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RESEARCH ARTICLE

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Work-related injuries and illnesses (WRII) presenting to Illinois hospitals, 2017–2021: The importance of emergency department (ED) data

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Abstract

Objectives: Research characterizing work-related injuries and illnesses (WRII) has predominantly focused on inpatients and deaths, despite evidence that 4% of WRII are admitted as inpatients and deaths are less than 0.2% of acute WRII. Our aim is to determine the usefulness of incorporating emergency department (ED) hospital data into current occupational health surveillance systems.

Methods: Data on ED and admitted WRII treated in Illinois hospitals from 2017 to 2021 were analyzed. Demographic characteristics, primary diagnosis, procedures undertaken, and unique patient estimates are described. Multivariable logistic regression models were developed to evaluate predictors of treatment in the ED and multivariable median regression models determined associations of total hospital charges.

Results: Between 2017 and 2021 there were 488,033 hospital presentations (95.9% nonadmissions) for WRII in Illinois, equating to a crude annual population rate of 1502.1/100,000. Non-Hispanic Whites (NHW) were disproportionately treated for illnesses, while Hispanic or Latino workers were disproportionately treated for injuries. African-Americans had the highest rate of ED emergent presentations (incident rate ratio [IRR] = 1.3, ref = NHW) and were less likely to be admitted for emergent presentations (IRR = 0.7, ref = NHW). ED presentations were more likely to be female, present with an injury, and at a rural, versus urban, hospital. Radiological investigations compromised the majority of procedures for nonadmitted patients (n = 403,317), and 94.8% were coded for a body region

Conclusion: Between 2017 and 2021 in Illinois, there were nearly 500,000 hospital visits charged to workers' compensation totaling over US$ four billion. ED data provide additional insights into work-related chronic conditions, health disparities, and the usage of diagnostic and therapeutic procedures for WRII.

KEYWORDS
emergency service—hospital, occupational health surveillance, workers compensation, work related injury and illness

1 | INTRODUCTION

Work-related injury and illness (WRII) is a leading cause of morbidity and mortality in United States, with an estimated annual cost of $163.9 billion, including medical expenses of $34.9 billion.[1] In 2021, the United States Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII), which relies on employer reporting, noted an injury and illness incidence rate of 2.7 per 100 full-time equivalent US workers, totaling over 2.6 million workers.[2] However, estimates from the SOII database have been shown to systematically undercount and misclassify WRII,[3–6] with recent research estimating that SOII captures between 33% and 70% of WRII.[7–10]

In the absence of a single comprehensive data source for WRII, a combination of federal and state data sources are required to better characterize the total WRII burden, including: (1) national surveys (SOII, BLS Census of Fatal Occupational Injuries, National Health Interview Survey (NHIS); (2) regulatory agency databases (Occupational Safety and Health Administration, Mine Safety and Health Administration); (3) hospital emergency department [ED] and hospital discharge databases; (4) death records; (5) workers' compensation [WC] databases; and (6) specialized data sources (e.g., blood lead registries and poison control center data).[11] As a result of systematic reporting biases, each of these data sources undercount specific WRII involving subgroups of workers (e.g., independent contractors and farmers) and medical conditions of varying severity and latency.[10,12–15] Consequently, research has demonstrated that collective use of multiple data systems provides a more comprehensive and accurate picture of occupational safety and health than any individual data system alone.[11]

Nonacute WRII and conditions with long latencies between onset of exposure and diagnosis of disease (e.g., chronic musculoskeletal conditions, cancer, respiratory conditions, and cardiovascular conditions) are the least likely to be accurately captured[12,16–19] and present unique barriers to reporting in occupational data systems. Firstly, most jurisdictions have statutes of limitations for filing WC claims limiting the amount of lapsed time since date of injury or manifestation of symptoms. Secondly, the long latency associated with many diseases and chronic musculoskeletal disorders can make it difficult to determine whether the conditions are work-related. Thirdly, chronic injuries and illnesses are typically identified by medical providers. When either the worker or clinician fail to recognize a condition as work-related or do not expect the condition to be covered by WC, these cases are less likely to present in the WC data system or be listed on mandated employer injury logs.[17,19] "Cost shifting" from WC to general health insurance is well described in the United States literature.[20]

Over the last 10–20 years, the availability of electronic health records as a resource for occupational health research has grown, particularly for evaluating acute WRII. Trauma registry and hospital admissions data have been widely used, but hospital-based outpatient medical services data which denote ED visits continues to be underutilized. Hospital-based outpatient data are important because US national BLS data indicate that only 4.3% of WRII resulting in days away, restricted or transferred cases are admitted to a hospital[15,21] and deaths account for less than 0.2% of acute WRII.[22] A study by Huang et al. using NHIS data is consistent with these estimates, showing that only 3.7% of all WRIIs are admitted to the hospital, with 39.8% of acute WRII treated in the ED without being admitted.[15] While hospital-based outpatient data disproportionately capture minor acute injuries, as compared to trauma registry and hospital admission data, they potentially do a better job capturing chronic nonemergent work-related health conditions missed by inpatient hospital data sources and substantially undercounted by employer injury logs and WC data[22] because many chronic conditions require imaging, diagnostic testing and ambulatory surgical intervention that only require outpatient services.

Federal and state outpatient data have been utilized to capture WRIIs from the National Electronic Injury Surveillance System (NEISS-Work),[23] the Massachusetts amputation surveillance system,[24] and from the state of Michigan for amputations, fractures, burns, and crush injuries as part of a multi-source surveillance system.[25–28] These findings have demonstrated that hospital outpatient data can fill the gaps in standard WRII surveillance systems and provide unique data elements and reporting of cases that may be otherwise missed.

The state of Illinois is a good jurisdiction to study the burden of WRII as it has a large workforce of 6.1 million that is representative of the broader US,[29–31] and has a comprehensive hospital data system that captures nearly all persons seeking medical care in the hospital setting (including attached ED). In this study, we conduct a broad analysis of cases treated in Illinois hospitals and charged to a Workers' Compensation payer, between 2017 and 2021. The aim of this research is to compare all employer-billed elective and emergent hospital presentations treated by hospital-based outpatient services (ED visits) or admitted to the hospital to better understand the needs and interventions related to WRIIs and to assess the value and limitations of outpatient data in mainstream occupational health surveillance and research.

