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Emergency department visits for heat-related illness among workers: Occupational health surveillance using Washington syndromic surveillance data

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Abstract

Background: Information on worker occupation and industry is critical to understanding the occupational risks of heat-related illness (HRI), yet few syndromic surveillance systems capture these key data elements. This study evaluates the work data reported through Washington syndromic surveillance for its utility in characterizing HRI ED visits by industry and occupation.

Methods: Standard industry and occupation codes were assigned to employer name and occupation descriptions reported in Washington ED visit records maintained within the state's syndromic surveillance system, for visits involving HRI in 2020–2022. HRI ED visits involving workplace heat exposure were identified based on discharge diagnoses or on keywords in the triage note or chief complaint fields. HRI ED visits were summarized by patient characteristics, and visit rates were calculated by industry and occupation.

Results: Employer name or occupation descriptions were reported in 21.5% of HRI ED records among patients age 16 and older, and in 41.2% of records with mention of heat exposure at work. Twice as many records were classified for industry as for occupation. Agriculture, forestry, fishing, and hunting and transportation and warehousing had the highest rates of HRI ED visits. Specific industries with the highest rates included support activities for agriculture and forestry, the postal service, and fruit and vegetable preserving and specialty food manufacturing.

Conclusion: Syndromic surveillance data are a valuable source of occupational health surveillance information when work characteristics are reported, enhancing our understanding of the occupational risks of injuries and illnesses.

KEYWORDS
emergency department, heat-related illness, industry, occupation, syndromic surveillance, work exposure

1 | INTRODUCTION

Working in hot environments can cause a range of conditions, from a mild heat rash to potentially fatal heat stroke. Deaths from occupational heat exposure have been increasing. In 2012 through 2017, an average of 32 workers in the United States died each year from exposure to environmental heat. In 2018 through 2022, the number of deaths from occupational heat exposure rose to an average of 46 workers each year.[1] Recently, in the absence of a federal standard addressing occupational heat exposure, several

states have implemented rules to protect workers from heat-related illness (HRI).[2–6]

In Washington, much of what is known about the burden and distribution of occupational HRI is based on workers' compensation claims data,[7–9] or employer-reported data from the Bureau of Labor Statistics Survey of Occupational Injuries and Illnesses. Among the strengths of both data sources are the detailed industry and occupation data—aspects that are fundamental to understanding patterns of occupational injuries and illnesses. But while informative, neither of these sources capture all work-related incidents, and each provides its own picture of occupational injuries and illnesses, shaped by restrictions on eligibility and barriers to reporting.[10–12] Illnesses in particular may go unreported because of healthcare providers' difficulty attributing a condition to work, inability to prove occupational exposures occurred, and state regulations limiting workers' compensation coverage by condition.

Emergency department (ED) visit records have been used in other states to identify work-related injuries independent of employer reporting or workers' compensation data.[13–15] To our knowledge, no state has characterized ED visits by industry and occupation. In Washington, ED records, which are captured in the state's syndromic surveillance data, include two variables related to a person's employment: occupation and employer name, each reported as a free text field. These data may be useful in enhancing our understanding of occupational injury and illness risks by industry and occupation beyond what is known from workers' compensation or employer-reported data alone.

We sought to assign industry and occupation codes to employer name and occupation data reported in Washington ED records, and estimate rates of ED visits for HRI by industry and occupation based on the coded data.

2 | MATERIALS AND METHODS

2.1 | ED data

Washington's ED visit records are captured in the state's syndromic surveillance data, maintained by the Washington State Department of Health (DOH) Rapid Health Information NetwOrk (RHINO) program. All nonfederal ED facilities in Washington have been actively reporting emergency visit data since May 2020.

ED visits for HRI that occurred between May 1 and September 30, in the years 2020–2022, were identified based on keywords or ICD-10-CM diagnosis codes in the chief complaint, admit reason, or diagnoses fields, using the query definition developed by the National Syndromic Surveillance Program (NSSP) and state partners. Visit data including patient demographics and clinical information were extracted from the NSSP ESSENCE platform (Electronic Surveillance System for the Early Notification of Community-Based Epidemics) and then linked to the RHINO database to collect patient occupation and employer data that are not included in ESSENCE. The RHINO ED visit data included two employment variables: occupation and employer name, each reported as a free text field. Employer and occupation data may be collected as a routine part of the clinical workflow, to inform various aspects of care.[16] The information can be used to document the role of work in the development of the health condition, to inform plans for treatment and recovery, and to identify potential financial resources. The data included all ED visits to a Washington facility, regardless of patient residence.

2.2 | Employment data

Employment data were used to help classify industry for HRI ED records. Most employers operating in Washington and their employees are captured in data files maintained by the Washington Employment Security Department (ESD), as part of the state's unemployment insurance (UI) program. The few occupations exempted from Washington's UI coverage include independent contractors and the self-employed, corporate officers, family employment, and domestic service workers.[17]

We used two data files maintained by ESD: quarterly employee wage data, which includes worker first and last names; and quarterly establishment data, which captures employer name, North American Industry Classification System (NAICS) code, and the number of workers employed at the establishment. Federal agencies are captured in the establishment data, but federal workers, who are covered by the Unemployment Compensation for Federal Employees program, are absent from the employee wage data.

2.3 | Data standardization

Responses recorded in the occupation and employer fields in the HRI ED records were manually reviewed to identify responses that indicated something other than an occupation, industry, or employer (e.g., "disabled," "unemployed," "unknown," and values that were numbers or dates). These responses were excluded from attempts to assign industry and occupation codes. HRI ED records indicating employment with an entity not included in the ESD employee wage data (e.g., self-employed, military) were flagged and excluded from attempts to match to ESD employment data.

