors. Claims with Infectious and Parasitic diagnosis codes occurred in the construction sector (37.3%) and in healthcare & social assistance (23.9%) workers with a tuberculosis diagnosis (Table 3).

The overall rate of respiratory-related claims was 5.8 claims per 10,000 FTE. The highest rate of claims by NORA sector was among the agriculture, forestry & fishing sector (11.4) (Table 3) which, when explored by more detailed NAICS industry, included an overall rate of 16.7 among the crop production industry (data not shown). All private employers in the public safety sector were in the ambulance services industry where the overall rate was 11.3 per 10,000 FTE. The overall rate of claims was also high among the manufacturing sector (10.7). More detailed NAICS industry subsectors within the manufacturing sector had high overall rates particularly among chemical manufacturing [20.9], petroleum and coal products manufacturing [13.8], and primary metal manufacturing [13.6] industry subsectors (data not shown). Sectors with the highest rates of lost-time claims were mining (2.5), oil & gas extraction (2.1), and construction (1.8). In general, severity of lost-time claims is greater than medical-only claims, although there are exceptions to this statement.

4. Discussion

This study identified 23,015 respiratory-related claims among private employers and summarized claim characteristics and causes. Slightly over half of all claims were for an Allergic Reaction, often caused by a Chemical Exposure, Dermal Exposure, or Activity Suggesting Exposure. Around 30% of claims were for Toxic Effects of Substances Chiefly Non-medicinal as to Source, often caused by VGDF Exposure, Chemical Exposure, or Activity Suggesting Exposure. About one-third of claims occurred in the services sector, a large and highly diverse NORA sector including teachers, finance workers, and restaurant cooks with various work exposures often causing Allergic Reactions, Toxic Effects, Diseases of the Respiratory System, and Pneumoconioses. Slightly less than one-third of claims occurred in the manufacturing sector where work to create new products is often performed in plants, factories, or mills causing a variety of respiratory-related diseases from exposures and events. This study shows a continued need to focus prevention strategies on workers in the healthcare & social assistance sector with a Trauma Event or Chemical Exposure leading to Respiratory Symptoms, Signs, and Ill-defined Conditions or with exposures to tuberculosis or other infectious diseases. Half of the claims among the construction sector were for neoplasms often caused by VGDF exposure, especially to asbestos, and over a third were Infectious and Parasitic disease claims (including histoplasmosis) often resulting from agriculture or animal exposures. The agriculture, forestry & fishing sector had the highest overall claim rate (11.4 per 10,000) due to plant, insect, or other exposures causing Allergic Reactions and Toxic Effects diseases. The public safety (ambulance services) industry had an overall claim rate of 11.3 and most claims were for Allergic Reactions or Toxic Effects.

The overall rate of respiratory-related claims from 2001 to 2018 was 5.8. While other data systems, including the BLS Survey of Occupational Injuries and Illnesses (SOII) and the NIOSH National Electronic Injury Surveillance System-Occupational Supplement (NEISS-Work), collect national information on nonfatal occupational illness or injuries, there are discrepancies in categories of illness, data collection, and inclusion criteria which prohibit their comparisons with OHBWC data. For example, in 2018, the BLS reported 176,900 cases of nonfatal occupational illness among all industries using SOII data. Of all nonfatal occupational illness cases, 14.2% (25,000) were "skin diseases or disorder" (2.2 per 10,000 FTE) and 11.1% (19,600) were respiratory conditions (1.7 per 10,000 FTE) (Bureau of Labor Statistics, 2009). Only Occupational Safety and Health Administration recordable cases (involving lost worktime, medical treatment other than first aid, restriction of work or motion, loss of consciousness, or transfer to another

job) were included in the BLS case count, so the total number of cases for diseases related to the respiratory system is likely underestimated. Chronic conditions like asthma and COPD are often not included in BLS counts, although an estimated 3 million causes of adult-onset asthma are attributable to occupational factors and 15.5 million adults reported ever being diagnosed with COPD in 2015, a disease where about 14% of cases are attributable to occupational factors (Blanc et al., 2019; Centers for Disease Control and Prevention (CDC), 2017; Croft et al., 2018).

Reflecting on the growing use of informatics in public health, data from state WC systems are increasingly being used to explore health outcomes as part of occupational health surveillance and improve workplace safety and health research among specific states (Morse et al., 2005; Reeb-Whitaker & LaSee, 2019; Reinisch et al., 2001; Wurzelbacher et al., 2021). However, little research focuses on identifying and describing the causes of respiratory-related claims especially with data from the OHBWC. Since this was our first analysis using respiratory-related OHBWC claims and all claims were work-related with nearly complete ICD-CM diagnosis code and free-text narrative fields, we took a comprehensive and wide-ranging analysis approach. We identified both chronic and acute respiratory-related diagnosis codes beyond the traditional occupational and acute diseases typically analyzed in WC claim studies. Analyzing a variety of respiratory-related diagnosis codes provided information on atypical diseases and causes. For instance, this study included claims with an Allergic Reactions diagnosis in attempt to identify claims where a work-related skin exposure caused larger systemic impacts, like the manifestation of occupational asthma. However, we learned that only a small proportion of Allergic Reactions claims could potentially lead to systemic impacts from a sensitizing exposure. Most Allergic Reactions claims were for contact dermatitis and other eczema, often caused by exposures to poison ivy, poison oak, or other plants while weeding, lawnmowing, or working outdoors. Therefore, future studies may need to apply stricter criteria to exclude Allergic Reactions claims unrelated to sensitization. Toxic Effects of Substances Chiefly Non-medicinal as to Sources diagnoses were included in attempt to identify specific work-related inhalation exposures to carbon monoxide, pesticides, metals, and other gases, fumes, or vapors. However, narrative text details suggest these claims were often coded with broad diagnosis codes not specifying the exposure or were caused by spills or accidental ingestion of chemicals (e.g., chemicals stored in soda cans or water bottles). Future studies may need to apply stricter text search criteria to appropriately identify claims caused by acute and chronic inhalation exposures.