2 | MATERIALS AND METHODS

2.1 | Data sources

The Illinois outpatient and inpatient hospital discharge databases were used to identify WRII treated in Illinois hospitals from January 2017 to December 2021. The outpatient database includes all patients treated in hospital-based outpatient services, including elective services and emergent ED visits for <24 h who were not admitted to the hospital. The inpatient database includes patients treated for 24 h or more in Illinois hospitals for any medical reason. Both datasets include demographic (age, race, and sex), clinical (diagnoses, hospital procedures, and discharge status), and economic (hospital charges and payer source) characteristics. The hospitals included in the datasets used for this analysis comprise 96.5% of all inpatient

admissions, state-wide.[32,33] The University of Illinois at Chicago (UIC) Institutional Review Board has approved this work (#2012-0116).

2.2 | Case definition

All patients ≥ 16 years with a WC payer code were classified as work-related (n = 488,033). Patients with International Classification of Diseases (ICD) 9 diagnosis coding were excluded (n = 1593; 0.3% of total); the majority of those omitted were from early 2017 when use of ICD-9 codes still sparsely occurred. The data set includes a variable that identifies if the hospital visit was elective or emergent. We understand elective cases to be where the patient's condition permitted adequate time to schedule clinical procedures per the availability of suitable accommodations in the hospital. Elective cases primarily include those requiring imaging, other diagnostic procedures, and ambulatory and nonambulatory surgical procedures that have been scheduled to present to the hospital. Elective visits generally involve two pathways; planned visit to the ED to undergo diagnostic procedures, investigations and treatment without hospital admission or planned visit to the hospital for admission for ambulatory and nonambulatory surgical procedures.

Emergent cases were generally patients with higher acuity presentations requiring immediate medical care for their adverse health condition and included all patients with an admission type code of "emergent," "urgent," "trauma center," or "unknown." Cases with an unknown admission type made up 1.9% of total cases (n = 9186). Emergent patients generally involve three management pathways: evaluation in the ED and admission as an inpatient, observation and treatment or clinical testing in the ED, or discharge with planned hospital or community health care follow-up. For the purposes of this analysis, admission type (elective vs. emergent) and inpatient status (outpatient vs. inpatient) variables were used to classify patients into four categories as defined in Table 1: (1) Elective admissions, (2) Emergent admissions, (3) Elective hospital-based outpatient services, and (4) Emergent outpatient ED visits. Non-Illinois residents accounted for 3.5% of total hospital visits (n = 16,850) and were excluded from hospital utilization rate calculations but included in the descriptive analysis to ensure accurate representation of the burden on the health care system.

2.3 | Statistical analyses

Statistical Analysis Software (SAS) 9.4 was used for all statistical analyses. We used descriptive analysis to examine the general characteristics of Illinois residents with WRII. We present frequencies (%) for categorical variables and means (standard deviation) for continuous variables. WRII were characterized across a large range of demographic, clinical and economic variables in the hospital database. Crude hospital utilization rates per 100,000 employed Illinois residents were calculated, all rates described in this report are based on state employment data by race/ethnicity and age. Multivariable logistic regression models were developed to evaluate predictors of treatment in the outpatient setting for WRII without admission to the hospital.

In this analysis, we summarize patient characteristics (gender, age, race, and ethnicity), facility information, reason for visit, insurance coverage, length of stay, total hospital costs, and discharge status. Total hospital charges are in 2020 US dollars ($) adjusted for annual inflation using the BLS consumer price index for all urban consumers.[34] The Elixhauser Comorbidity Index was used to assess comorbidities.[35] Current Procedural Terminology used for outpatient billing and procedure codes used for inpatient billing describe medical procedures provided during the service which were billed for, such as diagnostic tests, imaging, surgeries. ED Current Procedural Terminology (CPT) codes were analyzed and grouped into common categories including anesthesia, orthopedic/surgical procedures, radiological investigations, pathology, clinical laboratory and medical services. Any patient could have undergone multiple procedures within and across categories and the percent totals will add up to more than 100%. Surgical codes were categorized by system (e.g., cardiovascular and musculoskeletal). Inpatient procedure codes were grouped into multiple categories. Primary diagnosis was based on six diagnosis fields: admit diagnosis (inpatient only), three reason for visit diagnoses (outpatient only), principal diagnosis, and secondary principal diagnosis. We utilized the 2013 USDA RUCC to evaluate degree of urbanization of the counties in which the treating hospitals were located. Hospitals located in RUCC codes 2–4 were defined as semi-urban hospitals and hospitals located in RUCC codes 5–9 were defined as rural hospitals.[36] Using ICD 10 codes, primary diagnoses of WRII were grouped into three categories in Table 4; Injuries (S01 to TX88, V00-Y99), chronic musculoskeletal conditions (M00-M99) and illnesses (A00-L99, N00-R99, and U00-Z99).

Probabilistic linkage methodology was used to estimate unique patient counts of WRII using direct matching.[32] Because the data is deidentified, we calculate both a liberal and conservative estimates of unique cases: (1) cases per year that match by treating hospital, age, gender, ethnicity, ZIP code, and detailed ICD-10 code used for primary diagnosis are treated as the liberal estimate of unique individuals because it assumes a patient is treated only in one facility and the detailed ICD-10 code remains unchanged; (2) matched cases

TABLE 1 Classification of work-related hospital presentations.

Inpatient (admissions) data		Outpatient (ED) data	
Elective cases: Predominately surgical procedures	Emergent cases: Persons admitted following an acute event	Elective cases: Hospital-based outpatient services including imaging, other diagnostic procedures and ambulatory surgeries	Emergent cases: Predominately ED visits in addition to urgent care and trauma units.

Abbreviation: ED, emergency department.

by age, gender, ZIP code, and major ICD-10 category of primary diagnosis (first letter operator only) to identify the conservative estimate of unique patients which allows for patients to be treated in different hospitals and have the detailed primary diagnosis change within a major category.

Crude hospital utilization rates per 100,000 Illinois residents were calculated for key demographic subgroups using American Community Survey (ACS) population estimates,[37] with 5-year estimates (2017–2021) used to determine rates by age group. The 2021 ACS data were also used to develop race-ethnicity employment denominators for the population. We did not calculate "other" race-ethnicity group due to the number of patients with missing race-ethnicity (n = 49,405, 10.1%)

Multivariable logistic regression models were developed to evaluate predictors of treatment in the ED for WRII without admission to the hospital. Statistical evaluation of covariates, as well as a priori knowledge, were used to determine inclusion of covariates in the final models. The first series of models evaluates predictors of treatment in the ED as compared to admission to the hospital. These models were stratified by emergent and elective cases. The final models included patient characteristics (gender, age, race, and ethnicity), diagnoses, geographic location, hospital trauma level, year and comorbidities. In a second series of models, we developed multivariable median regression models to evaluate factors associated with total hospital charges stratified by the four patient categories by admission type (elective and emergent) and admission status (ED visits and admissions). We excluded 1,031 inpatient emergent cases (7.9%) who were treated in out-of-jurisdiction hospitals from these latter multivariable models because of high variability in hospital charges across jurisdictions. In addition, payer information was not included as a covariate in any of the models because all the cases were paid by WC insurance providers.

