# Occupational Injury Surveillance Using the Washington State Trauma Registry

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**Objective:** Traumatic injuries are a leading cause of death and disability among US workers, yet state trauma registries are rarely used for occupational research. Many, including the Washington State Trauma Registry, include information about work-relatedness. The objective is to explore and document the Washington State Trauma Registry as a resource for occupational injury surveillance and research. **Methods:** State-designated trauma facilities report traumatic injuries meeting specific inclusion criteria to the Washington State Trauma Registry. This study included 16+ year-olds injured in Washington during 1998 to 2008. **Results:** Of 125,625 injuries, 7.3% were work related. We found no evidence of downward trends in traumatic occupational injuries (2003 to 2008). **Conclusions:** Capturing industry and occupation would enhance utility for occupational injury surveillance and research. Trauma registry data could contribute to prevention planning/evaluation, improve case ascertainment for severe occupational injuries, and aid identification of high-risk populations and emerging trends.

Acute work-related trauma is a leading cause of death and disability among US workers. 9000 workers are treated daily in emergency departments (EDs), and approximately 200 of those are hospitalized.[1] Severe traumatic injury can lead to long-term pain and disability and is very costly for workers' compensation (WC) systems and society as a whole.[2,3] Although there are many constraints on comprehensive measurement of work-related injury costs, a 1995 study estimated annual costs in the neighborhood of $140 billion,[3] and an unrelated 1997 study estimated $145 billion using different methods.[2]

Most states have an active state trauma registry, but these registries often remain an untapped resource for occupational injury surveillance and research. At least 21 state trauma registries, including the Washington State Trauma Registry (WTR), include an indicator of work relatedness[4] making it theoretically feasible to identify work-related trauma. In addition, trauma registries contain very detailed information about the injury and initial treatment that is not commonly available in other databases. Trauma registries also frequently include information about protective devices used, such as helmets and safety restraints.[4] Trauma registry data have been used in Alaska and Illinois for occupational injury surveillance,[5–9] but WTR data have not previously been used for such purposes.

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Occupational injury surveillance involves efforts to accurately characterize trends in the extent and burden of work-related injuries, and is necessary for the effective planning and evaluation of prevention and mitigation efforts. Numerous local, state, national, and private databases have been used for this purpose, but all have significant limitations and gaps.[4,5,10–13] Researchers have a high degree of interest in exploring new data sources for occupational injury surveillance, because of filters and barriers to full and complete work injury reporting by employers, workers, and/or health care providers that differentially affect various databases. For example, workers, employers and/or health care providers may be reluctant to file a WC claim, workers may not report a work injury to their employers or health care providers to avoid retaliation or stigma, work may not be identified as the cause of an injury, Occupational Safety and Health Administration 300 logs are incomplete, and there have been changes in WC coverage and in various record-keeping and reporting requirements over time.[10–20]

The use of hospital-based surveillance systems, including trauma registries, may avoid some recognized reporting filters,[16] specifically whether a WC claim is filed or accepted for a particular injury or whether an employer recognizes and reports a particular injury as work related. Several studies based on data from the National Electronic Injury Surveillance System (NEISS-Work), a hospital ED-based surveillance survey, have not found evidence of downward trends in injury rates, in contrast to reports based on WC claims and national employer-reported surveillance data.[21,22] Furthermore, researchers working with the Illinois Trauma Registry found no significant decline in occupational traumatic injuries between 1995 and 2003.[6]

The aims of this project were (1) to explore and document the WTR as a resource for occupational injury surveillance and research, (2) to describe work-related traumatic injuries captured by the WTR, and (3) to evaluate trends in severe work-related traumatic injuries reported to the WTR.

## METHODS

### Study Population and Data Sources

We conducted a retrospective analysis of existing WTR data to describe work-related traumatic injuries captured by the WTR for the span of 11 years from 1998 through 2008. All traumatic injuries recorded in the WTR from 1998 through 2008 for individuals aged 16 years or more at the time of injury were requested, excluding injuries occurring outside Washington State. This study was approved by the Washington State institutional review board.

