Hospitalized Work-Related Burns in Washington State

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REPORT SUMMARY

Hospitalized work-related burn injuries are a significant public health concern, with physical, psychological, social and economic consequences that are often severe. The purpose of this report is to provide information on these serious injuries in order to prompt interventions to reduce workplace hazards and prevent future burns.

From September 2000 through December 2005 there were 350 workers hospitalized as a result of work-related burns. About 90% were male and the average age was 37 years. Most of the workers sustained thermal burn injuries; however about 10% each received electrical or chemical burns. Those with electrical burns tended to have more severe injuries. A total of 22 workers received fatal injuries – either the worker died as a direct result of his/her burn injuries or a severe burn occurred in addition to another fatal injury.

The overall annual incidence rate was 24.5 hospitalized work-related burns per million workers. The rate was higher for male workers than for female workers. Workers between the ages of 22 and 24 years were at the highest risk for hospitalized work-related burn injuries.

Most workers filed state-fund workers' compensation claims. The average cost per claim exceeded $50,000 with an average of 135 lost workdays.

Industry rates were calculated in order to prioritize industries by the frequency and risk of hospitalized work-related burn injuries. These high-risk industries were then reviewed to identify common injury scenarios. Based on these results, future research and prevention activities should be aimed at the following:

- Hot tar burns among roofers, including, but not limited to, the filling and transferring of buckets.
- Thermal burns from arc flash explosions and electrical burns from direct contact with electrical current among electricians working on or near energized equipment.
- Scald burns among cooks, other kitchen workers, and servers, particularly during the handling and transfer of containers of hot water, oil, and other liquids and while working with and around deep fryers.
- Molten metal burns among foundry workers, particularly addressing burns to the lower extremity while filling and working with molds.
- Flame burns among scrap metal recycling workers, including those in which clothing ignites while welding or using cutting torches.

INTRODUCTION

Work-related burn injuries are an important public health concern. A recent study estimated that 183,000 work-related burn injuries occur each year in the US.[1] This study estimated that 42% of burn injuries were work-related. Regardless of whether the burn injury occurred at work, the physical, psychological, social and economic consequences are often severe. One study found that two years post-burn injury, only 37% of cases who had sustained hospitalized burn injuries were able to return to the same job with the same employer without workplace accommodations.[2]

In order to characterize work-related burn injuries in Washington State, an analysis of workers' compensation claims from 1994-1999 was conducted.[3] This study reported that almost 4,000 work-related burn injuries occurred each year in Washington, a small percentage of which (approximately 60 per year) required hospitalization. These hospitalized burn cases represented only 1.5% of all burns, yet they incurred 55% of the costs. Further, results showed that workers' compensation claims data underestimated the frequency of hospitalized work-related burn injuries by 26%, relative to hospital discharge data. This study concluded that a surveillance system for hospitalized burns would be best accomplished through the use of multiple data sources for case ascertainment.

In September 2000, the Safety & Health Assessment & Research for Prevention (SHARP) program at the Washington State Department of Labor and Industries (L&I) developed a surveillance system to identify cases of work-related burns resulting in inpatient hospitalization. Case ascertainment for this surveillance system comes from three data sources: (1) L&I's state-fund workers' compensation data, (2) voluntary reports from two burn centers, and (3) fatality surveillance data from the Fatality Assessment Control and Evaluation (FACE) program, also maintained by SHARP.

This report has two aims. First, we will provide the results from a descriptive analysis of the hospitalized work-related burn surveillance system. The main goal of this descriptive analysis is to identify high-risk industries for future research and prevention purposes. Second, we will report the findings of an evaluation of the relative contributions of hospital reporting and workers' compensation data to the overall surveillance system.

METHODS

Washington's Workers' Compensation System

In Washington State, non-federal employers are required to obtain workers' compensation insurance through L&I, unless they meet specific requirements to self-insure. There are approximately 400 self-insured entities (individual companies or groups of companies), which tend to be the largest employers in the state. L&I's state fund covers approximately two-thirds of the state's workers. The state fund generally does not cover self-employed workers, though optional coverage is available.

Case Ascertainment

Hospitalized work-related burn cases identified through the surveillance system from September 1, 2000 through December 31, 2005 were included in this analysis. On a monthly basis, the workers' compensation databases were queried for claims meeting the following criteria:

(1) The nature of injury was coded as a heat burn, chemical burn, non-ionizing radiation, or welders flash; AND
(2) The claimant was identified as an inpatient from a hospital bill

OR

(1) The nature of injury was coded as an electric shock, AND
(2) The claimant was identified as an inpatient from a hospital bill, AND
(3) At least one diagnosis code from the hospital bill was consistent with a burn injury.

Hospital billing information for self-insured claims is typically not entered into L&I's databases. Therefore, the workers' compensation data generally do not identify cases in which the injured worker is employed by a self-insured company. Similarly, workers not covered by state-fund workers' compensation insurance, such as federal workers or the self-employed, are not captured by the workers' compensation data. In an effort to fill these significant gaps in case ascertainment, voluntary reporting agreements were developed with two burn centers. Contacts at the burn centers agreed to report cases of workers sustaining burn injuries while working in Washington that resulted in inpatient hospitalization--either for the initial burn treatment or for any subsequent treatment of the injury. Finally, cases were also identified through the Fatality Assessment Control Evaluation (FACE) program, which tracks all work-related traumatic fatalities in Washington State. Fatal injuries in which a burn might have been involved are reviewed periodically. If the injury description or cause of death was suggestive of a severe burn, the fatal injury was considered to be a case.