3 | RESULTS

3.1 | Demographic and baseline information

From 2017 to 2021 there were 488,033 hospital visits for WRII in Illinois, nearly all were treated in the outpatient setting without being admitted (n = 467,989; 95.9%). Based on the probabilistic data linkage, there were an estimated 369,092–450,760 unique patients treated for WRII (liberal and conservative estimates, respectively), of which there were an estimated 353,681 to 432,286 treated in the outpatient setting. Elective visits totaled 226,643 and the estimate of unique patients (detected through data linkage) ranged between 158,398 and 197,016 (69.9%–86.9% of total visits; up to 30.1% had more than one outpatient visit). Emergent visits totaled 261,390 and the estimate of unique patients ranged between 210,694 and 253,744 (80.6%–97.1% of total visits).

Across all WRII combined, work-related hospital visits disproportionately involved males (n = 291,796; 59.8%), patients aged 45–64 years (n = 204,489; 41.9%), and non-Hispanic Whites (NHW) (n = 283,556; 58.1%). Youth visits (16–19 years) totaled 13,118 (2.7%) and older workers over 65 years totaled 56,737 (11.6%). Table 2 presents characteristics of WRII cases stratified by admission type and admission status. For inpatient cases, the median length of hospitalization was 3 days for emergent cases and 2 days for elective cases. Patients treated in hospital-based outpatient services compared to those admitted to the hospital were disproportionately female, younger than 45 years and had fewer comorbidities (mean number of comorbidities: 0.2 vs. 2.5 respectively; p = <0.0001). Among emergent cases only (ED vs. admissions), patients treated in the ED were disproportionately African–American and under 25 years old. Among all the hospital-based outpatient services, 173 died (n = 18 died during elective visits; n = 17 had a surgery) compared to 408 inpatient WRII deaths (n = 16 during elective visits)

3.2 | Crude population rate

Table 3 presents crude average annual hospital utilization rates by the four treatment groups and gender. Among Illinois residents only, the crude annual hospital utilization rate of all WRII was 1502.1 per 100,000 employed Illinois residents. Inpatient and outpatient rates were consistently higher for males compared to females in all groups except among Asians and workers 75 years and older (Table 3). WRII hospital utilization rates increased with age for all treatment groups except for outpatient emergent cases (ED visits) which showed a U-shaped curve with peaks in younger workers 24 years and younger, as well as older workers 75 years and older. Rate ratios by ethnicity using White non-Hispanic as the reference group showed that African American workers had higher rates of ED emergent presentations (incident rate ratio [IRR] = 1.3, 95% confidence interval [CI]: 1.2–1.4), but were less likely to be admitted for emergent presentations (IRR = 0.7, 95% CI: 0.5–1.1). The highest hospital utilization rates involving elective hospital-based outpatient services were observed among white non-Hispanics.

3.3 | Primary diagnosis

Table 4 shows characteristics of WRII cases stratified by three primary diagnosis categories among ED visits only. Of ED visits, illnesses and musculoskeletal conditions were primarily elective cases (56.1% and 71.4% respectively), while treatment for injuries were predominately emergent cases (70.6%). ED visits for illnesses, injuries and musculoskeletal conditions were relatively steady between the years 2017–2019, but there was decline observed during the first 2 years of the severe acute respiratory syndrome-coronavirus-2 pandemic including among illnesses. In fact, there were only 965 confirmed COVID cases treated for other conditions. Both emergent illnesses and injuries increased during the summer months, particularly during July and August. While there was a decrease in all cases during the weekends, only 8.7% of elective ED visits occurred on weekends compared to 20.3% of emergent ED visits. While males

TABLE 2 General characteristics of workers compensation cases treated in hospital; inpatient and emergency department database (Illinois): 2017–2021.

	Inpatient elective (*n* = 7011)	Inpatient emergent (*n* = 13,033)	Outpatient elective (*n* = 219,632)	Outpatient emergent (*n* = 248,357)
Gender				
Male	4660 (66.5%)	8690 (66.7%)	129,244 (58.8%)	149,202 (60.1%)
Female	2351 (33.5%)	4343 (33.3%)	90,364 (41.1%)	99,131 (39.9%)
Unknown	0	0	24 (0.01%)	24 (0.01%)
Age				
16–19 years	25 (0.4%)	159 (1.2%)	2063 (0.9%)	10,871 (4.4%)
20–24 years	112 (1.6%)	459 (3.5%)	7742 (3.5%)	27,271 (11.0%)
25–34 years	623 (8.9%)	1423 (10.9%)	26,879 (12.2%)	57,353 (23.1%)
35–44 years	987 (14.1%)	1653 (12.7%)	40,472 (18.4%)	48,715 (19.6%)
45–54 years	1647 (23.5%)	2253 (17.3%)	55,961 (25.5%)	47,815 (19.3%)
55–64 years	2092 (29.8%)	2582 (19.8%)	53,946 (24.6%)	38,193 (15.4%)
65–74 years	1076 (15.3%)	2086 (16.0%)	23,144 (10.5%)	11,429 (4.6%)
75 years and older	449 (6.4%)	2418 (18.6%)	9425 (4.3%)	6710 (2.7%)
Mean comorbidities (sd)	1.86 (sd = 1.71)	2.49 (sd = 2.28)	0.22 (sd = 0.65)	0.30 (sd = 0.70)
Mean age (sd)	53.89 (sd = 14.20)	56.23 (sd = 18.93)	49.79 (sd = 14.50)	41.68 (sd = 15.66)
Race/Ethnicity				
White, non-Hispanic	4570 (65.2%)	8331 (63.9%)	119,092 (54.2%)	151,563 (61.0%)
Hispanic	965 (13.8%)	1747 (13.4%)	23,534 (10.7%)	42,026 (16.9%)
African American	881 (12.6%)	1139 (8.7%)	18,966 (8.6%)	35,485 (14.3%)
Asian/Pacific Islander	99 (1.4%)	212 (1.6%)	2836 (1.3%)	4900 (2.0%)
American Indian/Alaska Native	16 (0.2%)	15 (0.1%)	495 (0.2%)	540 (0.2%)
Other/Unspecified	480 (6.8%)	1589 (12.2%)	54,709 (24.9%)	13,843 (5.6%)
Median charges (IQR)	$64,514.1 (39,035.7–103,563)	$38,012.3 (21,281.4–71,200.2)	$3450.2 (831.3–10,568.8)	$1933.4 (1172.7–3538.3)

