

Multisource Surveillance System for Work-Related Burns

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Objectives: The purpose of this study was to develop a multisource surveillance system for work-related burns. **Methods:** For 2009, records about work-related burns were obtained from Michigan's 134 hospitals, the Workers' Compensation Agency, the state's sole Poison Control Center, and death certificates. Companies where the most severe burns occurred were referred to the Occupational Safety and Health Administration. **Results:** There were 1461 work-related burns in 2009. Sixty-six percent of the burns were reported in male workers and 85.3% in whites. One third of the individuals sustained burns to the wrist(s) and hand(s). Second-degree and thermal burns were the most common. Accommodation and food services and health care and social assistance industries accounted for 50% of all burns. **Conclusions:** The Michigan multisource surveillance system identified three times more burns than the Bureau of Labor Statistics' employer-based system, which reported 450 burns in 2009.

Surveillance is a basic premise of public health. Accurate counting of the magnitude of a condition and the circumstances under which it occurs is essential to determining the amount of resources to devote to the problem, to planning interventions, and to evaluating the effectiveness of these interventions. Occupational injury and illness surveillance is somewhat unique in that the national reporting system in the United States is based on the submission of reports from entities (employers) that are involved in the causation of the condition under surveillance. The Bureau of Labor Statistics (BLS) in the Department of Labor administers a survey to a sample of employers to generate both state and national data.¹ It is generally accepted that the surveillance system is inadequate for providing an accurate estimate of chronic diseases.² There is less recognition that the system also markedly undercounts the burden of occupational injuries.^{3,4} In response to an Institute of Medicine review in 1987 that the employer-based system missed 50% of acute traumatic fatal occupational injuries,² the BLS instituted a multisource surveillance system for acute traumatic fatal occupational injuries. As a consequence of this new multisource surveillance system, the count of workplace deaths in the national system doubled. No such change was implemented for work-related illnesses or non-fatal injuries. The BLS reported 24,730 work-related burns in 2009. Work-related burns are preventable injuries that, in addition to causing pain and suffering, are costly, averaging more than \$20,000 per worker compensation claim.⁵ This article describes a multisource surveillance system for work-related burns and compares the results with the BLS employer-based survey.

METHODS

Surveillance Population

The burn surveillance population consists of individuals working in the state of Michigan at the time of the injury, includ-

ing out-of-state and out-of-country workers, who received medical treatment in one of Michigan's 134 hospitals, who had a burn for which the Michigan's Poison Control Center (PCC) was contacted, who were 7 or more days away from work and were in the Michigan Workers' Compensation Agency (WCA) computerized database, or who were identified as dying by the Michigan surveillance system for acute traumatic fatalities (Michigan Fatality Assessment Control and Evaluation [MIFACE]).⁶

Data Collection Time Period

The time period for data collection covers those individuals injured while "working for pay" in the state of Michigan from January 1, 2009, to December 31, 2009.

Data Sources

Hospital/Emergency Department

All 134 Michigan's acute care hospitals including Veterans' Administration hospitals are required by state regulations to identify and report work-related burns.⁷ Hospitals submitted discharge summaries and emergency department (ED) evaluations of individuals 16 years or older for whom a burn-related diagnosis code was assigned (the *International Classification of Diseases, 9th Revision* [ICD-9]⁸ codes for burns):

- 940.0-.9 (burn confined to eye)
- 941.0-.5 (burn of head, face, neck),
- 942.0-.5 (burn of trunk),
- 943.0-.5 (burn of upper limb),
- 944.0-.5 (burn of wrist[s] and hand[s]),
- 945.0-.5 (burn of lower limb),
- 946.0-.5 (burns of multiple, specified sites),
- 947.0-.9 (burns of internal organs),
- 948.0-.9 (burns classified according to extent), and
- 949.0-.5 (burn, unspecified)

and/or ICD-9 codes for accidents caused by fire:

- E890.0-.9 (fire in private dwelling),
- E891.0-.9 (fire in other building or structure),
- E892 (fire not in a building or structure),
- E893.0-.9 (accident caused by ignition of clothing),
- E894 (ignition of highly flammable material),
- E895 (controlled fire in private dwelling),
- E896 (controlled fire in other building or structure),
- E897 (controlled fire not in a building or structure),
- E898.0-.1 (other specified fire and flames), and
- E899 (accident caused by unspecified fire).

These records were reviewed by a single staff person to differentiate work- and non-work-related burns.