Descriptive and Statistical Analyses

Frequency distributions of hospitalized work-related burn claims by age, sex, burn type, and source are provided, where sources were coded using the American National Standards Institute Z 16.2 coding manual.[4]

Analysis of costs and lost workdays was limited to cases in which a state fund workers' compensation claim was filed. This analysis included cases where claims were filed and not identified through the workers' compensation automated data queries, but identified later after receipt of a hospital report. In Washington State, medical billing information for self-insured claims is rarely provided in the workers' compensation claims database, limiting cost analyses to state-fund cases. Workers' compensation costs include costs for medical care, as well as reimbursements for lost work time and disability. Costs reflect those that have actually incurred plus the actuarially estimated future costs for open claims.

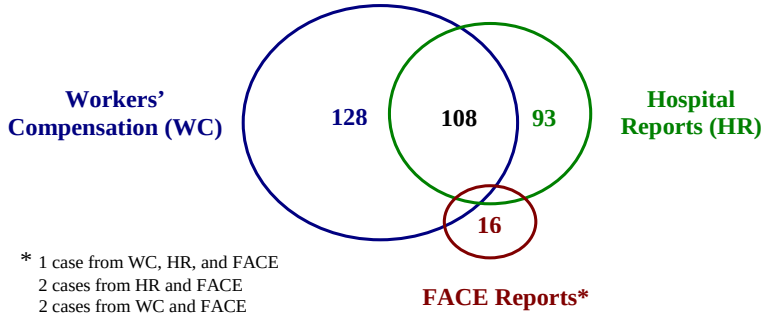
Rate analyses were conducted using quarterly employee counts obtained from the Washington State Employment Security Department (ESD) for the period January 1, 2001 through March 31, 2005. Average annual incidence rates were calculated by dividing the total number of cases by the average number of employees, and then dividing by 4.25 years (i.e., the time period of the analysis). Employment data for federal workers and the self-employed are not available through ESD; therefore, these cases were not included during the analyses of incidence rates. Incidence rates were calculated for two-digit industry sectors and four-digit industry groups using the North American Industrial Classification System (NAICS, 2002).[5] Analyses of incidence rates were limited to sectors and industry groups with a minimum of five claims during the 4.25-year time period. The Prevention Index (PI), which is the average of the frequency and incidence rate rankings, was calculated to prioritize industries for prevention (Silverstein, Viikari-Juntura, and Kalat, 2002).[6] Additionally, incidence rates were calculated for all industries combined by age group.

RESULTS

General Overview

From September 2000 through December 2005, a total of 464 reports were received for 350 individual cases (see Figure 1).

Figure 1: Hospitalized Work-Related Burn Cases by Data Source (n=350 cases)



Cases ranged in age from 16 to 74, with a median age of 36.0 years (mean of 36.7 years). Three of the injured workers were minors (<18 years), all of whom worked in food service. A large majority of the cases (90.3%) were male. A total of 267 cases (77%) received thermal burns, 39 workers had chemical burns, and 39 had electrical burns. The most common burn source was flame/fire. Table 1 lists the sources that were associated with at least five cases.

Table 1: Commonly Reported Sources of Hospitalized Work-Related Burn Injuries (n = 328)

Source	Frequency	Percent
Flame, Fire, and Smoke	75	22.9
Electrical Apparatus (not elsewhere classified or specified)	35	10.7
Hot Water	32	9.8
Cooking Oils	27	8.2
Asphalt and Road Oil	18	5.5
Chemicals (not elsewhere classified or specified)	16	4.9
Conductors	11	3.4
Steam	9	2.7
Molten Metal	7	2.1
Liquids (not elsewhere classified)	7	2.1
Gas Compounds	6	1.8
Hydrofluoric Acid	5	1.5
Sulfuric Acid	5	1.5

* Only sources associated with at least 5 cases are shown. Twenty-two cases did not have enough information to describe the source of injury.

Of the 350 cases, 22 (6%) received fatal injuries, in which the worker died either as a direct result of his/her burn injuries or a severe burn occurred in conjunction with other fatal injuries, Box 1. Larger proportions of workers with electrical burns had third degree burns (82%) and fatal burns (15%), relative to either workers with thermal burns (35% and 6%, respectively) or workers with chemical burns (48% and 3%, respectively).

Box 1: Work-Related Fatalities Resulting From or Associated with Severe Burn Injuries

Electrocutions (6 cases)

- Painter electrocuted when man lift contacted overhead power line.
- Worker electrocuted while working on energized electrical equipment.
- Maintenance worker electrocuted while changing a lightbulb.
- Mechanic electrocuted while repairing machinery.
- Logger electrocuted when tree struck an overhead power line.
- Farmworker electrocuted when working on machinery.