TABLE 3 Crude average annual rate per 100,000 and incident rate ratios by gender, race/ethnicity and age in Illinois, emergency department and inpatient workers' compensation cases treated in Illinois hospitals, 2017–2021.[a]

	Inpatient elective (n = 6556)			Inpatient emergent (n = 12,198)			Outpatient elective (n = 213,291)			Outpatient emergent (n = 239,138)			All workers compensation cases (n = 471,183)		
Gender	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Race/Ethnicity rates															
African American	30.4	17.1	23.0	38.9	21.1	28.9	518.7	492.5	504.1	1069.9	835.9	938.9	1657.8	1366.6	1495.0
Hispanic/Latino	23.5	9.9	17.6	46.2	12.1	31.4	485.7	367.5	434.5	925.7	579.8	775.6	1481.1	969.3	1259.1
White non-Hispanic	14.4	29.3	21.5	45.6	31.9	39.1	646.7	526.1	589.3	841.4	622.6	737.3	1560.4	1196.6	1387.2
Asian	4.5	4.5	4.5	10.8	9.2	10.1	106.3	173.3	137.8	200.0	266.3	231.2	321.6	453.3	383.6
Incident rate ratios															
African American	2.1	0.6	1.1	0.9	0.7	0.7	0.8	0.9	0.9	1.3	1.3	1.3	1.1	1.1	1.1
Hispanic/Latino	1.6	0.3	0.8	1.0	0.4	0.8	0.8	0.7	0.7	1.1	0.9	1.1	0.9	0.8	0.9
White non- Hispanic	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF
Asian	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.2	0.2	0.4	0.3	0.2	0.4	0.3
Age rates															
16–19 years	2.1	2.1	2.1	17.6	7.7	12.4	231.6	133.6	180.5	1172.9	732.7	943.4	1424.0	876.0	1138.3
20–24 years	4.3	2.7	3.5	21.4	8.5	14.9	334.6	202.0	268.3	1129.8	768.1	949.0	1490.2	981.3	1235.8
25–34 years	9.9	6.3	8.2	25.6	11.3	18.8	457.5	284.3	375.0	941.7	630.3	793.2	1434.7	932.2	1195.1
35–44 years	18.7	7.6	13.5	34.1	9.7	22.8	692.9	447.4	578.6	818.6	549.7	693.4	1564.3	1014.4	1308.3
45–54 years	31.1	14.8	23.4	47.0	15.5	32.1	945.6	709.6	833.8	807.4	596.4	707.4	1831.0	1336.3	1596.6
55–64 years	47.4	23.1	35.8	60.0	24.6	43.2	1085.9	823.9	961.3	730.8	607.9	672.3	1924.1	1479.4	1712.7
65–74 years	68.5	64.8	66.8	140.1	115.4	128.6	1247.8	1716.5	1464.7	689.2	744.6	714.8	2145.6	2641.3	2375.0
75 years and older	141.2	192.6	163.6	638.5	1177.9	872.7	2379.0	4842.4	3448.3	1773.7	3306.3	2438.9	4932.5	9519.2	6923.4
Total	26.2	15.0	20.9	48.8	28.0	38.9	760.5	591.3	680.0	868.3	645.8	762.4	1703.9	1280.0	1502.1

[a]Excludes non-Illinois residents in rate calculations.

TABLE 4 Type of presentation of workers compensation cases treated in Illinois hospitals, emergency department visits only 2017–2021.

	Illnesses (n = 103,657)	Injuries (n = 234,990)	Musculoskeletal conditions (n = 129,342)
Presentation type			
Outpatient Elective	58,128 (56.1%)	69,133 (29.4%)	92,371 (71.4%)
Outpatient Emergent	45,529 (43.9%)	165,857 (70.6%)	36,971 (28.6%)
Year			
2017	24,381 (23.5%)	49,890 (21.2%)	27,176 (21.0%)
2018	21,687 (20.9%)	52,892 (22.5%)	28,678 (22.2%)
2019	20,030 (19.3%)	52,879 (22.5%)	28,208 (21.8%)
2020	17,046 (16.4%)	37,261 (15.9%)	21,255 (16.4%)
2021	20,513 (19.8%)	42,068 (17.9%)	24025 (18.6%)
Gender			
Male	54,874 (52.9%)	148,512 (63.2%)	75,060 (58.0%)
Female	48,778 (47.1%)	86,449 (36.8%)	54,268 (42.0%)
Unspecified	5 (0.0%)	29 (0.0%)	14 (0.0%)
Mean age (sd)	52.0 (sd = 18.1)	42.0 (sd = 14.8)	47.8 (sd = 13.5)
16–19 years	1623 (1.6%)	9995 (4.3%)	1316 (1.0%)
20–24 years	5674 (5.5%)	24,344 (10.4%)	4995 (3.9%)
25–34 years	15,217 (14.7%)	51,019 (21.7%)	17,996 (13.9%)
35–44 years	15,604 (15.1%)	46,527 (19.8%)	27,056 (20.9%)
45–54 years	19,203 (18.5%)	49,186 (20.9%)	35,387 (27.4%)
55–64 years	18,789 (18.1%)	41,907 (17.8%)	31,443 (24.3%)
65–74 years	16,766 (16.2%)	9412 (4.0%)	8395 (6.5%)
75 years and older	10,781 (10.4%)	2600 (1.1%)	2754 (2.1%)
Race/Ethnicity			
White, non-Hispanic	68,517 (66.1%)	135,431 (57.6%)	66,707 (51.6%)
Hispanic	11,168 (10.8%)	39,612 (16.9%)	14,780 (11.4%)
African American	10,424 (10.1%)	27,649 (11.8%)	16,378 (12.7%)
Asian/Pacific Islander	1987 (1.9%)	4241 (1.8%)	1508 (1.2%)
American Indian/Alaska Native	184 (0.2%)	571 (0.2%)	280 (0.2%)
Other/Unspecified	11,377 (11.0%)	27,486 (11.7%)	29,689 (23.0%)

disproportionately were treated for injuries and musculoskeletal conditions (63.2% and 58.0%, respectively), there was near parity between males and females for illnesses (52.9% vs. 47.1%; Table 4). Patients were youngest in the acute injury group and disproportionately under 35 years of age (mean age = 42.0). Patients treated for musculoskeletal conditions were disproportionately between the ages of 35 and 64 years (mean age = 47.8) and patients treated for illnesses were disproportionately 65 years and older (mean age = 52.05; Table 4). White non-Hispanics comprised the majority of patients across all three categories: illnesses, injuries and musculoskeletal conditions. However, white non-Hispanics were disproportionately treated for illnesses, while Hispanic or Latino workers were disproportionately treated for injuries.