The same procedures were used to standardize employer and worker names in both the HRI ED data and the ESD data. Employer names were standardized by removing punctuation and special characters, store numbers, business structure nomenclature ("LLC," "INC"), and "THE" at the beginning of text strings. Ampersands, "NORTHWEST," and "SERVICES" were replaced with "AND," "NW," and "SVC," respectively. Lastly, all spaces were removed. Patient names were standardized by removing punctuation, special characters, and the suffixes JR, SR, III, IV.

2.4 | Record linkage

RHINO ED records with work responses recorded in the employer free text field (excluding responses such as "unemployed," "unknown") were linked to employment records through a multiple-step process. After each step, linked records were reviewed to identify erroneous links. Records left unlinked after a particular step were included in the next step (i.e., records unlinked after step 1 advanced to step 2; records unlinked after step 2 advanced to step 3, etc.).

In step 1, records were linked based on the first three letters of person first name or first initial if only an initial was provided, exact match on last name, and first initial of employer name, plus a similarity in employer names as measured by a generalized edit distance (GED) score no greater than 500 (cutoff values for GED scores were determined by manually reviewing linkage results). When one HRI ED record linked to multiple establishment records, we retained the link to the establishment record with the most similar employer name (lowest GED score). When one HRI ED record linked to multiple establishment records with identical GED scores, we used employment as the tie-breaker, retaining the link to the establishment record with the greatest number of workers.

In step 2, we allowed for slight differences in both person and employer names, linking remaining RHINO ED records (unlinked after step 1) to ESD records on the first initial of person first name, and requiring similarity between person last names (GED score no greater than 200), and similarity in employer names (GED score under 350). When RHINO ED records linked to multiple ESD records, we retained the link with the most similar last name and the most similar employer name. Again, employment was used as a tie-breaker, retaining the link to the ESD record with the greatest number of workers.

In step 3, we linked on employer name only, requiring a match on the first letter of the employer name and a similarity in employer names (GED scores no greater than 350), retaining the link to the establishment record with the lowest GED score and greatest number of workers.

In step 4, we linked on worker name only, requiring identical matches on person first and last names (or first initial if only initial was provided), and employment in year-quarter of the ED visit. This step allowed us to link records where the employer name was recorded under the occupation field in the RHINO ED data, and where there were large differences in employer name between the two data sources. When HRI ED records linked to multiple employment records, we retained links to the establishment with the greatest employment. As with the previous steps, all links resulting from this step were reviewed to ensure that the employment information linked was appropriate given the information reported in the HRI ED record.

In the final step, step 5, we linked remaining HRI ED records to HRI ED records already linked to employment data, based on the standardized employer name data. Links were required to have a GED score for employer name similarity of 200 or less and were manually reviewed to identify false matches.

2.5 | Free text coding of industry and occupation

To assign industry codes to the HRI ED records not linked to employment data, and to assign occupation codes to all HRI ED records with work data, we used the National Institute for Occupational Safety and Health (NIOSH) Industry and Occupation Computerized Coding System (NIOCCS),[18] a web-based tool that uses machine learning to translate text descriptions of industry and occupation into standardized codes. Because NIOCCS considers both the industry and occupation data inputted to assign codes, industry codes may be assigned based on occupation descriptions, and vice versa. Supporting Information: Figure 1 provides an overview of the coding process.

Two files were submitted for NIOCCS coding. The first file consisted of the NAICS code identified from the linkage to the employment data and the occupation free text data recorded in the HRI ED record. The second file was limited to records where no NAICS code was assigned via the record linkage to ESD. In this case, the file included the free text employer name and occupation fields recorded in the HRI ED record, uploaded to NIOCCS as industry and occupation, respectively.

2.6 | Classifying heat exposure at work

To identify ED visits for work-related heat exposure, we searched for keywords in the triage notes and chief complaint, and for work-related discharge diagnoses. Visits were classified into two categories: (1) mention of heat exposure at work or while working; and (2) no mention of heat exposure at work (list of keywords and diagnoses codes listed in Supporting Information: Table I).

2.7 | Data analysis

We compared patient demographics and timing of ED visit by availability of work data (i.e., employer name and occupation) and mention of workplace heat exposure. The timing of ED visit was classified as occurring during the 2021 heat dome versus some other time, with the heat dome defined as June 26 to June 30, 2021, when temperatures in Washington reached record highs and exceeded normal daily maximum temperatures by more than 30°.[19]

We estimated annualized rates of ED visits for HRI by industry and occupation, using 1-year American Community Survey (ACS) employment estimates (number of employed persons) for Washington for years 2020–2022, dividing the sum of visits for years 2020–2022 by the sum of employment estimates for the same years. Rate ratios, adjusted for sex and age, were calculated for individual industry sectors and occupation groups, compared to all other groups combined (e.g., transportation and warehousing compared to all other industries combined).

The analysis was limited to records among patients age 16 and older. Estimates based on fewer than 10 records were suppressed.

All analyses were conducted using SAS 9.4 (SAS Institute). The Washington State Institutional Review Board determined this project to be a public health surveillance activity and exempt from further IRB review.

