Work-Related Burn Injuries Hospitalized in US Burn Centers: 2002 to 2011

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Objective: To develop a comprehensive definition to identify work-related burns in the National Burn Repository (NBR) based on multiple fields and describes injuries by occupation. **Methods:** The NBR, which is an inpatient dataset, was used to compare type and severity of burn injuries by occupation. **Results:** Using the definition developed for this analysis, 22,969 burn injuries were identified as work-related. In contrast, the single work-related field intended to capture occupational injuries only captured 4696 cases. The highest numbers of burns were observed in construction/extraction, food preparation, and durable goods production occupations. Occupations with a mean total body surface area (TBSA) burned greater than 10% include transportation and material-moving, architecture and engineering, and arts/design/entertainment/sports/media occupations. **Conclusions:** The NBR dataset should be further utilized for occupational burn injury investigations and multiple fields should be considered for case ascertainment.

In the United States, an estimated 65,000 nonfatal occupational burns were treated in hospitals in 2013 based on a National Institute for Occupational Safety and Health/Centers for Disease Control and Prevention survey.[1] Depending on the data source, work-related burn injuries comprise 20% to 40% of overall burn injury burden in United States, and it is frequently catastrophic for the worker, their families, and society as a whole as a result of the impairment, disability, and deaths resulting from occupational burn injuries.[1–4] Work-related burns also tend to be more costly relative to other types of occupational injuries. Based on workers' compensation claims, the average claim cost is more than $20,000 for burn injuries.[5,6] In a recent burn care cost review, the average total cost per burn patient was $88,218 in high-income countries.[7]

Because workplace hazards, safeguards, and practices vary dramatically by worksite, region, and country, studies frequently identify differing hazards and high risk groups for burn related injuries at work. In an analysis of West Virginia workers' compensation data, welders, cooks, laborers, food-service workers, and mechanics had higher incidence rates when compared with other occupations.[8] Hunt et al[9] had conducted a study to investigate the characteristics of burn injuries in the workplace and concluded that vehicle and equipment cleaners, food service personnel, and millwrights (ie, heavy machinery installers) were high-risk occupations. The most frequent causes of work-related burns vary across studies and includes: fire/flame/smoke,[10] caustics and hot objects and substances,[9] hot water/steam,[11] and flame/scalds.[12]

A major limitation of the current occupational burn literature is that existing studies usually involve data from a single facility, city, or specific region with a few thousand observations or less in the study sample.[2,10,13,14] Because of the narrow sample frames and the lack of important burn injury variables, it is difficult to compare between occupations regarding specific injury patterns, sources of injury, burn severity, mortality, and length of hospitalization (LOS).

The National Burn Repository (NBR) is a large burn-specific database which includes patient information from most of the burn centers across the United States. It is the most comprehensive and detailed burn database in United States and contains valuable and necessary burn injury related information, such as total body surface area burned (TBSA), body region-specific TBSA, injury etiologies, and burn-injury process narrative descriptions. Importantly, it is feasible for researchers to identify work-related burn injuries from this dataset since there are multiple fields that can be used including job titles, work-relatedness of the injury, payer information, and narratives describing the sources and circumstances relating to the injury. However, there have been no publications that formally define a method for identifying work related burn injuries in this dataset so that occupational health researchers can uniformly use this valuable data source for research purposes and NBR data manager can use it as guidance to improve the usefulness of NBR in work-related burn-injury surveillance.

The aim of this study was to evaluate the usefulness of the NBR for occupational research and specifically to (1) develop and test a case ascertainment definition for work-related cases, (2) provide a descriptive analysis of work-related burn injuries as reported in a large population, multisite database, (3) compare injury etiologies, severity, and outcomes among various occupations as to identify high-risk occupations across multiple measures, and (4) develop multivariable logistic regression models to compare in-hospital mortality and higher TBSA among occupations.

MATERIALS AND METHODS

Data Sources

This study is a retrospective analysis of work-related burn injuries hospitalized in US burn centers during 2002 to 2011, including records reported in the NBR research dataset version 8.0. The NBR is compiled and managed by the American Burn Association (ABA) and the American College of Surgeons. The dataset includes variables on patient demographics, cause and nature of injury, type, and severity of injury, comorbidities, medical complications, diagnoses, toxicology screens, and medical procedures during the course of hospitalization. The public dataset is de-identified of all identifiers including spatial and facility information. However, the ABA does include a "member key"

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which is the unique patient identifier, which is not available in the version 3/4 TRACS software and Non-TRACS centers. Burn centers contribute to NBR voluntarily, which represents a convenience sample of US burn centers and may differ from those that do not participate. However, according to an NBR report,[15] the burn centers that contribute to NBR are representative of burn centers in the United States geographically and represent 73% of all burn centers in the United States (91 out of 125 centers). All 60 ABA verified burn centers contribute to the NBR.