Motor Vehicle Incidents (5 cases)

- Driver received chemical burns and other injuries when truck overturned.
- Two truck drivers killed when their trucks collided and caught fire.
- Driver hauling gasoline killed when truck crashed and exploded.
- Truck driver killed after truck exploded into flames following collision.

Firefighter Fatalities (4 cases)

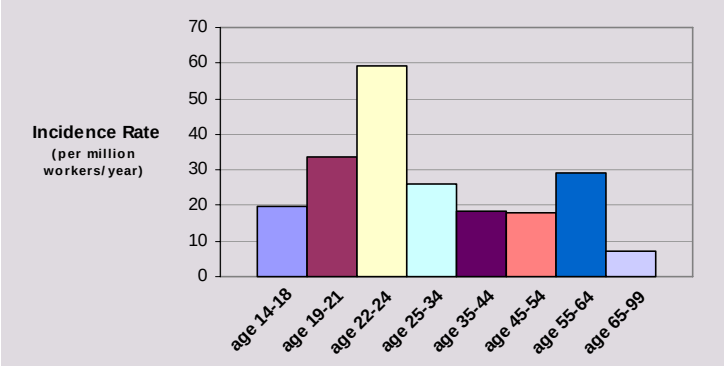
- Four firefighters received fatal burns while fighting a forest fire.

Other Severe Burns Resulting in Death (7 cases)

- Worker's clothing ignited by a spark while welding in an enclosed space.
- Worker died in house fire while remodeling.
- Worker received fatal burns from molten metal.
- Construction worker engulfed in flames when chemical vapors ignited.
- Worker seriously burned when clothing caught on fire.
- Food service worker involved in a kitchen fire.
- Worker scalded by radiator coolant when hose broke.

From January 1, 2001 through March 31, 2005, the time period in which rates can be calculated, there were 271 cases and an average of 2,606,698 workers. The overall annual incidence rate was 24.5 hospitalized work-related burns per million workers. The rate was higher for male workers than for female workers, 43.2 relative to 5.0 burns per million workers per year. Annual incidence rates for the different age groups are shown in Figure 2. Workers aged 22-24 years had the highest incidence rate at 59.3 burns per million workers per year, 2.4 times higher than the rate for all age groups combined.

Figure 2: Incidence Rates for Hospitalized Work-Related Burns by Age Group



Claim Costs and Lost Workdays

Of the 350 cases, 274 had associated state-fund workers' compensation claims with available data on costs and lost workdays. Overall costs incurred by these 274 claims exceeded $13.7 million, including over $2 million to reimburse workers for almost 29,000 lost workdays. The median cost per claim was $15,648, with a mean cost per claim of $50,194. One claim incurred costs exceeding $1 million; three additional claims exceeded a half million dollars each. The median number of lost workdays per claim was 38 days (mean was 135 days).

Industry Rates

Tables 2 and 3 provide frequencies and annual incidence rates for hospitalized work-related burns by two-digit NAICS industry sector and four-digit NAICS industry group, ranked by the Prevention Index. Construction, Accommodation and Food Service, and Manufacturing were the top three ranked industry sectors. Within the Construction sector, specific industry groups with relatively high frequencies and rates included: (1) Foundation, Structure & Building Exterior Contractors, (2) Building Equipment Contractors, (3) Utility System Construction, and (4) Other Specialty Trade Contractors. Within the Accommodation & Food Service industry sector, Full Service Restaurants ranked as a higher priority than Limited Service Eating Places. Foundries and Cement & Concrete Product Manufacturing were identified as priorities within the Manufacturing industry sector.

Industry Reviews

Industry sectors and groups identified as high priorities for prevention were reviewed in an attempt to better understand the specific industries, occupations, job tasks, and exposures associated with burn injuries.

Construction

The Construction industry sector has both the highest frequency (71 cases total) and the highest rate of hospitalized work-related burns.

Foundation, Structure, and Building Exterior Contractors had the third highest frequency and the third highest rate of all industry groups, ranking it as the number one priority industry group according to the Prevention Index. Of the 19 cases identified, the majority, 12 cases or 63%, were in the Roofing Contractors industry (see Box 2). Three cases each worked in the Poured Concrete Foundation and Structure industry and the Framing Contractors industry. One case was from the Glass and Glazing Contractors industry.

Building Equipment Contractors had the second highest frequency of all industry groups, a total of 27 cases. Of these, 18 cases (67%) were in the Electrical Contractors industry (see Box 3). Eight cases worked in the Plumbing, Heating, and Air Conditioning Contractors industry. These eight cases varied considerably with respect to the source of the burn and the work task being conducted. For example, one worker was burned when his propane torch broke while welding, another was scalded with hot water, and a third received chemical burns while snaking a drain.