3 | RESULTS

3.1 | Patient characteristics of HRI ED visits

In May through September, 2020–2022, there were 5067 ED visits involving HRI in Washington among patients age 16 years and over. Of those, 1087 records (21.5%) included employer or occupation data recorded in the free text fields, and 714 records (14.1%) included keywords in the chief complaint, triage notes, or a discharge diagnosis that mentioned work as the place of heat exposure. Records that included both employer or occupation data, and mention of heat exposure at work totaled 294 (Figure 1). Of the 714 visits with mention of workplace heat exposure, 41.2% (294 records) included employer or occupation data recorded in the free text fields. Of the 1087 records with employer or occupation data reported, 27.0% (294 records) mentioned workplace heat exposure.

The percent of HRI ED records with employer or occupation data reported varied by year, from a high of 28.3% for records in 2020, to 18.4% for records in 2021, and 24.5% for records in 2022. The pattern was similar among records with mention of workplace heat exposure, with employer or occupation reported in 55.5%, 38.0%, and 39.7% of records in 2020, 2021, and 2022, respectively.

Records with mention of workplace heat exposure and those with employer name or occupation reported were seen in younger patients (mean 41.2 and 41.7 years, respectively), when compared to the patient age among all HRI ED visit records (mean 50.8 years) (Table 1). The percentage of males was greatest in records with mention of workplace heat exposure (70.2%), followed by records with employer name or occupation reported (63.5%), and all HRI ED visit records (57.1% males). Records with mention of workplace heat exposure had the highest percentage of Hispanic or Latino patients (19.3%), followed by records with employer name or occupation (12.3%), and total HRI ED visit records (10.7%). More than one in three HRI ED visits in 2020–2022 occurred during the 2021 heat dome; visits with mention of heat exposure at work or with employer name or occupation reported were more likely to occur outside of the heat dome period.

3.2 | Industry and occupation data reported and coded

Among the 1087 records with employer or occupation recorded in the free text fields, employer name was more commonly reported than occupation (16.9% vs. 8.7% of records) (Table 2); only 4.1% of records reported both employer name and occupation data. The percentage of records with employer name or occupation reported was greater among ED visits with mention of workplace heat exposure, although still missing for the majority of records: 68.6% of records with mention of workplace heat exposure lacked employer name and 85.5% lacked occupation.

Based on the information reported for employer name or occupation, 920 (18.2%) of the 5067 ED records for HRI were assigned an industry code and 410 records (8.4%) were assigned an occupation code (Table 2). Of the 714 ED visits for HRI with mention of heat exposure at work, 249 (34.9%) were assigned a code for industry, and 128 (17.9%) were assigned a code for occupation.

3.3 | Visits by industry and occupation

Among the 920 ED visits for HRI assigned an industry code, construction accounted for the greatest portion of visits (13.7%),

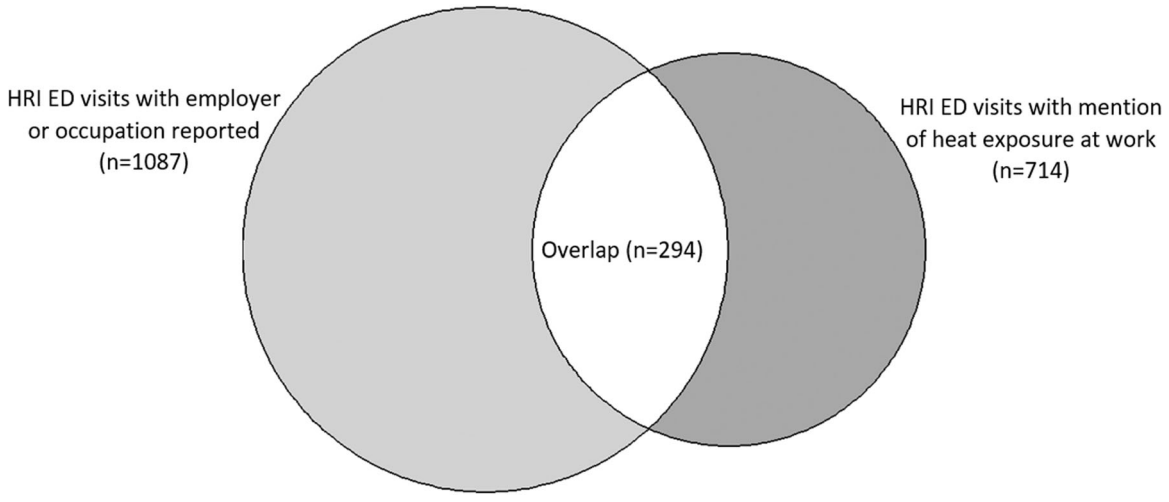

FIGURE 1 Overlap among visits with employer name or occupation data reported and visits with indication of heat exposure at work.

TABLE 1 Demographic characteristics of HRI ED visits by availability of work data, Washington 2020–2022.