ED elective presentations (n = 219,632) were most common for diagnoses of musculoskeletal and connective tissue disorders (n = 92,371, 42.1%), sprain/strains (n = 20,208, 9.2%), fractures (n = 18,657, 8.5%), dislocations (n = 8,436, 3.8%), nonspecific symptoms (n = 8,121, 3.7%) and diseases of the peripheral nervous system (n = 5,501, 2.5%). ED emergent cases (n = 248,357) were the largest group of hospital presentations and were most commonly diagnosed with open wounds (n = 47,560, 19.1%), musculoskeletal and connective tissue disorders (n = 36,971, 14.9%), superficial contusions

(*n* = 30,470, 12.3%), sprains and strains (*n* = 24,940, 10.0%) and fractures (*n* = 19,033, n = 7.7%). For elective inpatient admissions (*n* = 7011) the five most common primary diagnoses included musculoskeletal and connective tissue disorders (*n* = 3827, 54.6%), fractures (*n* = 659, 9.4%), complications postorthopaedic care (*n* = 340, 4.8%), disorders of circulatory system (273, 3.9%), pregnancy complications (*n* = 196, 2.8%) and traumatic brain injuries (*n* = 196, 2.8%). The most common primary diagnoses for emergent inpatient admissions (*n* = 13,033) included fractures (*n* = 2935, 22.5%), disorders of the circulatory system (*n* = 1418, 10.9%), infectious diseases (*n* = 751, 5.8%), traumatic brain injuries (*n* = 632, 4.8%) and respiratory diseases (*n* = 594, 4.6%) and skin diseases (*n* = 564, 4.3%).

Among the 103,657 ED visits treated for illnesses, the most common diagnoses were circulatory system disorders (*n* = 10,719, 10.3%), diseases of the peripheral nervous system (*n* = 6260, 6.0%) and central nervous system (*n* = 5900; 5.7%), digestive system disorders (*n* = 7995, 7.7%), disorders of the respiratory system (*n* = 5123; 4.9%), psychiatric conditions (*n* = 4683; 4.5%) of which *n* = 2346 are drug and alcohol related, disorders of the eyes and ears (*n* = 4740), diseases of the skin (*n* = 4159; 4.0%), blood disorders (*n* = 3068; 3.0%) and malignant neoplasms (*n* = 2509 2.4%). There were 9881 encounters related to personal or family medical history or exposure, of which 54.3% (*n* = 5426) were related to contact with and (suspected) exposure to potentially hazardous body fluids. There were 1090 pregnancy complications of which 37 resulted in abortive outcome.

3.4 | Radiological imaging

Radiological imaging comprised the majority of procedures for hospital-based outpatient services, with 403,317 radiological investigations, and 94.8% of those were coded for a body region (Figure 1). Patients can have more than one radiological investigation during the same visit, therefore proportions shown in Figure 1 are the percentage of the total number of radiological investigations in the cohort by body region. Radiology not coded under a body region included guided radiological procedures (*n* = 6508, 1.6%), mammogram (*n* = 4298, 1.1%), radiation and nuclear oncology (*n* = 3274,