The NBR dataset has been widely used by researchers for various studies, from investigations of specific clinical hypotheses to the evaluation of broad associations and predictors of mortality, such as the relationship between mortality and inhalation injury and burn size. Although there is some effort by the ABA to clean the data and ensure data quality, prior assessment of the databases have found duplicate records, inclusion of multiple records for patients readmitted multiple times, and lack of agreement between fields within the data. In a validity review of the NBR,[16] researchers found the inclusion of some burn patients without any burn injuries indicated (TBSA = 0) and disagreement between variables providing information on deaths and discharge status.

Case-Ascertainment of Work Related Burns

Even though there is a ''work-related'' field in the original NBR dataset, we identified occupational burn injuries using the following four variables: ''Work-Related,'' ''Injury Circumstance,'' ''Insurance Payor,'' and ''Injury Event Description.'' Figure 1 summarizes the inclusion and exclusion criteria used for identifying work related cases for this analysis.

The analysis focused on new incident work-related burn injury cases. Therefore, all cases indicated as a readmission or duplicate entry based on matching member key numbers, cases with only a diagnosis for a skin disease, any case with an etiology identified as a ''non-burn,'' and cases younger than 15 or older than 67 were excluded. Although work-related injuries can occur in both younger and older individuals, the proportion of occupational injuries is substantially lower at both ends of the age spectrum. In most states, aged 15 is the legal working age and 67 is the upper range for retirement. To be more conservative, among those with duplicate member keys, we kept the record with youngest age and earliest injury year and all subsequent records for that patient were removed.

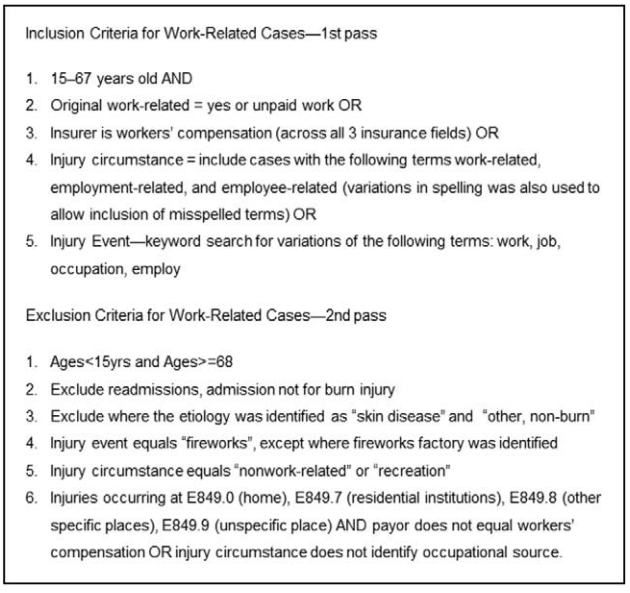

FIGURE 1. Inclusion and exclusion criteria for work-related cases using four fields in the National Burn Repository v8.0. Footnote: Exclusion criteria 4, 5, and 6 only apply to field of ''Injury Event Description.''

TABLE 1. Case Identification of Work-Related Burn Injuries Using Four Fields in the National Burn Repository*

Original Work Related†	Injury Circumstance	Workers Compensation	Injury Event Description	*N*	%
0	0	0	1	38	0.2
0	0	1	0	1,160	5.1
0	0	1	1	47	0.2
0	1	0	0	5,432	23.7
0	1	0	1	450	2.0
0	1	1	0	10,019	43.6
0	1	1	1	1,127	5.0
1	0	0	0	1,131	5.0
1	0	0	1	12	<0.1
1	0	1	0	1,038	4.5
1	0	1	1	7	<0.1
1	1	0	0	480	2.1
1	1	0	1	88	0.4
1	1	1	0	1,629	7.1
1	1	1	1	311	1.4

*Value ''1'' indicates the field was used to identify work-related burn injuries; value ''0'' indicates the field was not used to identify work-related burns; each row represents different combinations of fields used to identify the respective number of cases.
†Work-related field originally in the NBR dataset.

Table 1 shows the number of cases identified using the varying combinations of fields. If researchers used only the ''work-related'' field, 20.44% (4696) of the work-related cases would be identified. Among work-related cases identified by ''workers' compensation payer'' or field of ''injury event,'' 1160 and 38 were not captured by any of the other variables, respectively. The greatest overlap across the four fields used to identify work-relatedness was observed between injury circumstance and workers' compensation (44%). The final number of work-related cases identified from this database was 22,969 out of 172,640 cases in the original file received by the ABA (Fig. 2).

Occupation Classification

The NBR uses the standard occupational classification (SOC) system to code occupations, which is also utilized by federal statistical agencies to classify workers into occupational categories.[17] The original occupation variables in our dataset were cleaned to coincide with 23 SOC major occupational groups. For cases where occupation was missing, two other fields (''etiology'' and ''Injury Event Description'') was used to define occupation. There were 701 cases in which the field ''etiology'' indicated ''cooking.'' These observations were then recoded as food preparation and serving-related occupations. Another 30 cases with missing occupation had an injury event description that identified them as firefighters, and these cases were then coded as protective-service occupations. In the end, 43% of all work-related cases were missing data on SOC occupation categories. A comparison of the cases with and without reported occupations was conducted (see Supplemental Table A, http://links.lww.com/JOM/A324). Two groups are similar in terms of sex, LOS, and Intensive Care Unit (ICU) days. Those with missing occupations tend to be older, having unknown injury etiology and unknown/unspecified place of injury, suffering higher mean TBSA and higher in-hospital fatality.