Table 2: Counts and Average Annual Rates for Hospitalized Work-Related Burns by two-digit NAICS Industry Sector,
Ranked by the Prevention Index, Washington State, January 1, 2001 – March 31, 2005

Industry Sector		Workers	Count	Rate	Rate Ratio	Count Rank	Rate Rank	PI
23	Construction	141,025	71	118.5	4.8	1	1	1
72	Accommodation & Food Service	199,044	49	57.9	2.4	1.5	2	1.75
31-33	Manufacturing	292,540	49	39.4	1.6	1.5	4	2.75
11	Agriculture, Forestry, Fishing, & Hunting	74,275	14	44.4	1.8	6	3	4.5
42	Wholesale Trade	114,527	19	39.0	1.6	4	5	4.5
44-45	Retail Trade	298,315	15	11.8	0.5	5	7	6
81	Other Services (except Public Administration)	109,888	9	19.3	0.8	7	6	6.5
56	Admin & Support & Waste Mgmt & Remediation Svc	125,085	6	11.3	0.5	9	8	8.5
54	Professional, Scientific, & Technical Services	132,231	6	10.7	0.4	9	9	9
61	Educational Services	240,900	6	5.9	0.2	9	11	10
92	Public Administration	134,462	5	8.8	0.4	10.5	10	10.3
62	Health Care and Social Assistance	293,798	5	4.0	0.2	10.5	12	11.3

* 8 other industry sectors had < 5 cases, and were not included in this analysis.

Table 3: Counts and Average Annual Rates for Hospitalized Work-Related Burns by four-digit NAICS Industry Group,
Ranked by the Prevention Index, Washington State, January 1, 2001 – March 31, 2005

Industry Group		Workers	Count	Rate	Rate Ratio	Count Rank	Rate Rank	PI
2381	Foundation, Structure, & Bldg Exterior Contractors	16,610	19	269.2	10.9	3	3	3
3315	Foundries	1,909	8	986.0	40.0	6.5	1	3.75
2382	Building Equipment Contractors	34,852	27	182.3	7.4	2	6	4
2371	Utility System Construction	7,923	9	267.3	10.9	5	4	4.5
4239	Misc. Durable Goods Merchant Wholesalers	5,046	7	326.4	13.3	8	2	5
7221	Full Service Restaurants	83,531	31	87.3	3.5	1	9	5
7222	Limited Service Eating Places	72,795	15	48.5	2.0	4	10	7
8111	Automotive Repair and Maintenance	18,891	8	99.6	4.0	6.5	8	7.25
3273	Cement and Concrete Product Manufacturing	5,078	5	231.7	9.4	12	5	8.5
2389	Other Specialty Trade Contractors	10,370	6	136.1	5.5	10	7	8.5
5413	Architectural, Engineering, and Related Services	30,202	6	46.7	1.9	10	11	10.5
6111	Elementary and Secondary Schools	14,9521	6	9.4	0.4	10	12	11

* 75 other industry groups had < 5 cases, and were not included in this analysis.

Box 2: Work-Related Burn Injuries among Roofers

Nine roofers received burns from hot asphalt while tarring roofs. Here are three of these workers' stories:

- A roofing apprentice was filling buckets with hot tar and transferring to other roofers. Tar splashed in his face, causing him to knock over a second bucket of hot tar. He then slipped in the tar and fell hands down in it. He was wearing gloves. He sustained partial thickness burns to his wrists, face, and eyes.

- A roofer was bringing down, what he thought was an empty bucket. However the bucket was full of hot tar, which spilled down his arm. He received third degree burns to his left forearm, requiring skin graft surgery.

- A worker was carrying two buckets of hot tar when he tripped and fell, landing with his left hand in the tar. The tar splashed onto his wrist and left ear.

Three roofers received burns from electricity. One of these workers was struck by lightening, and the other two workers contacted overhead power lines. Here's one worker's story:

- A worker was installing gutters from a ladder when the steel gutter he was holding contacted a powerline. He sustained severe electrical burns to his head, neck, and upper extremities and fell about 20 feet off the ladder.

Box 3: Work-Related Burn Injuries among Electricians

Ten electricians received burns during arc flash explosions. The story of two of these workers is provided below:

- A journeyman electrician and an electrical apprentice were removing a circuit from an electrical panel when a ground wire contacted the energized terminals on the main circuit breaker. An arc flash occurred, causing the electrician's clothing to ignite. The apprentice patted out the flames and sustained second degree burns to his hands. The journeyman received second and third degree burns covering nearly 50% of his body.

Eight electricians received electrical burns resulting from direct contact with energized wires. Here's one worker's story:

- A journeyman electrician was attempting to strip a wire in an electrical panel that he thought was de-energized. Either the wrong circuit had been de-energized, or the circuit he was working on became re-energized, so that when he contacted the wire, he was shocked. He was in contact with the wire for nearly 20 seconds before he was able to push himself away. He received multiple third degree burns to his hand.

Nine cases worked in the Utility System Construction industry group, including five cases from the Water and Sewer Line Construction industry and four cases from the Power and Communication Line Construction industry. These workers were injured

from diverse sources while performing varied tasks. For example, one worker from the Water and Sewer Line Construction industry was burned with hot water when a water pump broke, while another was injured during a gas line explosion. In the Power and Communication Line Construction industry, a lineman using an aerial bucket truck received severe electrical burns when the bucket contacted an overhead powerline. Another worker's clothing ignited while welding.