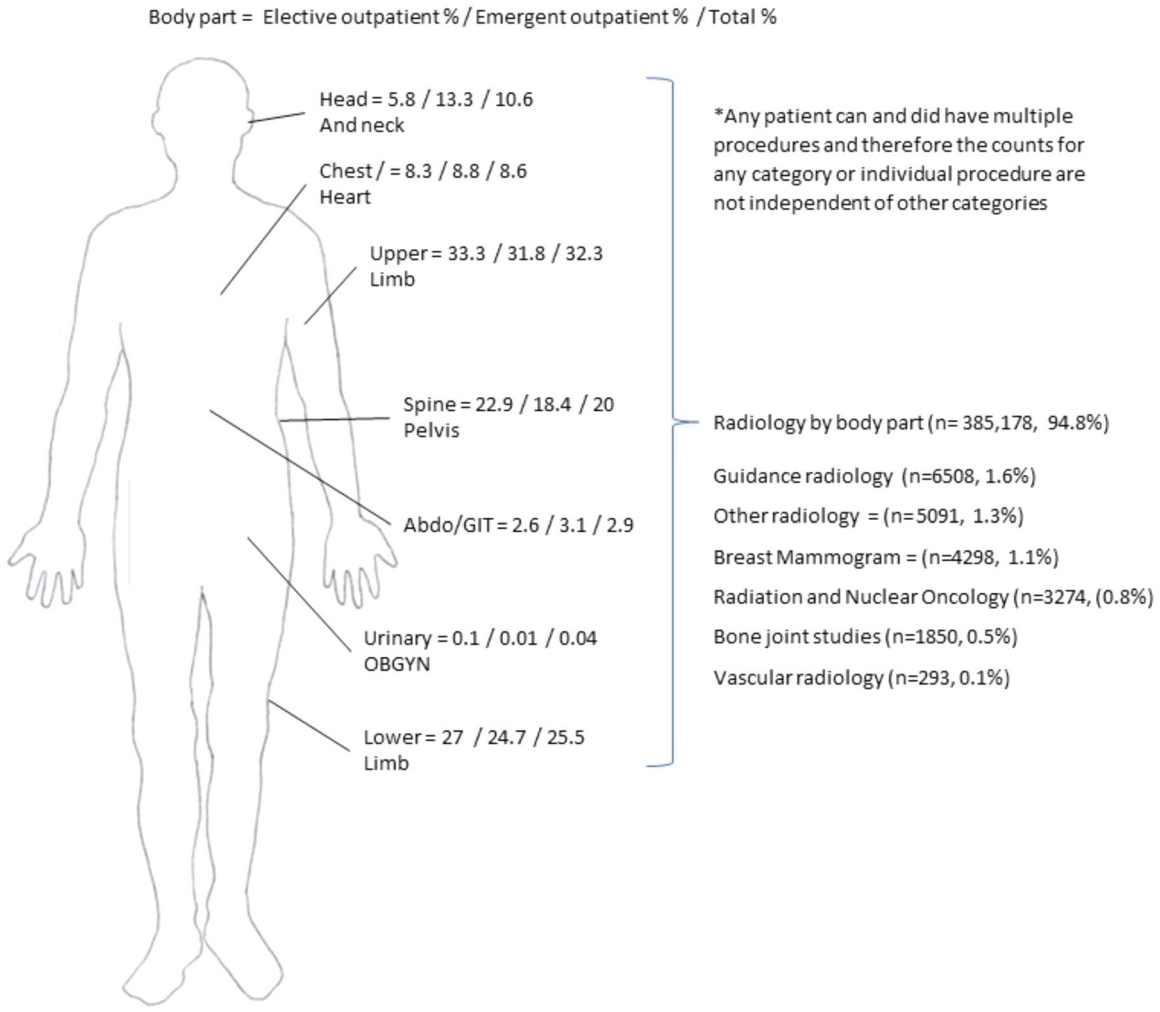

FIGURE 1 Radiology imaging in workers' compensation emergency department patients (outpatients) based on Current Procedural Terminology codes from 2017 to 2021.

0.8%) and bone and joint studies ($n = 1850$, 0.5%). As shown in Figure 1, the most common body regions that underwent radiological imaging were the upper limb ($n = 124,452$, 30.6%), lower limb ($n = 98,210$, 24.2%) and spine and pelvis ($n = 76,962$, 18.9%).

3.5 | Procedures undertaken

There were 25,194 cardiac procedures carried out in ED cases, with the majority of those being Electrocardiogram (ECG/EKG) ($n = 21,948$, 87.1%) or echocardiograms ($n = 2843$, 11.3%). There was a total of 275,600 laboratory and pathology tests done for ED cases, with 75% of those in emergent cases ($n = 208,049$). Despite only 21.1% of emergent ED cases having any laboratory and pathology tests done, of those cases with any testing the mean number of tests conducted were high (mean = 4.0). Of the emergent ED cases 78.9% had no tests, 5.2% had 1 test, 3.1% had 2 tests, 7.7% of cases had 3–5 tests 4.1% had 6–10 tests and 1% of cases had 11 or tests. Of the ED cases, 8.3% had at least one test classified as a disease panel, 7.4% had at least one test classified as a chemical test, and 5.2% had at least one urinalysis. The most common laboratory and pathology tests done in the ED included complete blood count ($n = 33,886$, 7.2%), complete metabolic panel ($n = 26,192$, 5.6%), basic metabolic panel ($n = 12,061$, 2.6%), urine human chorionic gonadotropin (hCG) ($n = 10,906$, 2.3%), urine test with culture ($n = 7162$, 1.5%), finger glucose ($n = 6098$, 1.3%), urine dipstick ($n = 5773$, 1.2%), beta hCG ($n = 3288$, 0.7%). By comparison, there were 22,460 inpatient procedure codes reported, predominantly within the categories of medicine/surgery (61.0%), administrative procedures (10.5%), measuring and monitoring procedures (7.9%) and imaging (7.2%). Among the inpatient cases only, 42.1% of emergent WRII ($n = 13,033$) required a surgical intervention compared to 77.9% of elective WRII ($n = 7011$).

3.6 | Factors associated with treatment in the ED

To evaluate factors associated with treatment in hospital-based outpatient services compared to admitted cases, we developed several multivariable logistic regression models shown in Table 5. The odds of treatment in elective hospital-based outpatient services increased with each 10 years of age as compared to elective admissions, while the odds of treatment as an emergent ED visit decreased with each 10 years of age as compared to emergent admissions. Both models demonstrated that persons treated in hospital-based outpatient services had increased odds of being female

TABLE 5 Multivariable logistic regression model assessing factors predicting the odds of emergency department (outpatients) only workers compensation cases compared to hospital admitted workers compensation cases.

Multivariable model	Predictors of outpatient elective treatment (ref = inpatient elective group)			Predictors of outpatient emergent treatment (ref = inpatient emergent group)		
Variable	Odds ratio	(CI 95%)	*p* Value	Odds ratio	(CI 95%)	*p* Value
Year	1.25	1.22–1.27	<0.0001	1.03	1.01–1.04	0.0006
Age per 10 years (continuous)	1.06	1.04–1.08	<0.0001	0.93	0.91–0.94	<0.0001
Female[a]	1.43	1.35–1.52	<0.0001	1.86	1.77–1.94	<0.0001
White non-Hispanic	REF			REF		
African American[b]	0.87	0.80–0.95	0.0016	1.62	1.50–1.75	<0.0001
Hispanic/Latino[b]	0.84	0.77–0.91	<0.0001	0.87	0.82–0.93	<0.0001
Other minority ethnicity[b]	0.66	0.59–0.73	<0.0001	0.91	0.83–1.00	0.0376
Illness case	REF			REF		
Injury case[c]	1.28	1.18–1.40	<0.0001	1.77	1.69–1.85	<0.0001
Musculoskeletal condition[c]	0.44	0.41–0.47	<0.0001	2.27	2.10–2.45	<0.0001
Elixhauser comorbidities	0.34	0.33–0.35	<0.0001	0.37	0.36–0.37	<0.0001
Hospital with trauma unit	0.47	0.44–0.49	<0.0001	0.51	0.48–0.53	<0.0001
Urban hospitals (RUCC 1)	REF			REF		
Suburban semi-urban hospital[d]	1.90	1.77–2.03	<0.0001	0.67	0.64–0.70	<0.0001
Rural areas with less than 20 k persons[d]	1.73	1.52–1.97	<0.0001	1.19	1.10–1.29	<0.0001

Abbreviation: RUCC, Rural-Urban Continuum codes distinguish US metropolitan and nonmetropolitan counties.

[a]Reference group = male;

[b]Reference group = non-Hispanic White;

[c]Reference group = Illness case;

[d]*Reference group* = Urban hospitals.

($p < 0.001$), presenting with an injury ($p < 0.001$), treated in a rural hospital ($p < 0.001$), and having fewer serious comorbidities ($p < 0.001$). African American workers compared to NHW workers and cases presenting with musculoskeletal conditions compared to illnesses had increased odds of being treated in the ED setting for emergent events but lower odds of treatment in other hospital-based outpatient services for elective events.