TBSA and Comorbidity

Even though some records were identified as burn injuries, their total TBSA was blank or had a value of zero. It is possible some

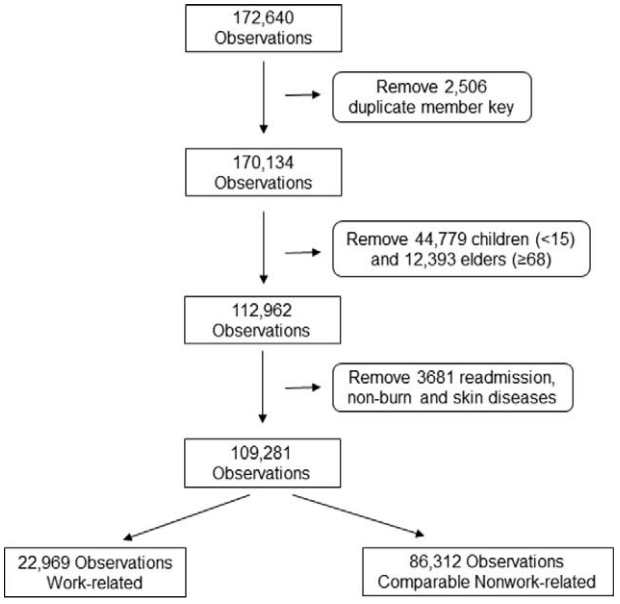

FIGURE 2. Flow chart of data cleaning and work-related cases classification using National Burn Repository Data, 2002 to 2011.

have burn injuries without a measured TBSA, as a result of internal burn injuries caused through inhalation or electricity. However, if there was no indication of an inhalation burn or electrical injury, all cases with a TBSA of zero were recorded as missing. Elixhauser comorbidity score calculation was based on NBR diagnosis codes.[18] Baux score is defined as the sum of age and percent body burned, which has been widely used to predict mortality after burn injury.[19]

Statistical Analysis

SAS software (v.9.3; SAS institute Inc., Cary, NC) was used in all statistical analyses. Pearson's chi-squared tests were used for categorical variables. For continuous variable, we used two sample *t* test. If a continuous variable was not normally distributed, Wilcoxon signed-rank test was used. In statistical assessments, a two-tailed *P* value lower than 0.05 was considered statistically significant. Multivariable logistic regression models were developed to investigate the association between occupations (reference group: food preparation and serving related) and in-hospital fatality, and TBSA over 10%. According to prior acknowledge, the following variables were included as covariates: age (continuous), sex, race (white as reference), inhalation injury, length of hospitalization, trauma mortality prediction model (TMPM), and Elixhauser comorbidity score.

RESULTS

Table 2 presents patient information stratified by major SOC occupations. The majority of work-related burns hospitalized in US burn centers were men (90%) and the overall distribution by race/ethnicity was white non-Hispanics (60.2%), followed by white Hispanic (20.1%), black (9.8%), and others/unspecified (9.9%). The occupations with the highest proportion of white Hispanics suffering work-related burn injuries were personal care and service occupations (29.9%), building and groups cleaning and maintenance occupations (29.6%), and food preparation and serving-related occupations (29.5%) (Table 2). Healthcare-support occupations had the highest proportion of black workers hospitalized in US burn centers due to work-related burns (41.2%) (Table 2). Over 70% of workers in community and social service, and business and financial operations are white non-Hispanic.

Overall, the occupations with most frequent burns hospitalized are construction/extraction, food preparation/serving related and production occupations. Across all work related burn injuries, the three most common causes of burn injuries were direct contact with fire/flame (32%), scalding (23%), and electricity (14%) (Table 2). However, nearly four out of five (79.8%) burn injuries among workers in food preparation and serving-related occupations were caused by scalding. Protective-service occupations, which include firefighters, had the highest proportion of burn injuries caused by direct contact with a fire/flame (72.9%). In both construction and extraction occupations, and installation, maintenance, and repair occupations, roughly 30% of the injuries were electrical burn. Chemical burns were most common among workers in healthcare practitioners and technical occupations (31.4%), health-care support occupations (26.5%), and life-, physical-, and social-science occupations (29.4%).

The overall mean TBSA among work-related patients was 8.14%, and 29% of the workers suffered third-degree burn injury. In both arts, design, entertainment, sports, and media occupations, and personal care and service occupations, more than 40% of them suffered from third-degree burn injuries, although only 78 and 144 patients were classified within these occupational categories, respectively. The following occupations had a mean TBSA greater than 10%: (1) transportation and material-moving occupations; (2) architecture and engineering occupations; (3) arts, design, entertainment, sports, and media occupations; (4) computer and mathematical occupations; and (5) farming, fishing, and forestry occupations. In both architecture and engineering occupations, and transportation and material-moving occupations, the mean Baux was about 53, which were the highest across the different occupations. In addition, 12.0% of workers suffering from burn injuries also suffered at least one non-burn traumatic injury. The most common non-burn traumatic injuries were fractures (5.2%), followed by open wounds (4.3%) as result of animal bite, avulsion, cut, laceration, puncture wound, and traumatic amputation.