The six workers from the Specialty Trade Contractors industry group also received their burn injuries while performing a variety of different work tasks. One worker was fatally injured in an apartment fire that likely started when chemical vapors ignited. Two workers were burned with hot tar when buckets they were using spilled or dropped. A laborer was burned when he contacted an underground powerline while using a jackhammer, a welder's shirt caught fire, and a final worker was burned in an explosion while using an electric drill to mix chemicals.

Accommodation and Food Service

The Accommodation and Food Service industry sector tied for the second highest frequency of hospitalized work-related burn cases and had the second highest rate. Of the 49 cases in this sector, about two-thirds worked in Full Service Restaurants and almost a third worked in Limited Service Eating Places (e.g., fast food restaurants). Exposures and work tasks were similar between these two industry groups. In about half of these cases, cooks and other kitchen workers were burned while moving pots or other containers of hot liquid (oil, water, soup) when the contents splashed or spilled on them. Sometimes these incidents were precipitated by the worker slipping on greasy or wet floors. In 12 cases, workers received grease burns from deep fryers, when their hands entered the fryer, a deep fryer fell, or objects fell into the fryer splashing the worker. See Box 4, for specific examples. Other burns among restaurant workers included two steam burns from pressure cookers, two burns from stove fires, and two workers burned while attempting to put out grease fires.

Manufacturing

The Manufacturing industry sector tied Accommodation and Food Service for the second highest frequency of hospitalized burns with 49 cases. Within this sector, only two industry groups had at least five cases – Foundries and Cement and Concrete Product Manufacturing. The Foundries industry group had the highest incidence rate – 986 cases per million workers each year, 40 times higher than the rate for all industries combined. Of the eight foundry workers who received hospitalized work-related burns, four worked in steel foundries, two worked in iron foundries, one in aluminum die-casting, and one in other nonferrous foundries. In four of these cases, workers were burned with molten metal, see Box 5. The other four injuries varied. For example, one worker was burned in an electric arc flash and another was grinding metal when his coveralls caught fire.

All five cases in the Cement and Concrete Product Manufacturing industry group worked in the Ready-Mix Concrete Manufacturing industry. One of these workers received third-degree chemical burns to his fingers when the hydrofluoric acid he was using to clean cement out of a truck penetrated through the holes in his gloves. Two workers

were scalded with hot water – one when a boiler pipe broke and the other when a hot water pipe burst. One worker was burned in an electric arc flash, and the final worker was electrocuted when he contacted a high voltage overhead powerline.

Box 4: Work-Related Burn Injuries among Restaurant Workers

Restaurant workers burned from containers of hot oil and water. Just a few of these examples are provided below:

- A cook was carrying hot oil in a bucket when it splashed on him, burning both of his hands.
- A waitress was carrying a teapot full of hot water on a tray, when she tripped on the pantry door that was slightly ajar. The tray fell, spilling hot water down the inside of her leg. She received second and third degree burns to her leg and foot, requiring skin graft surgery.
- A cook was moving a vat of boiling oil when he slipped and spilled the oil on himself. He received second degree burns to nearly 20% of his body.
- A cook was attempting to carry a pot of cooking oil outside after it caught on fire. He tripped with the pot, burning his arms, face, neck and hands with the hot oil and flame.
- A food prep worker dropped a bucket of boiling water on his feet. The water went down his leg and pooled in his shoe, causing severe third degree burns that required skin graft surgery to repair.

Cooks and other kitchen workers burned from deep fryers. Here are two workers' stories:

- A cook received second degree burns to his legs and ankle after a deep fryer tipped over, splashing him with hot grease.
- A cook slipped on a greasy floor and plunged his hand and arm into a deep fat fryer.

Box 5: Work-Related Burn Injuries among Foundry Workers

Four of the eight hospitalized work-related burns among foundry workers involved molten metal. Their stories were all very similar:

- Worker received third-degree burns to his ankle and toes when a mold broke causing molten steel to fall on his foot.
- Worker was pouring molten bronze into a cast and a co-worker was transferring some of the bronze when it spilled onto his foot and became trapped in his shoe.
- Foundry worker was burned when a cast broke spilling molten steel on his leg and into his boot.
- Worker was filling a mold with molten metal when the metal broke through the mold and poured on his foot. It seeped through his boot and caused second and third degree burns to his foot, which required skin graft surgery.

Agriculture, Forestry, Fishing, and Hunting

The 14 cases identified in the Agriculture, Forestry, Fishing and Hunting industry sector worked in 11 different specific industries – two each in Wheat Farming, Beef Cattle Ranching and Farming, and Postharvest Crop Activities, and one each in Potato Farming; Other Vegetable and Melon Farming; Other Noncitrus Fruit Farming; Nursery and Tree Production; Other Miscellaneous Crop Farming; Finfish Farming and Fish Hatcheries; Logging; and Soil Preparation, Planting and Cultivating. The job tasks and burn sources also varied considerably for these 14 cases, such that common injury causes could not be identified.

Wholesale Trade

Within the Wholesale Trade sector, Miscellaneous Durable Goods Merchant Wholesalers had the second highest rate of all other industry groups. Of the seven cases in this industry group, six worked in the Recyclable Material Merchant Wholesalers industry. All six of these workers were burned while welding or using a cutting torch (see Box 6).