	Mention of heat exposure at work		EO data reported		Total ED visits for HRI
	Yes	No	Yes	No	
Total visits	714 (100.0)	4353 (100.0)	1087 (100.0)	3980 (100.0)	5067 (100.0)
Age at visit					
16–24	132 (18.5)	530 (12.2)	169 (15.5)	493 (12.4)	662 (13.1)
25–44	325 (45.5)	1246 (28.6)	512 (47.1)	1059 (26.6)	1571 (31.0)
45–64	166 (23.2)	1107 (25.4)	302 (27.8)	971 (24.4)	1273 (25.1)
65 years and older	91 (12.7)	1470 (33.8)	104 (9.6)	1457 (36.6)	1561 (30.8)
Age					
Mean years (SD)	41.2 (17.1)	52.4 (21.7)	41.7 (16.2)	53.3 (22.0)	50.8 (21.5)
Sex					
Male	501 (70.2)	2391 (54.9)	690 (63.5)	2202 (55.3)	2892 (57.1)
Female	213 (29.8)	1962 (45.1)	397 (36.5)	1778 (44.7)	2175 (42.9)
Race-ethnicity					
White	460 (64.4)	3185 (73.2)	796 (73.2)	2849 (71.6)	3645 (71.9)
Hispanic or Latino	138 (19.3)	403 (9.3)	134 (12.3)	407 (10.2)	541 (10.7)
Black or African American	26 (3.6)	201 (4.6)	55 (5.1)	172 (4.3)	227 (4.5)
Asian	22 (3.1)	128 (2.9)	27 (2.5)	123 (3.1)	150 (3.0)
All other	42 (5.9)	290 (6.7)	55 (5.1)	277 (7.0)	332 (6.6)
Unknown	26 (3.6)	146 (3.4)	20 (1.8)	152 (3.8)	172 (3.4)
Time of visit					
2020	104 (14.6)	540 (12.4)	182 (16.7)	462 (11.6)	644 (12.7)
2021, during heat dome	197 (27.6)	932 (21.4)	229 (21.1)	900 (22.6)	1129 (22.3)
2021, other than heat dome	161 (22.5)	1638 (37.6)	310 (28.5)	1489 (37.4)	1799 (35.5)
2022	252 (35.3)	1243 (28.6)	366 (33.7)	1129 (28.4)	1495 (29.5)
Mention of heat exposure at work					
Yes			294 (27.0)	420 (10.6)	714 (14.1)
No			793 (73.0)	3560 (89.4)	4353 (85.9)
EO data reported					
Yes	294 (41.2)	793 (18.2)			1087 (21.5)
No	420 (58.8)	3560 (81.8)			3980 (78.5)

Note: Note that mention of heat exposure at work and EO data reported are not mutually exclusive categories.

Abbreviations: 2021 heat dome, June 26–30, 2021; ED, emergency department; EO, employer or occupation; HRI, heat-related illness; SD, standard deviation.

while the rate of visits among construction ranked fourth by sector. Agriculture, forestry, fishing, and hunting, along with transportation and warehousing had the highest rates of ED visits for HRI—both among all visits coded for industry (920 records), and among the 249 visits that mentioned heat exposure at work (Table 3). These two sectors, along with administrative support and waste management and remediation services, experienced rates of HRI ED visits (with or without mention of workplace heat exposure) that were over two times greater than the rate among all other industries, adjusted for worker age and sex. The lowest rates of ED visits for HRI were observed among healthcare and social assistance, educational services, finance and insurance, and professional, scientific, and technical services.

TABLE 2 Work data reported and coded among HRI ED visits by indication of work-related heat exposure, Washington 2020–2022.

	Records with mention of heat exposure at work	Records with no indication of workplace heat exposure	Total ED visit records for HRI
Total	714 (100.0)	4353 (100.0)	5067 (100.0)
Records with any work data reported (employer name or occupation)	294 (41.2)	793 (18.2)	1087 (21.5)
Records with data reported			
Employer name reported	224 (31.4)	630 (14.5)	854 (16.9)
Occupation reported	128 (17.9)	315 (7.2)	443 (8.7)
Records able to be coded			
Coded for industry	249 (34.9)	671 (15.4)	920 (18.2)
Coded for occupation	121 (16.9)	289 (6.6)	410 (8.1)

Abbreviations: ED, emergency department; HRI, heat-related illness.

The six industries with the highest rates of ED visits for HRI also had the highest rates of ED visits for HRI with mention of heat exposure, with nearly identical rate ranks. Among records with mention of heat exposure at work, adjusted rates of HRI ED visits were 3.8 times greater among transportation and warehousing than among all other industries, and 3.2 times greater among agriculture, forestry, fishing, and hunting than among all other industries.

Among the 410 HRI ED visits coded for occupation, military specific occupations had the highest visit rate (12.7 visits per 100,000 workers), and was nearly four times greater than the rate for all other occupations, adjusted for worker age and sex (Table 4). Among the 121 HRI ED visits with mention of heat exposure at work that were coded for occupation, three occupation groups had visit counts large enough to be published. Two of these occupation groups—construction and extraction occupations and transportation and material moving occupations—had rates of HRI ED visits with mention of heat exposure at work that were approximately four times greater than the visit rates among all other occupations combined, adjusted for worker age and sex.

3.4 | Detailed industry and occupation

Detailed industries with HRI ED visit rates that exceeded the rate for the sector overall are presented in Figure 2. The highest rates were observed for the postal service (72.2 per 100,000 workers), support activities for agriculture and forestry (60.1 per 100,000 workers), and fruit and vegetable preserving and specialty food manufacturing (45.1 per 100,000 workers).

Detailed occupations with HRI ED visit rates that exceeded the rate for the occupation group are presented in Figure 3. The highest rates were observed for firefighters (classification includes wildland firefighters) (50.9 per 100,000 workers) and painters and paperhangers (31.4 per 100,000 workers).

4 | DISCUSSION

We found the work data associated with ED records, specifically employer name and occupation free text descriptions, could be coded according to standard industry and occupation classification systems and analyzed for public health surveillance. This is the only study we know that characterizes HRI by industry and occupation using ED records.