Across all the injured workers, the overall average length of hospitalization was 8.3 days, with a median of 3 days. Arts, design, entertainment, sports, and media occupations; transportation and material-moving occupations; office and administrative support occupations; and farming, fishing, and forestry occupations were associated with longer median lengths of hospitalization (Table 2).

Among work-related burn injured patients, 447 (1.95%) of them died during the hospitalization. And about one-third of them required treatment in an ICU. Although construction and extraction occupations and production occupations had the highest number of in-hospital deaths, the occupations with the highest within-group in-hospital fatality rate was transportation and material-moving occupations (4.59%) (Table 2).

Table 3 showed the multivariable logistic regressions for in-hospital fatality and TBSA over 10% controlling for predefined covariates. Compared with food preparation/serving related occupations, transportation and material-moving occupations, and unknown occupations were significantly associated with 2.91 and 2.93 odds of dying in hospital, respectively; community and social service and protective service were associated with decreased odds of suffering TBSA over 10%, while construction and extraction, farming, fishing, and forestry, installation, maintenance, and repair, production, transportation and material moving, and unknown occupations are associated with increased odds of suffering TBSA over 10%.

DISCUSSION

This study identified approximately 23,000 work-related burn-injury patients hospitalized in 91 US burn centers from 2002 to 2011. For this analysis, we were able to develop a new case ascertainment definition for identifying occupational burn

TABLE 2. Characteristics of Workers Suffering Work-Related Burn Injuries in the United States by Major Occupations, National Burn Repository 2002 to 2011

	Overall		Construction/ Extraction		Food Preparation/ Serving Related		Production		Installation/ Maintenance/ Repair		Protective Service		Transportation/ Material Moving		Building and Grounds Cleaning/ Maintenance	
Occupations*	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***
Total	22,969		3,121	13.6	2,421	10.5	1,981	8.6	1,638	7.1	638	2.8	623	2.7	568	2.5
Mean age†	37.9	12.3	37.8	11.6	33.7	12.5	38.4	11.8	40.0	11.8	34.4	9.9	41.8	11.9	38.2	12.6
Male	20,579	89.6	3,069	98.3	1,701	70.3	1,850	93.4	1,593	97.3	603	94.5	600	96.3	527	92.8
Race																
White	13,831	60.2	1,877	60.1	1,041	43.0	1,270	64.1	1,074	65.6	499	78.2	373	59.9	306	53.9
Black	2,245	9.8	215	6.9	304	12.6	227	11.5	127	7.8	91	14.3	93	14.9	31	5.5
Hispanic	4,609	20.1	680	21.8	715	29.5	307	15.5	270	16.5	22	3.5	93	14.9	168	29.6
Etiology																
Fire/flame	7,413	32.3	853	27.3	216	8.9	670	33.8	591	36.1	465	72.9	297	47.7	171	30.1
Scald	5,235	22.8	620	19.9	1,933	79.8	489	24.7	272	16.6	56	8.8	113	18.1	106	18.7
Hot object	916	4.0	108	3.5	80	3.3	191	9.6	36	2.2	29	4.6	15	2.4	21	3.7
Electrical	3,246	14.1	935	30.0	46	1.9	113	5.7	491	30.0	21	3.3	30	4.8	110	19.4
Chemical	2,035	8.9	213	6.8	82	3.4	319	16.1	152	9.3	8	1.3	101	16.2	86	15.1
Inhalation	1,135	4.9	119	3.8	16	0.7	115	5.6	89	5.4	63	9.9	54	8.7	26	4.6
Fatality (%)	447	2.0	47	1.5	8	0.3	46	2.3	26	1.6	3	0.6	28	4.5	11	1.9
Median LOS‡	3	1,10	3	1,11	3	1,9	3	1,10	3	1,9	1	1,2	4	1,12	3	1,10
Mean ICU†	3.06	11.2	3.69	12.5	1.45	4.8	3.44	12.9	3.36	11.3	1.6	6.9	4.76	13.7	3.38	11.6
Severity																
NISS≥16	3,318	14.5	655	21.0	141	5.8	378	19.1	294	18.0	41	6.4	151	24.2	77	13.6
Elixhauser≥1	2,610	11.4	395	12.6	258	10.7	305	15.4	360	22.0	47	7.4	139	22.3	86	15.1
Mean TBSA†	8.1	12.5	8.0	11.8	5.1	6.1	9.8	14.5	8.1	12.4	5.0	8.9	12	15.9	8.3	12.9
Full thickness	6,659	29.0	1,062	34.0	575	23.8	755	38.1	506	30.9	81	12.7	233	37.4	190	33.5
Head burn	7,096	30.9	1,044	33.5	498	20.6	655	33.1	635	38.8	216	33.9	251	40.3	179	31.5