3.7 | Costs of medical care

The total cumulative hospital charges between 2017 and 2021 was $4.44 billion for all WRII, of which $3.06 billion was for ED WRII, with median total charges of $2269.80 and $47,316.80 for ED and inpatient WRII respectively. Table 6 presents multivariable median regression models evaluating key predictors of total hospital charges for WRII, stratified by the four treatment groups. Both models evaluating costs associated with elective and emergent ED visits showed charges significantly increased with each serious comorbidity the worker had diagnosed, those requiring surgical intervention and patients treated in hospitals with level 1 or 2 trauma facilities (Table 6). For ED elective WRII visits, we also found that charges were significantly higher for African American patients ($\beta = \$266$, 95% CI \$226, \$306; $p < 0.0001$), among males ($\beta = \$322$, 95% CI \$297, \$347; $p < 0.0001$), and patients treated in hospitals located in rural counties ($\beta = \$95$, 95% CI \$64, \$126; $p < 0.0001$). For ED

TABLE 6 Multivariable median regression model assessing associations of total hospital charges[a] (in US dollars) by inpatient status and elective presentation status, workers compensation cases presenting to Illinois hospitals 2017–2021.

	Inpatient elective estimates ($n = 7011$) Estimate (95% CI)	Inpatient emergent estimates ($n = 13,033$, 12,002 used) Estimate (95% CI)	Outpatient elective estimates ($n = 219,632$) Estimate (95% CI)	Outpatient emergent estimates ($n = 248,357$) Estimate (95% CI)
Year	5046 (4452, 5641)*	1818 (1523, 2112)*	117 (110, 124)*	155 (150, 160)*
Age per year	2 (−72, 75)	−117 (−146, −89)*	0.6 (−0.2, 1.4)	10 (9, 11)*
Male[b]	3755 (1927, 5584)*	4339 (3471, 5206)*	332 (309, 355)*	155 (140, 171)*
White non-Hispanic	REF	REF	REF	REF
African American[c]	290 (−2423, 3002)	−118 (−1546, 1309)	288 (246, 329)*	10 (−8, 27)
Hispanic/Latino[c]	−2510 (−5477, 456)	−2645 (−4196, −1094)**	39 (6, 72)**	77 (57, 98)*
Other minority ethnicity[c]	−1896 (−5254, 1462)	−1066 (−2814, 682)	172 (112, 232)*	−2 (−31, 27)
Illness	REF	REF	REF	REF
Injury case[d]	521 (−1565, 2608)	10,376 (9282, 11,470)*	527 (498, 556)*	59 (37, 81)*
Musculoskeletal condition[d]	13,095 (10,803, 15,387)*	−2237 (−4656, 182)	428 (399, 457)*	−195 (−219, −171)*
Elixhauser comorbidities	968 (333, 1604)**	722 (438, 1007)*	2218 (2143, 2293)*	613 (593, 633)*
Hospital with Trauma Unit	2250 (521, 3979)***	5487 (4413, 6560)*	589 (568, 611)*	316 (303, 330)*
Suburban Semi-urban hospital[e]	163 (−2102, 2429)	1155 (77, 2233)***	−24 (−49, 0)	−152 (−166, −138)*
Hospital in rural areas with less than 20 k persons[e]	−9579 (−12,607, −6551)*	−1038 (−2695, 618)	110 (80, 141)*	−257 (−277, −237)*
Operation	54,397 (524,63, 56,331)*	20,838 (19,600, 22,075)*	11,254 (11,191, 11,317)*	6930 (6281, 7578)*
Length of stay	4709 (4527, 4892)*	8257 (8001, 8512)*	~	~

Abbreviation: RUCC, Rural-Urban Continuum codes distinguish US metropolitan and nonmetropolitan counties.

*p = <0.0001; **p = <0.01; ***p = <0.05;

[a]Median hospital charges charges for Inpatient Elective = \$64514.1, Inpatient emergent = \$38012.3, Outpatient Elective = \$3450.2, Outpatient Emergent = \$1933.4;

[b]Reference group = male;

[c]Reference group = non-Hispanic White;

[d]Reference group = Illness case;

[e]Reference group = Urban hospitals.

emergent WRII visits, we found that hospital charges were significantly lower in hospitals located in semi-urban counties (β = $-146, 95% CI −$186, −$106; $p < 0.0001$).

4 | DISCUSSION

Our results demonstrate the value of incorporating hospital data in occupational surveillance, particularly the importance of integrating and utilizing outpatient data in addition to widely used inpatient data. In this analysis, 95.9% of all WRII hospital presentations were not admitted. Inpatient data are typically used for identifying the most severe cases and estimating WC costs. However, research demonstrates that the majority of injuries with days away from work involve injuries that are not admitted to hospitals[15] and our analysis shows that the cumulative cost of WRII outpatient cases was almost threefold higher than the cost of admissions.

Beyond expanding our understanding of the cumulative burden of WRII, analysis of outpatient data provides important clinical insights on the presentation of subacute and chronic conditions and patterns of medical utilization that are not available in other data sources. There were 17-times more hospital visits relating to illnesses and musculoskeletal conditions treated in the ED (n = 232,999) compared to admissions (n = 13,467). The majority were specifically for subacute or chronic musculoskeletal conditions, but there were many visits relating to disorders of the circulatory system, nervous system, and digestive system. Traditional occupational surveillance systems fail to capture data relating to chronic health conditions. ED data provides an opportunity to further examine the distribution of work-related musculoskeletal conditions and evaluate the relationship between elective procedures and interventions for early return-to-work. Our data showed an average of 26,000 work-related hospital visits per year in Illinois for musculoskeletal conditions, affecting an estimated 15,347–23,070 unique persons per year. In contrast, there was an average of 11,388 musculoskeletal WC cases per year from 2017 to 2020 in Illinois that involved days away from work estimated by US Department of Labor data.[38] The estimate count of unique patients that we provide in the manuscript attempts to count a patient once even if they had multiple visits for care (such as imaging, surgery and postsurgical care). Musculoskeletal WC cases can involve multiple hospital visits, conflicting diagnoses between clinicians, protracted care spanning years and may involve lost work over several periods during a year. These are likely the main causes for the disparity in the number of cases estimated by SOII and enumerated in hospital data. This will primarily be relevant for elective musculoskeletal WC hospital cases that had additional elective presentations in sequential years, yet the difference in estimates warrants further investigation into musculoskeletal WC cases. There is a growing number of studies that describe occupational health disparities, highlighting Hispanic/Latino,[39] young,[40] and elderly workers[41] as having a higher risk for WRII; there is evidence that they also have limited access to health care and worse outcomes after a work-related injury. However, our findings demonstrate that African American workers have a higher rate of emergent ED visits compared to other racial-ethnic groups. This disparity is missed when evaluating admissions data alone. In non-work-related cases, research shows that African American patients are less likely to be admitted to a hospital even after controlling for severity and condition, which might explain the lower admission rates but higher emergent ED visit rates.[42,43]