Workers' Compensation Agency

The Michigan Department of Licensing and Regulatory Affairs WCA provided access to a database of all claims for wage replacement due to lost work time that occurred in 2009. Individuals are eligible for wage replacement when they have had at least 7 consecutive days away from work.

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Poison Control Center

Michigan has a single PCC that covers the whole state. The PCC provided Toxicall^{reg} reports about individuals for whom a call was made regarding a consultation for a work-related burn in 2009. Toxicall^{reg} is the computerized data collection system used by 70% of PCCs in the United States to compile and analyze data collected from calls to the PCCs.

Michigan Fatality Assessment Control and Evaluation Program

The MIFACE program, which is a surveillance system for acute traumatic fatalities, provided records of individuals who died from a work-related burn in 2009.

Analysis

Information about the hospital/ED medical records, PCC reports, and MIFACE reports was abstracted onto a burn injury analysis form. Information abstracted from the records included reporting source(s), type of medical care (hospital, ED, outpatient), hospital name, type of visit, date of admission and discharge, patient demographics, city and county of residence, employer information (name, address, North American Industry Classification System code⁹), injury date, mechanism of the injury (type of burn), part(s) of body burned, severity of burn, and percentage of burn (percent of total body surface area [TBSA]). The four major burn types identified were thermal, chemical, electrical, and radiation. Burn severity was described as first, second, third, or fourth degree, or as, according to their thickness superficial, partial, or full.

Data were entered into a Microsoft Access database (Redmond, WA), and records were manually linked to reports in the workers' compensation database. Matches were identified using individual's first and last names, date of birth, and date of injury. Duplicates identified by more than one reporting source were eliminated.

Work-related burn rates by age, gender, and industry were calculated as the total number of burns divided by the estimated number of workers during the year 2009 and expressed as the number of burns per 100,000 workers per year. The US Census/Department of Labor's Current Population Survey was used to calculate denominators.¹⁰ The Current Population Survey is a monthly survey of the population representing the civilian noninstitutionalized population of the United States. It provides information about workers' demographics, employment, occupation, industry, and other labor force characteristics. Data analysis was conducted using queries in Microsoft Access.

During the data collection process, names of employers from selected industry sectors of interest to the Michigan Occupational and Safety Health Administration (MIOSHA) were referred to MIOSHA for a possible enforcement inspection. Referral criteria of the MIOSHA for a work-related burn that occurred in 2009 were that employees had to be either hospitalized for a work-related burn or had at least second-degree burn if treated as an outpatient within 6 months of receipt of the report.

RESULTS

There were 1461 work-related burns in Michigan in 2009, including 2 fatalities, in 1453 individuals. Eight individuals had two separate burn incidents. A total of 1248 cases were identified by hospital/ED reports, 306 cases by WCA, 106 cases by PCC, and 2 fatalities by the MIFACE program. Figure 1 shows the overlap between reporting systems. The BLS reported 450 burns for Michigan in 2009.¹¹ Because of confidentiality restrictions, no attempt was made to match our data set with the BLS data set.

Demographics

Information about age was available for 1451 workers (99.3%). The age of workers with burn injury varied from 16 to

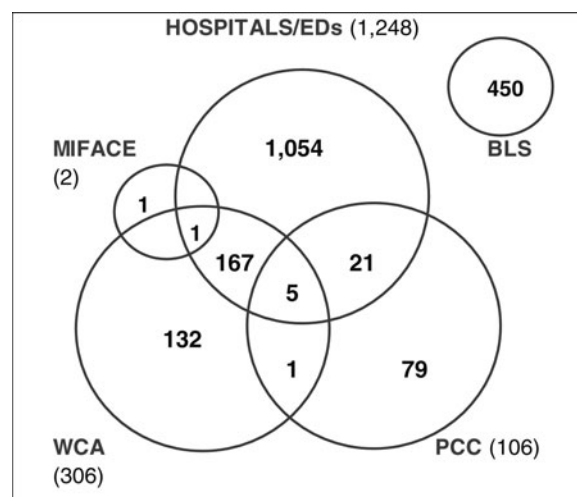


FIGURE 1. Reporting sources of 1461 work-related burn incidents, Michigan, 2009.

72 years, and the average age was 35 years. Male workers were more likely to sustain a work-related burn (60.6%) (Table 1). Rates for burn decreased with age (Fig. 2). The highest burn rate for male workers (74.8 per 100,000) was for the 20 to 24 years age group, whereas for female workers (61.3 per 100,000), it was in the 16 to 19 years age group (Table 1).