	Overall		Farming, Fishing/ Forestry		Community and Social Service		Sales and Related		Management		Personal Care and Service		Business and Financial Operations		Architecture and Engineering	
Occupations*	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***
Total	22,969		433	1.9	286	1.3	190	0.8	179	0.8	144	0.6	112	0.5	110	0.5
Mean age†	37.9	12.3	40.0	13.1	38.5	10.5	37.2	12.7	40.9	11.2	35.0	13.1	41.9	12.2	43.2	10.2
Male	20,579	89.6	411	94.9	272	95.1	141	74.2	151	84.4	72	50.0	92	82.1	107	97.3
Race																
White	13,831	60.2	265	61.2	208	72.7	123	64.7	110	61.5	56	38.9	81	72.3	74	67.3
Black	2,245	9.8	19	4.4	27	9.4	25	13.2	17	9.5	22	15.3	5	4.5	7	6.4
Hispanic	4,609	20.1	101	23.3	38	13.3	24	12.6	23	12.9	43	29.9	17	15.2	15	13.6
Etiology																
Fire/flame	7,413	32.3	185	42.7	164	57.3	72	37.9	62	34.6	19	13.2	50	44.6	33	30.0
Scald	5,235	22.8	39	9.0	40	14.0	49	25.8	52	29.1	68	47.2	23	20.5	20	18.2
Hot object	916	4.0	20	4.6	15	5.2	7	3.7	9	5.0	37	25.7	9	8.0	1	0.9
Electrical	3,246	14.1	63	14.6	22	7.7	20	10.5	27	15.1	3	2.1	13	11.6	30	27.3
Chemical	2,035	8.9	43	9.9	5	1.8	25	13.2	20	11.2	9	6.3	13	11.6	16	14.6
Inhalation	1,135	4.9	16	3.7	47	16.4	15	7.9	14	7.8	2	1.4	7	6.3	7	6.4
Fatality (%)	447	2.0	6	1.4	4	1.4	3	1.6	5	2.8	1	0.7	0		2	1.8
Median LOS‡	3	1,10	4	1,12	2	1,7	3	1,8	3	1,10	4	1,9	3	1.5,9.5	3	1,11
Mean ICU†	3.06	11.2	5.3	12.9	1.9	8.6	3.8	14.6	4.7	19.4	0.7	3.0	3.3	9.1	5.5	13.2
Severity																
NISS ≥16	3,318	14.5	98	22.6	56	19.6	28	14.7	30	16.8	32	22.2	15	14.4	21	19.1
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Mean TBSA†	8.1	12.5	10.6	13.9	5.2	10.9	8.3	13.1	9.6	14.5	3.7	8.3	7.2	7.7	10.4	13.0
Full thickness	6,659	29.0	147	34.0	109	38.1	58	30.5	65	36.3	65	45.1	39	34.8	38	34.6
Head burn	7,096	30.9	150	34.6	109	38.1	67	35.3	64	35.8	22	15.3	51	45.5	48	43.6

	Overall		Military Specific		Arts, Design, Entertainment, Sports/ Media		Life, Physical, and Social Science		Computer and Mathematical		Education, Training, and Library		Healthcare Practitioners and Technical		Healthcare Support	
Occupations*	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***	***N***	***%***
Total	22,969		96	0.4	78	0.3	51	0.2	47	0.2	47	0.2	35	0.2	34	0.2
Mean age†	37.9	12.3	30.0	9.9	38.8	13.6	39.5	10.9	41.7	11.0	40.0	13.1	39.0	11.7	39.4	11.7
Male	20,579	89.6	93	96.9	61	78.2	42	82.4	45	95.7	28	59.6	19	54.3	18	52.9

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TABLE 2. (*Continued*)

Occupations*	Overall		Military Specific		Arts, Design, Entertainment, Sports/ Media		Life, Physical, and Social Science		Computer and Mathematical		Education, Training, and Library		Healthcare Practitioners and Technical		Healthcare Support	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Race																
White	13,831	60.2	66	68.8	62	79.5	28	54.9	36	76.6	34	72.3	21	60.0	13	38.2
Black	2,245	9.8	14	14.6	5	6.4	4	7.8	2	4.3	4	8.5	8	22.9	14	41.2
Hispanic	4,609	20.1	8	8.3	5	6.4	8	15.7	4	8.5	2	4.3	1	2.9	4	11.8
Etiology																
Fire/flame	7,413	32.3	46	47.9	42	53.9	18	35.3	13	27.7	16	34.0	8	22.9	11	32.4
Scald	5,235	22.8	17	17.7	7	9.0	9	17.7	15	31.9	10	21.3	11	31.4	10	29.4
Hot object	916	4.0	2	2.1	7	9.0	2	3.9	1	2.1	3	6.4	0	0.0	2	5.9
Electrical	3,246	14.1	19	19.8	4	5.1	1	2.0	9	19.2	6	12.8	4	11.4	1	2.9
Chemical	2,035	8.9	5	5.2	7	9.0	15	29.4	6	12.8	8	17.0	11	31.4	9	26.5
Inhalation	1,135	4.9	3	3.1	5	6.4	3	5.9	3	6.4	2	4.3	2	5.7	3	8.8
Fatality (%)	447	2.0	1	1.0	3	3.9	1	2.0	1	2.1	0		0		1	2.9
Median LOS‡	3	1,10	2	1,8	4.5	1,9	2	1,7	4	1,13	2	1,11	2	1,8	3	1,7
Mean ICU†	3.06	11.2	1.2	3.3	3.9	11.3	1.5	4.8	2.1	5.0	1.9	7.5	3.3	15.7	11.2	44.7
Severity																
NISS ≥16	3,318	14.5	15	15.6	20	25.6	8	15.7	11	24.4	5	10.6	7	20.0	3	8.8
Elixhauser ≥1	2,610	11.4	10	10.4	12	15.4	6	11.8	7	14.9	6	12.8	4	11.4	8	23.5
Mean TBSA†	8.1	12.5	6.5	10.1	10.9	17.9	5.7	7.4	10.9	14.7	5.7	10.5	7.0	11.9	8.0	14.0
Full thickness	6,659	29.0	24	25.0	33	42.3	16	31.4	12	25.5	15	31.9	7	20.0	12	35.3
Head burn	7,096	30.9	27	28.1	26	33.3	15	29.4	19	40.4	12	25.5	9	25.7	11	32.4