Our crude average annual rates show that workers aged 16–24 and 75 years and older had the highest rates of emergent ED visits. When examining only admitted WRII patients, the burden of WRII in younger age groups would be missed. This age group requires further research to detail the epidemiology of WRII and understand the long-term consequences of these presentations as it relates disability, return-to-work in the short term, and long-term employment outcomes. Using outpatient data, disparities in the level of hospital care could be evaluated specifically for work-related cases.

Examination of CPT codes allowed for further evaluation of investigations and procedures undertaken for outpatient patients only. Regular examination of CPT codes will help determine trends and allow for evaluation of these procedures against clinical guidelines. Future studies examining clinical and return-to-work outcomes stratified by clinical management pathways for outpatient cases (investigations that result in admission vs treatment in the ED vs. discharge with planned hospital or community follow-up) will be helpful to understanding the recovery and cost burden of this patient group.

Given the burden of WRII that present to hospital-based outpatient services, this setting presents a unique opportunity for early intervention to improve return to work outcomes. Opportunity exists for targeted efforts toward leveraging the Electronic Medical Records (EMR) system for the purpose of occupational health surveillance as well. For example, an event monitoring function could use the EMR to detect, predict, and prevent adverse events.[44] There is an unseen prospect in Illinois and many other states to expand on previous work undertaken in Michigan and Massachusetts[24–28] and develop state-wide surveillance systems linking hospital records, including outpatient data, with other databases: this would provide an opportunity for conducting comprehensive research by allowing exploration of relationships between exposure factors, adverse health events, treatment protocols, return to work and long-term physical, psychosocial and economic outcomes.

There are limitations to our study. First, our findings do not account for WRII that do not present to a hospital (e.g., primary care, urgent care, or occupational health clinic presentations) or cases where work-relatedness is not captured (i.e., not reported by the patient, not queried by the provider) and thereby did not have a WC payer. Data from nonhospital sources would likely identify additional cases, since less severe injuries are frequently managed in the non-tertiary setting; however, we were able to review a large sample of moderate to severe cases that presented to hospital. While integrating outpatient data into occupational surveillance and research will greatly expand case capture, past research has demonstrated that over 50% of WRII are treated outside of the hospital setting and these WRII represent 40% of total missed days of work.[15] A limitation of this study is the use of workers' compensation payer as the source of work-relatedness for hospital patients. Prior Michigan studies

using multi-source surveillance systems for injuries have shown workers' compensation payer can miss 34–58% of work-related cases.[25–28] There might be different reasons for under-reporting of workers' compensation payer based on hospital, region, reason for visit and patient demographics and this requires future investigation in Illinois through multisource surveillance systems. Private-public partnerships that integrate occupational health clinic data and private WC insurance claim data into a surveillance system would also be beneficial in characterizing patients seeking care in the nontertiary setting. Second, our study does not capture work-related deaths occurring before or after presentation to a hospital, underscoring that hospital data are likely not the ideal source for enumerating work-related fatalities.[21] Third, a proportion of cases did not record race/ethnicity (n = 49,405, 10.1%) most of whom were elective ED cases. Fourth, the hospital data utilized for this analysis are deidentified; therefore it was not possible to determine the exact number of unique patients seen at Illinois hospitals in this study. To address this limitation, we used probabilistic linkage to estimate unique patients, which comprised 75.6%–92.4% of all hospital visits. Many emergent injuries are going to require subsequent follow-up for elective presentation for diagnostic investigations or surgical procedures. Despite calculating unique patient counts we have not been able to identify the timeline of clinical care for individual cases of a WRII, including the number of visits required and length between initial presentation and follow-up care. Hospital data is prone to misclassification and WC payments may vary based on insurer/provider/region/hospital/condition necessitating further investigation. Further validation of the accuracy of coding for WC payers needs to be conducted since we observed a small fraction of outpatient and inpatient cases that involved procedures that are not typically covered by WC (e.g., obstetrics services, mammography). Furthermore, prior research has found Hispanic workers are 33% less likely to disclose nonfatal workplace injuries nationally,[45] which may also reflect underreporting in other minority race/ethnicities as well, with resulting differential misclassification by payer type in in these groups.

5 | CONCLUSION

Between 2017 and 2021 in Illinois, there were nearly 500,000 hospital visits charged to WC totaling over four billion US$. While most occupational researchers have integrated inpatient data into surveillance systems, outpatient hospital data are able to paint a larger picture of WRII. In this analysis, integrating outpatient data characterized 96% of WRII visits treated in hospitals, and provided insights into chronic conditions, health disparities, and potential clinical treatment guidelines. The omission of outpatient data from occupational surveillance systems limits our understanding of: (1) the magnitude and distribution of occupational illnesses and injuries, particularly adverse health outcomes that are more likely to be underreported to or by employers; (2) time trends of all adverse health events, including illnesses and musculoskeletal conditions; (3) emerging injury and work-related exposures; (4) specific cases or situations that would benefit from follow-up investigations; (5) intervention priorities; and (6) evaluation of the efficacy and effectiveness of intervention activities, including both resolution of the health condition and return to work. Integrating elective hospital-based outpatient services and emergent ED visits data into occupational health research provides numerous opportunities to expand our current knowledge of occupational health.

AUTHOR CONTRIBUTIONS

Brett Shannon was involved in the conception and design, analysis, literature review, interpretation of data, drafting and revisions of the manuscript, and approval of the final version. Chibuzor Abasilim, Kirsten Almberg, Courtney Ryder and Tessa Bonney were involved in the drafting and revisions of the manuscript, and approval of the final version. Lee Friedman was involved in the conception and design, analysis, literature review, interpretation of data, drafting and revisions of the manuscript, and approval of the final version

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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 in summarized/aggregated form on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS APPROVAL AND INFORMED CONSENT

The University of Illinois at Chicago (UIC) IRB approved this work (#2012-0116).

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