Data on race/ethnicity were available for 744 workers (50.9%). Whites comprised 85.3%, African Americans 8.7%, and Hispanics 4.4% (Table 1).

Type of Medical Encounter

Sixty-four (4.4%) individuals were hospitalized overnight, 1104 (75.6%) individuals were seen in the ED only, 80 (5.5%) individuals were seen in a hospital outpatient clinic, and for 213 (14.5%) individuals, the type of hospital medical encounter could not be determined (these included 132 WCA records, 79 PCC records, 1 both for WCA and PCC records, and 1 fatality record) (Table 1). For all burns that required hospitalization, male workers (87.5%) were more likely than female workers (12.5%) to be hospitalized. Among those hospitalized because of burns, thermal exposure comprised 43.8%, electrical 26.6%, and chemical 21.9%. An electrical burn (34%) was more likely than a chemical (3.5%) or thermal burn to require hospitalization (3.0%).

Part of Body Injured

Part of body injured was specified for 1445 individuals (98.9%). In 34.2% of cases, the most often burned body part were the wrist(s) and hand(s) (Table 2), 73% of which were thermal burns. The eye was most often affected by a chemical burn (74.9%).

Severity

Degree of burn was specified for 818 individuals (56.0%). Second-degree burns were the most common (65.4%), followed by first-degree burns (28.7%), third-degree burns (5.8%), and finally fourth-degree burns (0.1%) (Table 1).

TBSA was specified for only 145 of individuals. Thirty-two (22.1%) of these individuals had 5% or more of their body burnt.

Causes of Burns

When the burn type was specified (96%), thermal burn in 921 individuals (65.7%) was the predominant burn type, followed by chemical in 396 individuals (28.2%) and electrical in 50 individuals (3.6%) (Table 1). When the industry was specified, the

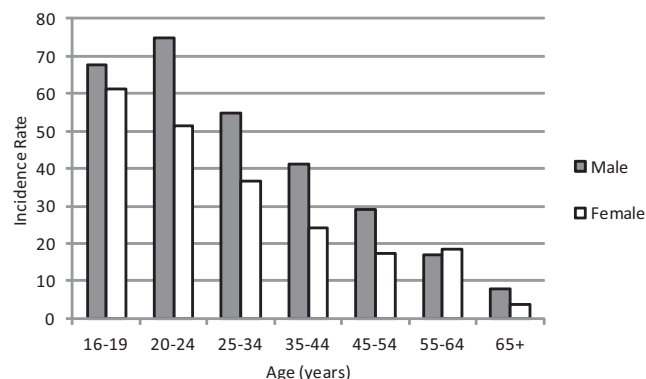
TABLE 1. Summary Characteristics of Work-Related Burns, Michigan, 2009

	n (%)
Gender	
Male	886 (60.6)
Female	575 (39.4)
Total	1,461 (100.0)
Age group, yr	
16–19	120 (8.3)
20–24	263 (18.1)
25–34	370 (25.5)
35–44	317 (21.8)
45–54	259 (17.8)
55–64	112 (7.7)
65+	10 (0.7)
Total	1,451 (99.9)
Medical encounter	
Emergency only	1,104 (75.6)
Overnight	64 (4.4)
Outpatient	80 (5.5)
Total	1,248 (85.5)
Race/ethnicity	
White	635 (85.3)
African American	65 (8.7)
Asian	2 (0.3)
Hispanic	33 (4.4)
Other	9 (1.3)
Total	744 (100.0)
Severity	
First degree	235 (28.7)
Second degree	535 (65.4)
Third degree	47 (5.8)
Fourth degree	1 (0.1)
Total	818 (100.0)
Burn type	
Thermal	921 (65.7)
Chemical	396 (28.2)
Electrical	50 (3.6)
Radiation	22 (1.6)
Other	13 (0.9)
Total	1,402 (100.0)
Seasonality	
Spring	361 (25.0)
Summer	431 (29.8)
Fall	354 (24.5)
Winter	299 (20.7)
Total	1,445 (100.0)

accommodation and food services industry had the highest percentage of thermal burns (43.5%). Thirteen percent of chemical burns occurred in the health care and social assistance industry, followed by 11.2% burns in both accommodation and food services and primary metal manufacturing industries.

Seasonality

Burns occurred slightly more in the summer (29.8%) and less in the winter (20.7%) (Table 1).