Comparing findings from this study to two studies based on workers' compensation data in Washington and California, we found similarities in relatively high rates of HRI in agriculture, forestry, fishing, and hunting, support activities for agriculture and forestry, and firefighters.[9,20] Unique to this study was the high rate observed in transportation and warehousing, a sector reported to have relatively lower rates of HRI in the two studies based on workers' compensation data. The high rate of HRI ED visits in the transportation and warehousing sector was driven largely by the elevated rate in the postal service, a group not covered by state workers' compensation systems. Another notable difference was in public administration, where workers' compensation data suggested high rates of HRI, while the ED visit data ranked the sector lower. Since not all workers eligible for workers' compensation insurance benefits file a claim, elevated rates may reflect a greater propensity for claim filing among public administration workers compared with workers in other industries.[21] ED visit data may be able to expand occupational health surveillance to groups often excluded because of issues related to workers' compensation eligibility or claim filing barriers.

Of the three industries with the highest rates of HRI ED visits, two involve indoor work: fruit and vegetable preserving and specialty food manufacturing, and support activities for agriculture and forestry (74% of the HRI ED visits in support activities for agriculture and forestry were attributable to postharvest crop activities, of which fruit packing is a large component in Washington). Indoor workers are susceptible to HRI. Programs and policies aimed at preventing HRI should consider both outdoor and indoor work environments.

TABLE 3 Counts, unadjusted annual rates, unadjusted rate rank, and adjusted rate ratios of ED visits for HRI by industry, Washington 2020–2022.

	HRI ED visits (920 records coded for industry)				HRI ED visits with mention of heat exposure at work (249 records coded for industry)			
Industry	Visits (%)	Unadjusted rate (95% CI)	Rate rank	Adjusted rate ratio	Visits (%)	Unadjusted rate (95% CI)	Rate rank	Adjusted rate ratio
Agriculture, forestry, fishing, and hunting	50 (5.4)	18.4 (14.0–24.3)	1	2.2 (1.7–3.0)	19 (7.6)	7.0 (4.5–11.0)	2	3.2 (2.0–5.1)
Transportation and warehousing	96 (10.4)	17.2 (14.1–21.0)	2	2.1 (1.7–2.6)	43 (17.3)	7.7 (5.7–10.4)	1	3.8 (2.7–5.3)
Administrative and support and waste management services	69 (7.5)	17.1 (13.5–21.7)	3	2.2 (1.7–2.8)	20 (8.0)	5.0 (3.2–7.7)	3	2.3 (1.5–3.7)
Construction	126 (13.7)	15.6 (13.1–18.5)	4	1.9 (1.6–2.3)	37 (14.9)	4.6 (3.3–6.3)	4	2.0 (1.4–2.8)
Accommodation and food services	72 (7.8)	10.5 (8.3–13.2)	5	1.3 (1.0–1.7)	24 (9.6)	3.5 (2.3–5.2)	5	1.5 (1.0–2.4)
Wholesale trade	27 (2.9)	10.1 (7.0–14.8)	6	1.2 (0.8–1.8)	-	-	-	
Public administration	57 (6.2)	10.1 (7.8–13.1)	6	1.3 (1.0–1.7)	17 (6.8)	3.0 (1.9–4.9)	6	1.5 (0.9–2.5)
Arts, entertainment, and recreation	19 (2.1)	8.5 (5.4–13.4)	8	1.1 (0.7–1.7)	-	-	-	
Manufacturing	86 (9.3)	8.4 (6.8–10.4)	9	1.0 (0.8–1.2)	26 (10.4)	2.6 (1.7–3.8)	7	1.1 (0.7–1.7)
Other services, except public administration	38 (4.1)	7.9 (5.8–10.9)	10	1.0 (0.7–1.4)	11 (4.4)	2.3 (1.3–4.1)	8	1.2 (0.6–2.1)
Retail trade	94 (10.2)	7.1 (5.8–8.7)	11	0.9 (0.7–1.1)	19 (7.6)	1.4 (0.9–2.2)	9	0.6 (0.4–0.9)
Information	19 (2.1)	6.6 (4.2–10.4)	12	0.8 (0.5–1.2)	-	-	-	
Military	11 (1.2)	5.7 (3.2–10.3)	13	1.8 (1.0–3.4)	-	-	-	
Real estate and rental and leasing	12 (1.3)	5.2 (2.9–9.1)	14	0.7 (0.4–1.2)	-	-	-	
Healthcare and social assistance	63 (6.8)	4.4 (3.4–5.6)	15	0.6 (0.4–0.7)	-	-	-	
Educational services	38 (4.1)	4.1 (2.9–5.6)	16	0.5 (0.4–0.7)	-	-	-	
Finance and insurance	13 (1.4)	3.5 (2.1–6.1)	17	0.5 (0.3–0.8)	-	-	-	
Professional, scientific, technical services	25 (2.7)	2.1 (1.4–3.0)	18	0.2 (0.2–0.3)	-	-	-	
Mining, quarrying, and oil and gas extraction	-	-	-		-	-	-	
Utilities	-	-	-		-	-	-	
Management of companies and enterprises	-	-	-		-	-	-	

Note: Rates presented as visits per 100,000 workers; adjusted rates adjusted for age and sex.

Abbreviations: ED, emergency department; HRI, heat-related illness; -, indicates calculations not reportable due to small numbers.

Examples of workplace heat standards that cover indoor workers include those adopted in Colorado, Minnesota, and Oregon.[4–6]

The attribution of visits to occupational heat exposure is inexact. Triage notes and chief complaints are not required to be reported, nor are they required to capture specific aspects of the visit (e.g., work-relatedness). While these fields can provide details related to the reason for the visit, relying on them for record classification will likely result in some misclassification due to missing values and descriptions that do not explicitly reference occupational heat exposure. However, instead of restricting analyses to records identified as work-related based on triage notes or chief complaints, this study suggests that evaluating all ED records with industry and occupation data may provide insight into the relative rates of HRI ED visits for work-related exposures, given the similarity in rate ranks by industry sector for all HRI ED records and for those with mention of workplace heat exposure.