TBSA, total body surface area burned.
*Occupations including students (173), retired (9), legal occupations (5) and office and administrative support occupations (22) were not included in the table.
†STD
‡IQR.

injuries in the NBR dataset. Utilizing the four variable fields, instead of relying solely on the ''work-related'' field, we identified four times the number of occupational burn injuries. The vast majority of work-related cases could be identified when combining the field ''work related'' and ''injury circumstances'' (94.6%). Our case ascertainment definition compared with the original work-related definition of the NBR identified a greater proportion of fire/flame and scalding burn injuries, a lower proportion of unknown etiology burns, more patients with a higher number of comorbidities and more burns with lower TBSA (Supplemental Material, Table B, http://links.lww.com/JOM/A324). Relying only on the ''work-related'' field would clearly have missed a large proportion of occupational injuries in this dataset.

Based on a Centers for Disease Control and Prevention (CDC) national survey,[1] there was an estimated 25,200 workers hospitalized for work related burn injuries between 2002 and 2011 among persons 15 to 65 years. If the national estimates are accurate, it appears that the vast majority (91.1%) of work related burn injuries that result in admission to a hospital are captured and treated by burn units, and consequently reported in the NBR. Unlike the CDC data system, the NBR provides narratives on the etiology of injury, complete details on the diagnoses, comorbidities, procedures during the course of treatment, and specific burn severity measures which inform researchers on the depth, extent, and types of burns suffered by the patients.

This analysis identified various high risk occupations based on different outcome measures. The greatest proportion of

TABLE 3. Multivariable Logistic Regression Models for In-hospital Fatality and TBSA

	In-Hospital Fatality*	TBSA >10*
	Adjusted Odds Ratio (95%CI)	Adjusted Odds Ratio (95%CI)
Food preparation and serving related	Ref	Ref
Building and grounds Cleaning and maintenance	2.5 (0.8,8)	1.3 (0.98,1.7)
Community and social service	0.9 (0.2,5.5)	0.6 (0.4,0.9)
Construction and extraction	1.7 (0.7,4.3)	1.3 (1.1,1.5)
Farming, fishing, and forestry	1.1 (0.3,4.2)	1.8 (1.4,2.5)
Installation, maintenance, and repair	1.6 (0.6,4.3)	1.3 (1.1,1.6)
Production	1.6 (0.6,4)	1.7 (1.4,2)
Protective service	0.8 (0.1,4.7)	0.6 (0.4,0.9)
Transportation and material Moving	2.91 (1.1,7.9)	1.8 (1.4,2.4)
Unknown/unspecified	2.93 (1.3,6.8)	1.4 (1.2,1.6)
Other Occupations with less than 200 cases†	1.9 (0.7,5.1)	1.2 (0.96,1.4)

CI, confidence interval; TBSA, total body surface area burned.
*Controlling for age (continuous), sex, race (white as reference), inhalation injury, length of hospitalization, TMPM, Elixhauser comorbidity score, and one of the two main variables (in-hospital fatality and TBSA over 10%).
†Occupations with less than 200 cases were collapsed into one category due to zero cell after adjusted for covariates.

burn-injured patients was employed in construction and extraction occupations, followed by food preparation and serving-related occupation. The most severe burn injuries in terms of higher TBSA percentage, in-hospital mortality, and length of hospitalization were observed among (1) transportation and material-moving occupations; (2) arts, design, entertainment, sports, and media occupations; and (3) management occupations.