Box 6: Work-Related Burn Injuries among Scrap Metal Recycling Workers

Six scrap metal recycling workers were burned while welding or using cutting torches. Here are their stories:

- Worker was welding a radiator when he was burned by steam.
- Worker was using a cutting torch when his pants caught on fire. He received third-degree burns to his legs, which required skin graft surgery.
- Worker was welding when the welding torch hose broke and ignited. His clothes caught on fire and he received second and third degree burns to his legs and groin.
- Worker at a scrap metal plant was welding when the flames traveled up his pant leg.
- Recycling center worker caught his glove on fire with a cutting torch. He received third degree burns to his hand.
- Laborer at a recycling center was preparing scrap metal for recycling. He severely burned his arm while using a cutting torch.

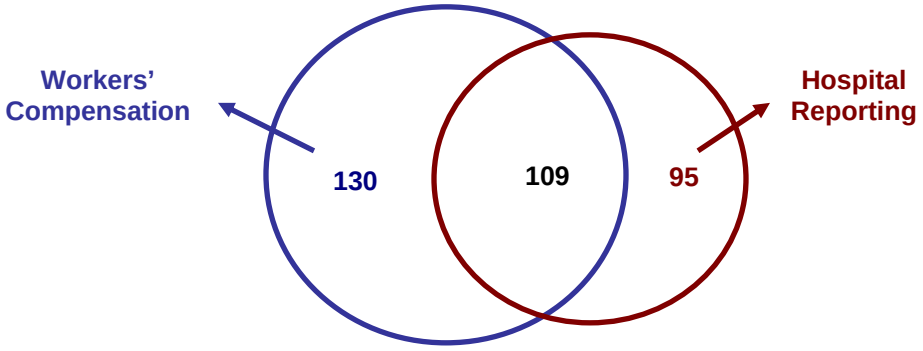
Evaluation of Data Sources: Workers' Compensation vs. Hospital Reporting

The purpose of this analysis was to evaluate the relative contributions of hospital reporting and workers' compensation data to the overall hospitalized work-related burn surveillance system.

Case Ascertainment

From September 2000 through December 2005, SHARP received 443 reports from either workers' compensation data or hospital reports (or both) for 334 individual cases of hospitalized work-related burn injuries. In addition, the FACE Project reported 16 additional cases that were not captured by these data sources for a total of 350 unique cases; however, these 16 cases will not be included in this analysis. Figure 3 illustrates the distribution of cases by workers' compensation data and hospital reports.

Figure 3: Distribution of Hospitalized Work-Related Burn Cases by Reporting Source



There was considerable overlap among the two reporting sources; 72% (239 cases) could have been identified solely with the workers' compensation data. Nonetheless, 95 cases (28%) would have been missed, because either a claim was not filed or was not identified through the current workers' compensation case extraction process.

A review of the 95 hospital-reported cases in which workers' compensation claims were originally not identified revealed that claims were actually filed for an additional 80 cases, leaving 15 cases without associated workers' compensation claims. The reasons why claims were not filed for three of the 15 cases are unknown. In six of the cases, the workers were federal employees, and therefore, not covered by the state's workers' compensation system. The remaining six workers appeared to be self-employed, and therefore would generally not be covered by the state-fund workers' compensation system.

A second review was undertaken to determine why we failed to identify the 80 cases using the automated queries of the workers' compensation databases. In 27 cases, the injured worker's employer was self-insured. In general, self-insured claims can not be identified through the current case extraction method because hospital billing information for self-insured claims is not entered into the system. In 38 cases, the claims were not identified due to coding issues (e.g., miscoded nature of injury or absence of inpatient codes). The reasons why claims were not identified for the remaining 15 cases are unknown.

Therefore, the addition of hospital reporting to current workers' compensation-based surveillance for hospitalized work-related burn injuries increased case ascertainment by 28%. Further, the hospital-reported cases included federal workers, self-employed workers, and workers employed by self-insured employers – three categories of workers that are generally not captured in the workers' compensation system.

In addition, the 130 cases received solely through workers' compensation data were reviewed to determine the hospital of admission. Sixty-five of these workers were treated at either of the two burn centers in which voluntary reporting agreements have been established. The reasons why these cases were not also reported by the two hospitals is unknown. The remaining workers were treated at 35 other hospitals. Only three of these

hospitals treated at least five workers over the study period, with the majority of these facilities (24 hospitals) treating only one worker.

Demographics

The average age of hospitalized work-related burn cases (37 years) was the same for those obtained through hospital reports and those obtained through workers' compensation data. Similarly, the proportion of cases that were male did not differ significantly between hospital-reported cases and workers' compensation cases, 91.6% relative to 90.0%.