TABLE 4 Counts, unadjusted annual rates, unadjusted rate rank, and adjusted rate ratios of ED visits for HRI by occupation, Washington 2020–2022.

	HRI ED visits (410 records coded for occupation)				HRI ED visits with mention of heat exposure at work (121 records coded for occupation)			
Occupation	Visit count	Unadjusted rate (95% CI)	Rate rank	Adjusted rate ratio	Visit count	Unadjusted rate (95% CI)	Rate rank	Adjusted rate ratio
Military specific occupations	12 (2.9)	12.7 (7.2–22.4)	1	3.9 (2.1–7.1)	-	-	-	-
Construction and extraction occupations	61 (14.9)	11.3 (8.8–14.5)	2	3.4 (2.6–4.6)	21 (17.4)	3.9 (2.5–6.0)	1	4.0 (2.4–6.5)
Protective service occupations	20 (4.9)	9.5 (6.1–14.7)	3	2.6 (1.7–4.1)	-	-	-	-
Transportation and material moving occupations	72 (17.6)	8.5 (6.8–10.7)	4	2.6 (2.0–3.3)	30 (24.8)	3.6 (2.5–5.1)	2	3.9 (2.6–6.0)
Installation, maintenance, and repair occupations	24 (5.9)	7.0 (4.7–10.5)	5	1.8 (1.2–2.8)	-	-	-	-
Building and grounds cleaning and maintenance occupations	19 (4.6)	6.2 (3.9–9.7)	6	1.7 (1.1–2.6)	-	-	-	-
Food preparation and serving related occupations	22 (5.4)	4.0 (2.6–6.1)	7	1.4 (0.9–2.1)	-	-	-	-
Healthcare support occupations	12 (2.9)	3.0 (1.7–5.3)	8	0.9 (0.5–1.7)	-	-	-	-
Production occupations	14 (3.4)	2.9 (1.7–4.8)	9	0.7 (0.4–1.3)	-	-	-	-
Healthcare practitioners and technical occupations	18 (4.4)	2.8 (1.8–4.5)	10	0.8 (0.5–1.3)	-	-	-	-
Sales and office occupations	56 (13.7)	2.7 (2.1–3.6)	11	0.8 (0.6–1.0)	16 (13.2)	0.8 (0.5–1.3)	3	0.7 (0.4–1.3)
Education, legal, community service, arts, and media occupations	24 (5.9)	2.0 (1.3–2.9)	12	0.5 (0.4–0.8)	-	-	-	-
Management, business, and financial occupations	33 (8.0)	1.6 (1.1–2.2)	13	0.4 (0.3–0.5)	-	-	-	-
Computer, engineering, and science occupations	10 (2.4)	0.8 (0.4–1.5)	14	0.2 (0.1–0.4)	-	-	-	-
Farming, fishing, and forestry occupations	-	-	-	-	-	-	-	-
Personal care and service occupations	-	-	-	-	-	-	-	-

Note: Rates presented as visits per 100,000 workers; - indicates calculations not reportable due to small numbers.

There are two notable strengths of this study. First, the classification of industry based on record linkage to employment data (for which NAICS codes are systematically assigned to establishments) augmented codes assigned through translation of worker-reported free text descriptions. Reliance on NIOCCS for translation of free text descriptions was limited by the work data available in the ED records, which included employer name but lacked industry free text description. Second, ED visit data are independent of workers' compensation data, and potentially free of some of the barriers that result in underreporting in workers' compensation data, a key source of occupational injury and illness data.

Further research should be done to characterize the types of records captured versus missed across multiple sources of occupational injury and illness data, and to evaluate the use of ED records for the occupational health surveillance of conditions other than HRI—particularly for conditions not well recognized in workers' compensation or employer-reported data.

4.1 | Limitations

Missing work data likely limited identification of high-risk industries and occupations and may have biased the results if the data are not missing at random. Moreover, while both industry and occupation were missing for most records among working age patients, including most records with mention of heat exposure at work, the occupation data, which were available for half as many records as industry data, may be less representative of