Previous studies have shown that workers employed in food preparation and serving-related occupations had the highest claim rates for burn injuries.[10,11] One thing to point out is this study does not have denominator to calculate rates nor would the rates be comparable to most studies since all the patients were treated in burn units. As shown in Carter's study, specialized burn units disproportionately treat serious burn injuries as indicated by the ratio of cases captured in the NBR with national estimates by the CDC,[1] while many minor burns are treated as outpatients in local community hospitals without transferring to a burn unit.[20] Studies based on workers' compensation claims and employer 300-logs would capture a greater proportion of minor/moderate burn injuries and may lead to disparate conclusions. Furthermore, lower-severity burn injuries among food preparation and serving-related occupations was observed compared with other occupations, which is related to a large degree to the fact that approximately 80% of burns in this group were caused by scalding, which usually leads to less-severe burns relative to other mechanisms.[21] Therefore, it is not surprising that studies that use workers' compensation data or OSHA logs commonly find the highest rate of injury among food service workers.[10,11]

This study also identified interesting areas of concern within certain occupations. Among transportation and material-moving occupations, 16% of burn injuries were caused by chemicals. This proportion was higher than most other occupations, which may be the result of hazards in chemical transportation during loading, transit, and unloading. The majority of arts, design, entertainment, sports, and media workers got injured by fire/flame. In our review of the narrative fields describing the cause of injury for these workers, many of the burn injuries occurred during stunt performances (eg, "Patient was assisting in preparing a stunt on a movie set"); certainly, this finding needs further investigation. In addition, the higher proportion of chemical burns among healthcare-support occupations, and healthcare practitioners and technician occupations are likely caused by skin contact with chemicals commonly used in healthcare facilities, such as phenol (narrative review, eg, "Pharmacy technician spilled phenol onto face and hands/arms."), or trichloroacetic acid.[22] Finally, the high mortality in management occupations indicates a need for risk assessments and hazard mitigation, including regular training, for both supervisors/managers as well as the general workforce.

Limitations

The NBR database is not a random sample of cases hospitalized in burn centers, but constitutes a census of patients treated in 73% of the burn centers (91/125) in the United States who voluntarily report their data to the ABA. Additionally, those burn centers that contributed to the NBR are geographically representative of burn centers in US, according to NBR 2012 report.[15] Despite the potential problems with the NBR sample frame, the NBR appears to capture nearly all of the severe work related burns when compared with national estimates by the CDC,[1] which provides evidence of the comprehensiveness of the NBR. However, further studies are needed to evaluate the comprehensiveness of the NBR including an independent audit of the records, in particular which work related cases are not captured within this data system and the reliability of the coding of the four fields used to ascertain cases.

As for the work-related case definition we developed, both the sensitivity and specificity of the definition are unknown. It is possible that unidentified work-related patients have more severe outcomes, since patients that die shortly after arrival or who are nonverbal, cannot provide the medical staff with information regarding the cause of their injuries. Correspondingly, we did observe a slightly higher in-hospital mortality rate among the work-related cases missing data on occupation. Consequently, this study may underestimate the injury severity of work-related patients within specific occupations.

The case-ascertainment criteria we developed helped identify work-related cases using multiple fields in the NBR and it appears that we capture approximately 91% of the national estimated count published by the CDC during the same timeframe.[1] If we had restricted the analysis only those whose "work-related" field was marked positive, we would have only identified 4696 cases (20.5% of the total). The CDC data[1] identify work related cases through abstracted chart reviews rather than a work related variable in a dataset. In light of the robustness of the sample frame for CDC data and the method of case identification, it appears that our screening criteria outlined in the methods section has a high positive predictive value for identifying occupational burn injuries in the NBR.

Patients treated in burn centers tend to disproportionately suffer severe burn injuries and be admitted to the hospitals. In contrast, most burn injuries are minor in severity and do not require hospitalization.[20,23] Occupations that are associated with severe burns are likely to be overrepresented in our study. In addition, the burn-center patients are more likely to be younger, have fewer comorbidities, and suffer from inhalation injury.[24] While the NBR provides a great depth of information about serious burn injuries, it is not likely to be informative in describing the universe of occupational burn injuries or minor burns treated in an outpatient setting.[23]

Finally, we observed large proportion of missing data on occupation within some hospitals. For example, in our study, among the work-related burn-injury patients, some facilities had up to 50% of the "occupation" field missing, while other facilities captured occupation well enough to have less than 5% missing. It is possible that reporting bias occurs in occupation reporting and if it is related to occupation itself or severity of injury, our estimations regarding injury characteristics comparison among occupations may not be accurate. In addition, even though this did not impact our screening criteria for identifying work-related cases, it did potentially impact the descriptive analysis comparing different occupations. The poor reporting of occupation potentially contributed to the small group sizes for some occupations, which restricted the analysis and the conclusions that could be drawn for these occupations. In some occupational groups, like health-support occupations ($N = 34$), even though a higher proportion of chemical-burn injuries was observed, it is difficult to draw conclusions from such a small number of cases. Improved capture of occupations as well as communicating the importance of capturing this information to data system managers, coders, and medical staff at burn centers would be a good way to improve occupational-burn surveillance and thereby the usefulness of the NBR.