Industry and Occupational Distributions

Hospital reporting identified 15 cases of work-related burn injuries that were not reported or identified through the workers' compensation system and 80 cases where workers' compensation claims were missed by the case extraction process (i.e., a total of 95 cases that would not have been obtained through current workers' compensation surveillance alone). The industry distributions for hospital-reported cases and those identified through workers' compensation data were compared. Data on industry were available for 81 of the 95 hospital-reported cases and for all 239 cases identified through workers' compensation data. The industry distributions, as shown in Table 4, were significantly correlated (Spearman's Correlation Coefficient was 0.582, $p \leq 0.05$). Data on occupation were available for 83 of the 95 hospital-reported cases and 193 of the 239 workers' compensation cases. Occupational distributions were also significantly correlated (Spearman's Correlation Coefficient was 0.703, $p \leq 0.01$), Table 5.

Table 4: Proportion of Hospitalized Work-Related Burn Injury Cases by Industry Sector* Obtained Through Hospital Reports (n = 81) vs. Cases Identified Through Workers' Compensation Data (n = 239)

Two-Digit NAICS & Description		Proportion (HR Data)	Proportion (WC Data)
31-33	Manufacturing	24.7	15.9
72	Accommodation and Food Services	21.0	16.3
23	Construction	18.5	28.5
11	Agriculture, Forestry, Fishing and Hunting	4.9	5.4
22	Utilities	4.9	1.3
61	Educational Services	4.9	0.8
92	Public Administration	3.7	2.1
44-45	Retail Trade	2.5	8.0
81	Other Services (except Public Administration)	2.5	4.6
56	Admin, Support, Waste Mgmt & Remediation Services	2.5	2.9
54	Professional, Scientific, & Technical Services	2.5	2.1
48-49	Transportation & Warehousing	2.5	1.7
62	Health Care and Social Assistance	2.5	1.3
42	Wholesale Trade	1.2	8.0
52	Finance and Insurance	1.2	0.0
53	Real Estate, Rental & Leasing	0.0	0.8
21	Mining	0.0	0.4

* Industries are categorized by two-digit North American Industrial Classification System (NAICS) Sectors

Table 5: Proportion of Hospitalized Work-Related Burn Injury Cases by Occupation Obtained Through Hospital Reports (n = 83) vs. Cases Identified Through Workers' Compensation Data (n = 193)

Two-Digit SOC Major Group & Description	Proportion (HR Data)	Proportion (WC Data)
47 – Construction and Extraction Occupations	25.3	28.0
35 – Food Preparation and Serving Related Occupations	20.5	17.6
49 – Installation, Maintenance, and Repair Occupations	13.3	12.4
53 – Transportation and Material Moving Occupations	10.8	14.0
51 – Production Occupations	10.8	11.9
37 – Building and Grounds Cleaning and Maintenance Occupations	4.8	2.1
17 – Architecture and Engineering Occupations	3.6	2.6
11 – Management Occupations	3.6	1.0
33 – Protective Service Occupations	2.4	0.0
45 – Farming, Fishing, and Forestry Occupations	1.2	4.7
25 – Education, Training, and Library Occupations	1.2	0.5
29 – Healthcare Practitioners and Technical Occupations	1.2	0.5
19 – Life, Physical, and Social Science Occupations	1.2	0.0
41 – Sales and Related Occupations	0.0	2.1
31 – Healthcare Support Occupations	0.0	1.0
39 – Personal Care and Service Occupations	0.0	1.0
43 – Office and Administrative Support Occupations	0.0	0.5

* Occupations are categorized by two-digit Standard Occupational Classification (SOC) Major Groups

In summary, hospital reporting identified subpopulations of workers that would otherwise not be captured through a surveillance system relying solely on workers' compensation data (e.g., federal workers, self-insured, self employed). Nevertheless, workers identified by the two sources did not differ significantly by age, sex, industry or occupation.

DISCUSSION

We used workers' compensation data, hospital reports, and reports from an existing fatality surveillance system to provide a descriptive analysis of hospitalized work-related burns in Washington State. The overall annual incidence rate was 24.5 hospitalized work-related burns per million workers. Incidence rates differed by sex, age, and industry. The average cost of a hospitalized work-related burn claim exceeded $50,000, which is much more expensive than the average cost per claim for all state fund workers' compensation claims ($5,970).[7] The average number of lost workdays for hospitalized burn claims was 135 days.

One of the primary goals of this report was to identify high-risk industries for future research and prevention purposes. Priority industries were identified through the use of the Prevention Index, which considers both the frequency and the rate of hospitalized work-related burn injuries. Using the Prevention Index, opportunities for prevention were identified in several industries: (1) tar burns among roofers, (2) thermal and electrical burns from electric arc flash explosions and direct contact with current among electricians, (3) burns from hot oil and water and from deep fryers among restaurant workers, (4) molten metal burns among foundry workers, and (5) burn injuries associated with welding and the use of cutting torches among scrap metal recycling workers.

While this study identified several potential opportunities for prevention, the most appropriate types of interventions will vary. The matrix presented in Table 6, based on the work of Silverstein, Viikari-Juntura, and Kalat (2002),[6] provides a framework for selecting an intervention strategy depending on the frequency and rate of injury in a given industry.

Table 6: Prevention Strategy Framework for Selecting Industry-Based Interventions Using the Prevention Index.