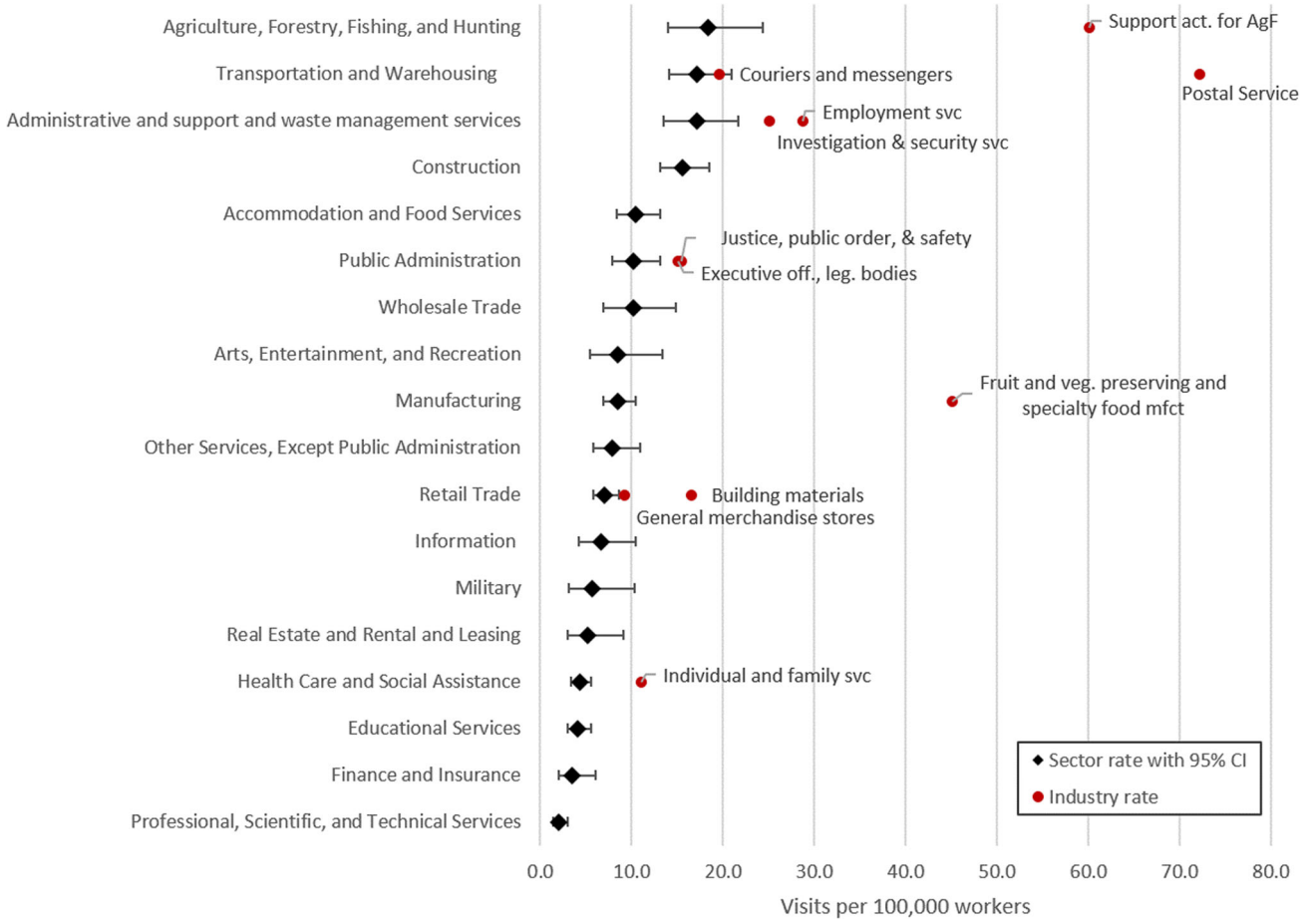

FIGURE 2 HRI ED visit rates by industry sector, and industries with rates greater than the sector rate, Washington 2020–2022 (n = 920).

Washington's working population compared with industry data, given that the percentage of records with occupation codes varied by industry (Supporting Information: Table II). For example, farming, forestry, and fishing workers were expected to have high rates of HRI ED visits based on visit rates by industry, but high rates were not observed for the occupation group, possibly due, in part, to the substantial amount of missing occupation data for records among the agriculture, forestry, fishing, and hunting industry. And while only 26% of records in the agriculture, forestry, fishing, and hunting industry were assigned an occupation code, nearly half of records in the construction industry were assigned an occupation code; as a result, workers in the construction industry were more likely to be included in the occupation estimates than workers in the agriculture, forestry, fishing, and hunting industry.

Incomplete industry and occupation data has been found in other health data sources.[22,23] In a study of notifiable conditions data in Washington, researchers found that the percentage of cases reported as employed was markedly lower than expected, based on employment estimates for the state, and that among cases reported as employed, fewer than 40% reported industry or employer name data.[24] In contrast with this study, occupation data was more complete, recorded in over 91% of employed cases of the select notifiable conditions, suggesting that factors influencing data collection vary across systems. Employer name may be more prevalent in ED records because of the link between healthcare access and employer-provided health insurance, whereas occupation may be more common in notifiable-conditions data because of the potential for work restrictions in select occupations, intended to control disease transmission. Approaches to improving industry and occupation data may need to differ by data source.

Attribution of work-relatedness was another limitation, as noted above. The methods used to classify work-related visits likely resulted in an undercount of visits involving workplace heat exposure. Additionally, expected payer is not systematically captured in Washington's ED data, limiting comparisons of the ED visit data to what might be expected in workers' compensation or other data sources that rely on workers' compensation as expected payer to classify work-relatedness, such as hospital discharge data.

ACS was selected as the source of employment data (for estimating rates) because the data include all workers, including the self-employed, farm, and federal workers, and because the sample size allows for detailed industry and occupation classifications, and analyses that control for worker demographics. As an annual