**FIGURE 2.** Work-related burn rates per 100,000 workers by age group and gender, Michigan, 2009.**TABLE 2.** Work-Related Burns by Part of Body Injured, Michigan, 2009*

Part of Body Burned (ICD-9 Code)	n (%)
Wrist(s) and hand(s) (944.0-.5)	494 (34.2)
Upper limb (943.0-.5)	298 (20.6)
Head, face, neck (941.0-.5)	194 (13.4)
Lower limb (945.0-.5)	168 (11.6)
Eye (940.0-.9)	155 (10.7)
Trunk (942.0-.5)	55 (3.8)
Multiple, specified sites (946.0-.5)	32 (2.2)
Unspecified (949.0-.5)	21 (1.5)
Classified according to the extent of body surface (948.0-.9)	21 (1.5)
Internal organs (947.0-.9)	7 (0.5)
Total	1,445 (100.0)

*Numbers and percentages are based on a burn-related primary diagnosis of 1445 individuals.

Industry

For 1016 individuals (69.5%), there was sufficient information for industry classification (Table 3). Eleven workers were self-employed. There were 13 out-of-state workers and 1 out-of-country worker. One third of the burns (34%) occurred in the accommodation and food services industry. Eighty-seven percent of those burns were of thermal nature. The predominant degree of burn across all industries was second-degree burn.

WCA Burn Type

Of the 306 WCA cases identified as a work-related burn, 280 had an injury description in the WCA database as a burn, thermal (262), or chemical (18). There were also 26 records that had an injury description as something other than "burn," which were identified after being matched to a burn record from hospital/ED or PCC records. The descriptions in WCA for these 26 were as follows: 6 "unclassified," 5 "electric shock," 5 "multiple injuries," 2 "fracture," 2 "inflammation-joints," 1 "crush/contusion," 1 "cut/laceration," 1 "strain/sprain," 1 "abrasion/scratch," 1 "toxic material," and 1 "skin infection."

Referrals to MIOSHA

MIOSHA performed 6 inspections of workplaces where a nonfatal burn occurred and 1 where a fatality occurred. Two brief case histories of the cases referred to MIOSHA are discussed.

TABLE 3. Work-Related Burns by Industry, Michigan, 2009*

Industry Classification (NAICS)	n (%)	Rate
Accommodation and food services (72)	345 (34.0)	115.8
Health care and social assistance (62)	168 (16.5)	25.5
Primary metal manufacturing (33)	72 (7.1)	15.5†
Public administration (92)	65 (6.4)	42.8
Retail trade (44)	55 (5.4)	17.7‡
Construction (23)	40 (3.9)	17.4
Educational services (61)	40 (3.9)	9.6
Wholesale trade (42)	39 (3.8)	38.1
Wood products/paper/petroleum and coal products manufacturing (32)	37 (3.6)	35.2
Food, beverage, textile manufacturing (31)	35 (3.4)	79.8†
Other services (except public administration) (81)	24 (2.4)	9.3
Arts, entertainment, and recreation (71)	23 (2.3)	30.5
Administrative and support and waste management and remediation services (56)	21 (2.1)	13.0
Sporting goods, hobby, book, and music stores (45)	15 (1.5)	9.7‡
Professional, scientific, and technical services (54)	11 (1.1)	4.5
Real estate and rental and leasing (53)	7 (0.7)	10.4
Transportation and warehousing (48)	6 (0.6)	5.9
Agriculture, forestry, fishing, and hunting (11)	5 (0.5)	9.1
Utilities (22)	5 (0.5)	11.2
Information (51)	2 (0.2)	2.8
Mining, quarrying, and oil and gas extraction (21)	1 (0.1)	10.8
Total	1,016* (100.0)	25.2

*Sufficient information for industry classification: 1016 individuals. Rates are the number of workers sustaining a burn per 100,000 workers (number of workers by industry used to calculate rates: Bureau of Labor Statistics' Current Population Survey).

†Rates do not include "Not specified manufacturing industries (part of 31, 32, and 33)".

‡Rates do not include "Not specified retail trade (part of 44, 45)".

Case Study 1

A 29-year-old woman was injured when an iron press came down on her left hand and upper limb in a dry cleaning establishment. At the time of the injury, the buttons protruded from the surface and were not protected from accidental activation. The dry cleaning machine could be activated if one button was depressed and the other accidentally leaned upon. The employee sustained 4% TBSA second- and third-degree burns to the left hand and the forearm. The employee was hospitalized for 4 days. MIOSHA's enforcement inspection found that the two hand controls of the shirt steam press were not guarded against accidental activation.