The insights obtained from the Exposure/Event and Disease/Symptom Keyword Categories highlight the practicality of the narrative text review method used in this study. Grouping narrative text keywords into broad categories provided additional claim cause and disease data that was not always evident from ICD-CM codes. The exposure and event causes identified from claims indicate opportunities to develop, improve, and target prevention strategies for respiratory-related diseases and conditions among workers at risk. Claims with a Trauma Event keyword included transportation related crashes leading to Diseases of the Respiratory System or Circulatory System. There are numerous prevention programs and interventions to address transportation-related hazards including in-vehicle monitoring systems, systems to monitor driver fatigue, and proximity sensors (Wurzelbacher et al., 2021). Prevention insights related to OHBWC claims caused by VGDF or chemical exposures include substitution of materials and industrial ventilation controls to reduce hazards as well as proper chemical labeling and storage. Fire and explosion prevention programs and principles are also important to reinforce as these claims were often high-severity events caused by smoke inhalation and/or other related injuries. Strategies to reduce respiratory disease among specific types of workers and additional information on protecting employees from inhalation hazards using respiratory protection are available (National Institute of Occupational Safety and Health (NIOSH), 2023; National Academies of Sciences, Engineering, and Medicine, 2022; National

Institute for Occupational Safety and Health (NIOSH), 2023).

4.1. Limitations

Understanding the limitations of WC claims as a source of work-related disease surveillance is necessary to interpret study results and develop study conclusions. Ohio WC claims offer standardized data to gain insight into clinician diagnosed respiratory-related diseases, but these data are from one state and are neither generalizable to other states nor a comprehensive source of work-related injury and illness surveillance. WC data does not include medical cases where a WC claim was not filed or cases for workers without WC coverage, thereby underestimating the work-related disease burden. The current study was limited to respiratory-related WC claims from OHBWC-insured, private industry employers and missed claims from self-insured employers and public employers. During the study period, there were 8,600 respiratory-related ICD-CM diagnosis codes on the 8,112 respiratory-related public employer claims. The proportion of diagnosis codes in each disease category for public employer claims was about the same (1–3% difference) as the distribution among private employers reported in this study. Furthermore, underreporting of work-related injury and illness occurs and is impacted by individual, workplace, industry, occupation, and disease-specific factors (Azaroff et al., 2002; Fan et al., 2006; Wurzelbacher et al., 2021). Examples of underreported chronic respiratory diseases include silicosis, where state-based silicosis surveillance indicated less than 40% of workers with silicosis applied for WC benefits, and asthma, where only 46% of all reports of work-related asthma submitted to NIOSH from selected states were from WC claims in 2009–2015 (National Institute for Occupational Safety and Health (NIOSH), 2021; Reilly et al., 2018; Stanbury et al., 1995).

Free-text narratives were not written for the purpose of keyword searches. Narrative text contained various level of detail, jargon, misspellings, or was incomplete or missing meaningful keywords, which could make it difficult to assign a keyword category at times. However, it would be too resource intensive to manually review all claim narratives or create a training dataset large enough to use a machine learning approach to assign keyword categories. The keyword search approaches used in the narrative text review process of this study served as a useful and practical method to identify claim cause and could be applied to other WC data sources when coding with OIICS or manual text review are not feasible. Further work could explore more specific keyword categories within each disease category.

The keyword category assignment process did perform poorly in some situations, which could impact data interpretation. For example, the word "pop" was considered a keyword in the Trauma Event category because it was frequently used to describe an injury such as "felt a pop in my arm" or "my knee popped." However, the word "pop" was also used in other contexts, such as "…had chemical in a pop container instead of the correct container and took a drink…," "took a drink from my pop and swallowed a bee…," or "bleach barrel popped open," Potentially misclassifying a claim as a having a Trauma Event keyword. The methods used to assign narrative text in this study summarized cause but were sometimes insufficient at providing the detail needed to understand the complexity of the Event/Exposure.

5. Conclusion

This was the first study to identify and explore respiratory-related claims in the OHBWC system. Respiratory-related claims were often medical-only claims for Allergic Reactions or Toxic Effects of Substances Chiefly Non-medicinal as to Source. The narrative text review process developed specifically for this study helped glean information on the work-related exposures and events causing claims or the disease and symptom factors surrounding claims. Work-related diseases and conditions are preventable and findings from our study can help inform reinforcement of existing industry-wide prevention actions or

development of new actions to reduce work-related respiratory disease. Continued disease surveillance will help identify ongoing, common claim causes and new, emerging claim causes to improve the health and safety of workers.

6. Practical applications

Narrative text from WC claims provides valuable information to identify and describe common work-related causes of respiratory-related claims. Narrative text detailing how an illness or injury occurred can inform injury and disease prevention strategies within specific industries to reduce respiratory-related diseases among workers.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsr.2024.06.004.

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