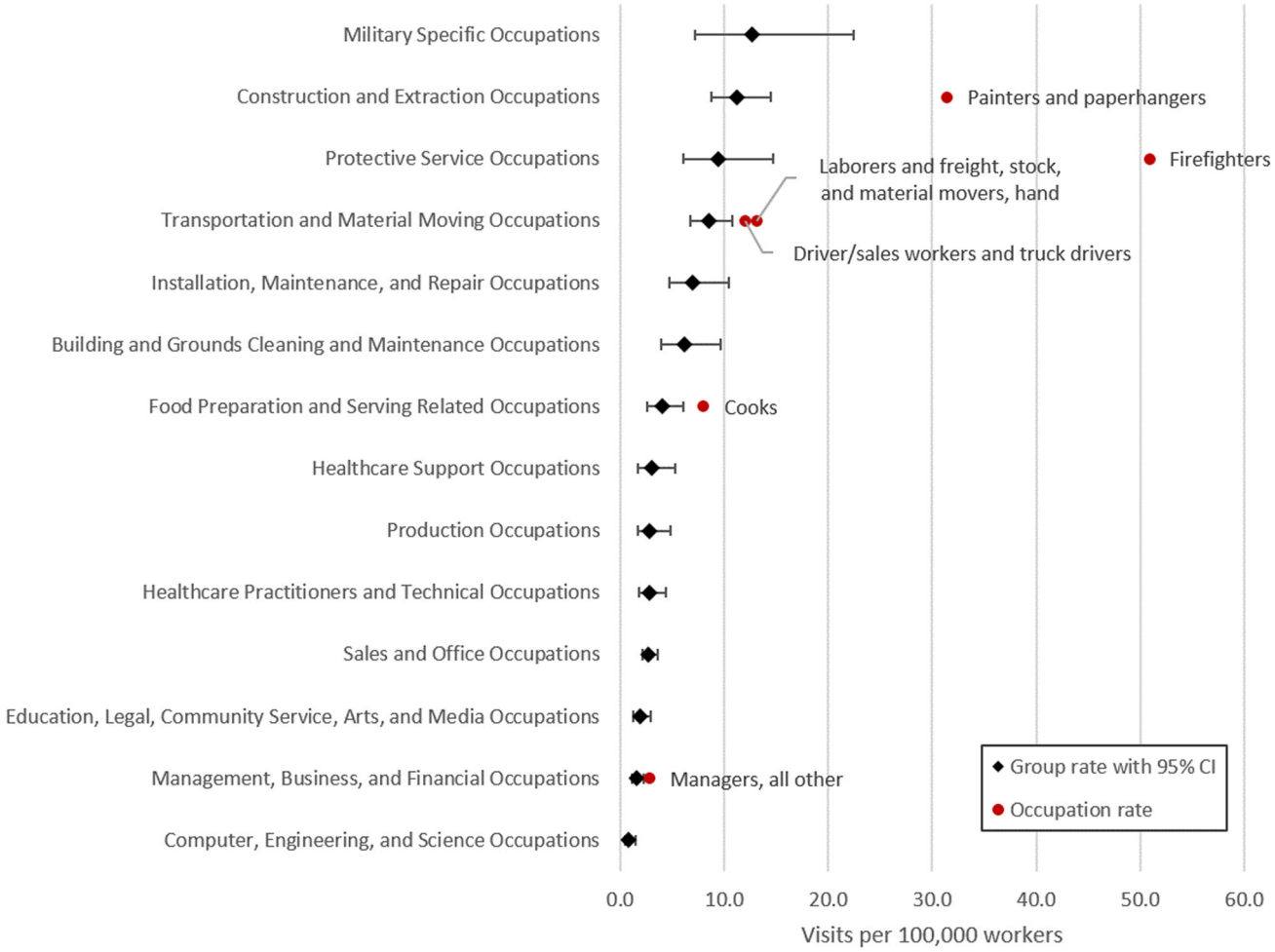

FIGURE 3 HRI ED visit rates by occupation group, and occupations with rates greater than the group rate, Washington 2020–2022 ($n = 410$).

estimate, ACS data do not reflect seasonal fluctuations in employment. If the annual estimates are lower than peak seasonal employment, ED visit rates calculated from ACS employment estimates may be inflated. To examine the difference, we used data published by the Quarterly Census of Employment and Wages (QCEW) program on workers covered by unemployment insurance. For support activities for agriculture and forestry, an industry with both high HRI ED visit rates, and a reliance on seasonal employment during traditionally warmer months, the QCEW data suggest that employment fluctuates by 58% over the course of a year.[25] If the ACS estimates are assumed to reflect the period of lowest employment in the industry, HRI rates calculated using QCEW data for the month with greatest employment would be 37% lower—yet still among the highest rates of any industry. Seasonal employment estimates may improve the accuracy of industry and occupation-specific rate estimates, but the rate rankings of high risk industries may remain largely the same as those based on annual employment estimates.

Finally, industry and occupation-specific rates may reflect differences in ED utilization, if some groups are more likely to seek care for HRI someplace other than an ED facility.

5 | CONCLUSION

Work-related data, including patient occupation and industry, are important characteristics for understanding the epidemiology of heat-related illness and many other health conditions and outcomes. While analyses of current ED visit data may be limited by incomplete or missing data, preliminary studies, such as this one, can strengthen the argument for collecting work data by demonstrating the potential insights gained if data collection were more robust, and by developing interest in the data among safety and health professionals, public health practitioners, policy advisors, and others. Data quality improvements may be achievable through increased data reporting, record linkages, data imputation, or other means. Approaches to improving the quality of the work-related data should be explored to enhance the use of syndromic surveillance data for occupational health surveillance.

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization and design of the study. Sara Wuellner and Kali Turner managed the acquisition of the

data. Sara Wuellner performed the data analysis and drafted the manuscript. All authors were involved in the interpretation of the data, provided critical reviews of the manuscript, and participated in final approval. Sara Wuellner agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity are appropriately investigated and resolved.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Washington State Department of Health. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from https://doh.wa.gov/public-health-provider-resources/healthcare-professions-and-facilities/data-exchange/syndromic-surveillance-rhino/request-rhino-data-or-support with the permission of the Washington State Department of Health.

ETHICS APPROVAL AND INFORMED CONSENT

The Washington State Institutional Review Board determined this project to be a public health surveillance activity and exempt from further IRB review.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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