Case Study 2

A 38-year-old man was operating a 60-ton hot-chambered die-cast machine on which the interlock for the safety door was bypassed using a wooden wedge. The temperature of the machine was 400°F and maximum pressure was 2000 lb. The machine was running in the automatic mode when the employee reached into the die cast to remove the finished piece, using channel locks as a hand tool. The machine cycled when the employee had his hand and hand tool between the dies. The employee's right hand was trapped in the press, and he sustained a severe crush injury and burn. The employee was hospitalized for 4 days. MIOSHA's enforcement inspection found 15 violations, including an inadequate guard for point of operation and no guard on an interlocked sliding door on the die-cast machine.

DISCUSSION

We identified 1461 occupational burns in Michigan in 2009. This contrasts with the number reported by the BLS (n = 450).¹¹

Michigan's multisource occupational injury surveillance system provides a more accurate count of the number of work-related burns than that by the current system, which is based on extrapolation from a statistical sample of employers. Barriers to obtaining accurate counts of work-related injuries and illnesses occur at many levels and speak to the importance of not relying on a single source.¹² Some of those barriers to obtaining accurate counts include reporting the injury to the supervisor, whether or not there is lost work time or medical care is sought, recognizing a work-related injury by the health care provider, charging medical care to workers' compensation, recording incidents on the Occupational Safety and Health Administration log, and filing first reports of injury to state workers' compensation agencies.

Michigan's comprehensive surveillance system of work-related burns identified approximately three times more burns than the official employer-based estimate (n = 450)¹¹ and five times more burns than in the Michigan WCA database, which included only wage replacement injuries (n = 306). The magnitude of the difference with BLS would be even greater if the Michigan WCA database of wage replacement injuries also included the additional medical-only cases (cases that have <7 consecutive days away from work).

Hospital discharge data reported in Michigan provided information about all occupational burns irrespective of the type of hospital visit or the percentage of body sustaining burn injury compared with data available from other selected states. The Massachusetts Burn Injury Reporting System requires hospitals to report burns covering 5% or more of the body,¹³ and in Washington State, only those burns that require hospitalization are reportable.¹⁴ In Michigan, only 4.4% of the work-related burns required hospitalization. Body surface was specified only in 10% of the work-related burns

in Michigan, but where it was specified, only 32 of burns (22.1%) involved 5% or more of the body.

The most common type of burn injury identified by the Michigan surveillance system was thermal ($n = 921$, or 65.7%), similar to results from Oregon¹⁵ and Washington state.¹⁶ The largest number of burns ($n = 345$) occurred in the accommodation and food services industry, with a rate of 115.8 per 100,000, which again is consistent with older data from Oregon¹⁵ and Washington state.¹⁶ Twenty-six percent of all burns were in workers younger than 25 years. Similarly, in Oregon, workers younger than 25 years accounted for 26.0% of burn claims in the Oregon workers' compensation database.¹⁵ More training, education about hazards at a workplace, and more safety interventions are needed to reduce the burn injuries among younger, less experienced workers.

BLS data are collected by an annual survey of a sample of employers, who are required by law to complete the survey when requested to report information about work-related illnesses and injuries among their employees. These data have many limitations, which partially explain the larger number of burns identified in our multisource system.^{3,4,12} First, the BLS includes in its statistics only those cases with 1 or more days away from work or with altered work duties. Michigan's surveillance system counted all work-related burn injuries. Second, the BLS excludes self-employed, independent contractors and farm workers who work on farms with fewer than 11 employees. These last exclusions do not explain the BLS's undercount in comparison with the Michigan data because Michigan's burn surveillance identified only 11 self-employed and 5 farmers with burns. Other possible reasons for the BLS's undercount may be that employers are not providing complete reporting, the statistical sampling procedure of the BLS for employer selection is not adequate, or employers are not properly identifying employees' injuries as burns.

The BLS estimated that there were 450 burns in Michigan in 2009 involving days away from work.¹¹ Age group 25 to 34 years had the highest number of burns both in the BLS data set ($n = 160$, or 35.6%) and in the Michigan multisource surveillance system ($n = 370$, or 25.3%). According to the BLS, 17.8% ($n = 80$) of burn injury occurred in workers younger than 25 years, whereas in the Michigan's surveillance system, 26.2% ($n = 383$) occurred in workers younger than 25 years. BLS data lacked information about the state-level industry classification for work-related burns, but it provided information about occupations, with service being the top occupation for work-related burns ($n = 210$, or 46.7%). According to the BLS, upper extremities suffered burn injury the most often ($n = 110$, or 24.4%), followed by hands ($n = 100$, or 22.2%). Our system identified 494 burns (34.2%) to wrists and hands, followed by 294 burns (20.6%) to upper extremities.