	High Count	**Low Count**
High Rate	Industries with large numbers of worksites and many workers at a high-risk of injury. ***Prevention Strategy:*** Choose an industry-wide approach with enforcement, consultation, education, and outreach.	Likely small industries with fewer worksites and few workers at a high-risk of injury. ***Prevention Strategy:*** Choose a focused approach based on enforcement and consultation.
Low Rate	Likely large industries with many worksites and workers at a lower risk of injury. ***Prevention Strategy:*** Choose an industry-wide educational campaign.	Less hazardous industries. ***Prevention Strategy:*** Minimal prevention resources are needed, unless complaints or emerging hazards arise.

Based on the framework presented above, multi-faceted prevention approaches using industry-wide educational interventions, enforcement, and consultation activities would be recommended for the Roofing and Electrical Contractors industries. Both Full-Service and Limited-Service Restaurants could benefit from educational activities; while more focused approaches using consultations and inspections would be more appropriate for Foundries and the Scrap Metal Recycling industry.

Another goal of this study was to evaluate the relative contributions of hospital reporting and workers' compensation data to the overall hospitalized work-related burn surveillance system. This analysis found that while a surveillance system based solely on workers' compensation data would likely identify the same industry priorities, it would significantly underestimate the overall burden of work-related burn injuries in Washington State.

Comparison with Other Studies

This study of hospitalized work-related burns found the overall annual incidence rate from January 1, 2001 through March 31, 2005 to be 24.5 per million workers. This incidence rate is slightly lower than those reported in previous studies of hospitalized work-related burns in Washington State. A study of workers' compensation claims data from 1994-1998, reported an annual incidence rate of 44 per million;[3] while an analysis of hospital discharge data found the incidence rate in 2000 to be 33 per million.[8] In the latter study, the Washington State rate could be compared to the U.S. rate of 40 per million and also to the rates in 11 other states with ranged from 18 to 39 per million. This apparent decline in rates over time may be a continuation of the declining rate reported in the previous study from 1994-1998.[3] However, due to differences in data sources, the rates reported in the current and the previous two studies are not directly comparable.

The current study reports rates of hospitalized work-related burn injuries to be higher among men than women. This finding is consistent with other studies of all work-related burns, not just hospitalized cases.[9-11] Similarly, we found rates varied by age group with younger workers at higher risk. Again, this finding is consistent with previous reports.[9,11]

Industrial groups previously identified as high priorities for addressing hospitalized work-related thermal burns included foundries, roofing, aluminum smelting, and electrical wiring;[3] industries similar to those identified in the current study. An analysis of workers' compensation claims data in Rhode Island estimated claims incidence rates by industry for all work-related burns (not just hospitalized cases). This study found elevated rates for Utilities and Sanitary Services, Retail Trade, Manufacturing, Personal Services, and Hospitals.[11] It is not surprising that the priority industries identified in the Rhode Island study differed from those identified in the current research, because priorities for all work-related burns and those requiring inpatient hospitalization have been shown to vary considerably.[3] Moreover, the Rhode Island study assessed industry rates, while the current study prioritized industries based on equal contributions of rate and frequency rankings.

Strengths and Limitations

A strength of this study was the use of multiple data sources for case ascertainment. While workers' compensation data identified the majority of cases; there are subsets of workers who will generally be missed, including the self-employed, federal workers, and employees of self-insured companies. The addition of reporting from the two burn centers that serve Washington State helps to fill these gaps. Moreover, workers who receive fatal burn injuries may be missed by these two data sources as they may never be admitted to a hospital if they die at the scene of the injury. Thus, reports from Washington State's fatality surveillance system (FACE) also help to supplement the overall surveillance system.

A limitation of this study is that many of the analyses rely on only subsets of the surveillance data. Specifically, analysis of costs and lost workdays was limited to only those cases with a state-fund workers' compensation claim, excluding 22% of the cases. Therefore, total costs and lost workdays reported in this study only reflect direct workers' compensation costs. Medical and wage replacement costs paid through other insurance systems or out of pocket are not reflected. Also excluded are indirect costs borne by employers (e.g., lost productivity, recruitment, retraining) or by the injured workers and their family members. Likewise, due to inherent limitations of the denominator data, the calculation of rates excluded certain cases (e.g., self-employed workers and those employed by the federal government). This may have impacted the prioritization of industries, by underestimating the burden in certain industries dominated by or with larger percentages of self-employed or federal workers.

Conclusions

Hospitalized work-related burns are tragic and devastating injuries that are also preventable. This study identified a number of industries that are at elevated risk. Moreover, through the review of injury narratives, we have identified common injury scenarios within these high-risk industries. Therefore, in an effort to reduce the magnitude and burden of these serious injuries, we recommend that future research and prevention resources be targeted to address the following:

- Hot tar burns among roofers, including, but not limited to the filling and transferring of buckets.
- Thermal burns from arc flash explosions and electrical burns from direct contact with electrical current among electricians working on or near energized equipment.
- Scald burns among cooks, other kitchen workers, and servers, particularly during the handling and transfer of containers of hot water, oil, and other liquids and while working with and around deep fryers.
- Molten metal burns among foundry workers, particularly addressing burns to the lower extremity while filling and working with molds.
- Flame burns among scrap metal recycling workers, including those in which clothing ignites while welding or using cutting torches.

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