CONCLUSIONS

Our study demonstrates that it is possible to identify occupational burn injuries in the NBR, and defines a comprehensive method to guide researchers in ascertaining cases. In addition, the large number of occupational burns within the NBR allows for stratified analyses and identifying high risk occupations using various criteria. More studies are needed to investigate burn-injury patterns by occupation. NBR is a useful dataset for identifying new groups for interventions as well as new hazards in high risk occupations, but there is also a need for analyses validating the quality of the NBR data system. One avenue for further investigation is to conduct a text analysis of the narrative field regarding the injury event by occupation. This approach could

potentially identify processes and hazards associated within each occupational group with severe burn injuries. However, because NBR data predominately captures the most severe cases, alternative datasets are still needed to better characterize the true incidence of work-related burn injuries in the United States. As of January 1, 2015, OSHA's new record keeping rule took effect. Employers are now required by OSHA to electronically or telephonically report not only deaths, amputations, and losses of an eye, but all work-related in-patient hospitalizations. This new dataset to be maintained by OSHA could augment existing data systems such as the NBR and the work-related injury statistics query system, to improve current surveillance of occupational burn injuries in the United States.

REFERENCES

1. CDC. Work-Related Injury Statistics Query System (WISARDS); 2013. Available at: http://wwwn.cdc.gov/wisards/workrisqs/default.aspx. Accessed June 14, 2016.
2. Clouatre E, Gomez M, Banfield JM, Jeschke MG. Work-related burn injuries in ontario, canada: A follow-up 10-year retrospective study. *Burns*. 2013;39: 1091–1095.
3. Reichard AA, Konda S, Jackson LL. Occupational burns treated in emergency departments. *Am J Ind Med*. 2015;58:290–298.
4. Smith GS, Wellman HM, Sorock GS, et al. Injuries at work in the US adult population: Contributions to the total injury burden. *Am J Public Health*. 2005;95:1213–1219.
5. National Safety Council. *Injury Facts.* 2011 ed. Itasca, IL: National Safety Council; 2011.
6. Kica J, Rosenman KD. Multisource surveillance system for work-related burns. *J Occup Environ Med*. 2012;54:642–647.
7. Hop MJ, Polinder S, Vlies CH, Middelkoop E, Baar ME. Costs of burn care: A systematic review. *Wound Repair Regen*. 2014;22:436–450.
8. Islam SS, Nambiar AM, Doyle EJ, Velilla AM, Biswas RS, Ducatman AM. Epidemiology of work-related burn injuries: Experience of a state-managed workers' compensation system. *J Trauma Acute Care Surg*. 2000;49:1045–1051.
9. Hunt JP, Calvert CT, Peck MD, Meyer AA. Occupation-related burn injuries. *J Burn Care Res*. 2000;21:327-.
10. Walters JK. Characteristics of occupational burns in oregon, 2001–2006. *Am J Ind Med*. 2009;52:380–390.
11. McCullough JE, Henderson AK, Kaufman JD. Occupational burns in washington state, 1989–1993. *J Occup Environ Med*. 1998;40:1083–1089.
12. Munnoch D, Darcy C, Whallett E, Dickson W. Work-related burns in south wales 1995–96. *Burns*. 2000;26:565–570.
13. Mian MA, Mullins RF, Alam B, et al. Workplace-related burns. *Ann Burns Fire Disasters*. 2011;24:89–93.
14. Lombardi DA, Matz S, Brennan MJ, Smith GS, Courtney TK. Etiology of work-related electrical injuries: A narrative analysis of workers' compensation claims. *J Occup Environ Hyg*. 2009;6:612–623.
15. ABA. National Burn Repository: Report of Data from 2002–2011; 2012. Available at: http://www.ameriburn.org/2012NBRAnnualReport.pdf. Accessed June 14, 2016.
16. Taylor SL, Lee D, Nagler T, Lawless MB, Curri T, Palmieri TL. A validity review of the national burn repository. *J Burn Care Res*. 2013;34:274–280.
17. Emmel A, Cosca T. The 2010 standard occupational classification (SOC): A classification system gets an update. *Occup Outlook Quart*. 2010;54:13–19.
18. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36:8–27.
19. Osler T, Glance LG, Hosmer DW. Simplified estimates of the probability of death after burn injuries: Extending and updating the baux score. *J Trauma*. 2010;68:690–697.
20. Carter JE, Neff LP, Holmes 4th JH. Adherence to burn center referral criteria: Are patients appropriately being referred? *J Burn Care Res*. 2010;31:26–30.
21. Herndon DN. *Epidemiological, Demographic, and Outcome Characteristics of Burn Injury. Total Burn Care, Third Edition.* Philadelphia, PA: Elsevier Health Sciences; 2007, 9–33.
22. Sosin M, Sosin BL, Rodriguez ED. Accidental trichloroacetic acid burn in a gynecology office. *Obstet Gynecol*. 2015;126:1290–1293.
23. Kahn SA, Bell DE, Hutchins P, Lentz CW. Outpatient burn data: An untapped resource. *Burns*. 2013;39:1351–1354.
24. Sen S, Greenhalgh D, Palmieri T. Review of burn research for the year 2010. *J Burn Care Res*. 2012;33:577–586.