Similar to the BLS statistics, Michigan's workers' compensation data do not show the true count of work-related burns. This discrepancy is likely explained by the fact that the only data on workers' compensation in Michigan that are computerized and therefore available for analysis are for wage replacement, which therefore require at least 7 consecutive days away from work. Workers' compensation also excludes the self-employed, but again there were only 11 self-employed workers in our reporting system. Another possible explanation may be a more widespread miscoding issue than among the 26 miscoded entries we were able to identify in the workers' compensation database. Finally, companies may be handling burn injuries unofficially and not reporting them to workers' compensation insurance companies or the WCA. All these factors likely contribute to the undercount.

The Michigan surveillance system for burns does have some limitations. One such limitation is a lack of data on the costs of burns. The data available on the costs of burns in other states have been limited only to costs associated with workers' compensation claims.^{17,18} In the state of Oregon between 1990 and 1997, the total

costs of workers' compensation burn claims averaged more than \$1.6 million annually,¹⁷ whereas in the state of Rhode Island between 1998 and 2002, they averaged more than \$1 million annually.¹⁸ However, any cost data would be an undercount because they do not include indirect costs associated with the injury.¹⁹ In addition, the amount of information available from the hospital/ED, PCC, and WCA reports varied. Therefore, important information such as severity of injury, percentage of body burned, and name of employer was limited. Finally, this study is the first compilation of data on work-related burns in Michigan, and the number and distribution of work-related burns may differ in subsequent years.

There have been some changes that are expected to improve the surveillance system in Michigan. Starting January 1, 2011, hospitals are now required to report data every 3 months instead of once a year. This modification will increase the timeliness of reports and the efficacy of follow-up investigations by MIOSHA program. In addition, the reporting requirement was lowered from 16 to 14 years of age. This change should help capture burn injuries among working teens, a group frequently employed in the food services industry—the industry with the highest burn rate in Michigan. Finally, the Michigan burn surveillance program plans to collect data on the source of payment listed in the medical records to assess how many burns had medical costs covered by workers' compensation, even though they were not eligible for wage replacement.

In conclusion, the Michigan surveillance system demonstrated a more accurate burden of work-related burns than existing data available from the BLS employer survey or the workers' compensation computerized database. The system also identified particular companies to target for inspections and industry sectors (eg, accommodation and food services) to target for more widespread outreach involving work practices and engineering. There are a number of implications that the official US statistics for occupational injuries and illnesses are based solely on employer reporting. On the basis of the Institute of Medicine study of the late 1980s,² which found that the then-current BLS system missed half of work-related deaths, it is not surprising to find that the now-current BLS system misses two thirds of nonfatal injuries such as work-related burns. Previous research in Michigan demonstrated that BLS data accounted for only 31% of injuries and illnesses in that state.³ Boden and Ozonoff²⁰ found that BLS data captures at most 76% (range, 51% to 76%) of injuries and illnesses in six states (Washington, West Virginia, Oregon, Wisconsin, New Mexico, and Minnesota). We have demonstrated similar results for work-related amputations.²¹ Given the limited number of acute traumatic fatalities that occur yearly, the BLS had the resources to switch to a national multi-data source system to provide a more accurate count. It is not feasible to contemplate such resources being available for the adoption of a national system for all occupational illnesses or injuries, which number from 4 to 9 million per year.¹⁹ The current BLS system is based on a statistical sampling and weighting of employer responses. What is missing from the current BLS statistical extrapolation is any attempt to include statistical procedures to estimate the number of events not reported for many different reasons.¹² The current national system to enumerate occupational illnesses and nontraumatic injuries is not a census and is totally dependent on statistical procedures. There is no reason not to develop more comprehensive statistical procedures that address the system's inherent undercount. Further statistical extrapolation from a limited number of comprehensive state-based systems such as has been developed in Michigan would be a feasible approach to address the undercount in the current national system and provide more accurate estimates of work-related injuries and illnesses.

We plan to continue to collect and monitor data on occupational burns because the surveillance of work-related burns is crucial to the recognition and prevention of these conditions.

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