The WTR, maintained by the Washington State Department of Health (DOH), contains reporting data for traumatic injuries meeting specific inclusion criteria from all state-designated acute trauma facilities (Levels I through V). The DOH designates trauma services as part of the comprehensive statewide emergency medical services and trauma care system. Mandatory reporting began in 1995, and trauma coverage gradually increased as the trauma system added new hospitals. The purposes of the registry as defined in the Washington Administrative Code are "to: (a) provide data for injury surveillance, analysis, and prevention programs; (b) monitor and evaluate the outcome of care of major trauma patients, in support of statewide and

regional quality assurance and system evaluation activities; (c) assess compliance with state standards for trauma care; (d) provide information for resource planning, system design and management; and (e) provide a resource for research and education."[23] The WTR has not been utilized for injury surveillance because the state's Comprehensive Hospital Abstract Reporting System is more comprehensive for most surveillance purposes. The Comprehensive Hospital Abstract Reporting System hospital discharge records do not contain specific information about whether the hospitalization was work related (other than payer), limiting its utility for occupational injury research. The WTR also has limitations for surveillance of severe occupational injuries due to narrowly defined inclusion criteria and incomplete trauma coverage, as well as changes over time in both. However, unlike Comprehensive Hospital Abstract Reporting System, the WTR does contain specific information about whether an injury was work related.

The specific WTR inclusion criteria have undergone some refinements over time. For most of the years of this study, reports were mandatory for adult patients who were discharged with *International Classification of Diseases* (ICD-9-CM) diagnosis codes of 800 to 904 or 910 to 959 (injuries), 994.1 (drowning), 994.7 (asphyxiation), or 994.8 (electrocution) and met at least one of the following criteria: trauma resuscitation team activation, dead on arrival or death during hospital stay, interfacility transfer by Emergency Medical Services (EMS) or ambulance, or inpatient admission of at least 48 hours. (The criteria for patients under 15 years old are somewhat different but are not relevant to this study.)

During the timeframe of this study, there were two changes to the WTR inclusion criteria that may have affected the number and severity of traumatic injury reports. In brief, as of May 6, 2000, drowning, asphyxiation, and electrocution were added as qualifying diagnoses and the criteria related to inpatient death and trauma team activation were added. As of January 31, 2002, qualifying facility transfers were limited to those involving EMS or ambulance. Therefore, years prior to 2003 were excluded from trend assessments.

In a nationwide survey conducted in 2004 by Mann et al, the WTR trauma manager estimated that the WTR captured about 85% of trauma victims with injuries satisfying registry inclusion criteria.[24] However, the WTR does not capture data for the many occupational injuries that do not meet inclusion criteria.[25] In addition, occupational fatalities can occur in any setting and only those occurring within the EMS and trauma system may be reported to the WTR.[5]

Data from the American Community Survey (ACS) were used for Washington State employed population denominators and employed subpopulations broken out by sex, age, race, and ethnicity. The ACS is a national annual representative survey administered by the US Census Bureau. Survey responses (mail, phone, and/or in-person) are required by law. Coverage rates were at least 95% and response rates ranged from 93.0% to 97.6% for the years pertinent to this study.[26]

## Data Quality and Consolidation of Injury Reports

The WTR has conducted periodic validity studies assessing factors such as coding accuracy. The software used by the hospitals to collect and submit data to the registry contains logic checks and error checks that facilitate data quality and completeness.

We conducted an assessment of the amount of missing data in key data fields for each year from 1998 through 2008. The WTR has made adjustments to mandatory reporting fields over time and worked to improve reporting, which is reflected in the amounts of and trends in missing data. First and last name, date of birth, sex, injury date, and ED arrival date were each missing in less than 1% of records. Social security number was missing in 8% of records. Zip code of injury was present in only 20% of records, and county of injury was not required and almost always missing prior to 2002, but missing only for 3% of records from 2006 through 2008. The work-related field, of key importance to this project, was missing for 2.5% of records overall, decreasing over time from 5% to 1% or less. Payer was missing for 4%, decreasing over time from 8% to 1% or less. Race (19%) and ethnicity (35%) were more frequently missing, with little decrease over time. Injury Severity Score (ISS), injury mechanism, and primary ICD-9-CM diagnosis and E-code were missing for less than 1% of records. Injury place was missing for only 3%, however another 8% had an "unspecified" place of injury. Hospital charges were missing for 25% of records and information on pre-existing conditions for 17% (the latter decreased markedly over time, from 56% to 5%).

Records were consolidated at the injury event level in 2 steps. First, The Link King was used to identify unique individuals based on name, sex, date of birth and Social Security number (last 4 digits). The Link King is a public domain software program for deterministic and probabilistic linkage of administrative records.[27] Next, within each unique individual, WTR injury reports were grouped together using "fuzzy" injury dates and ED arrival and discharge dates. 16% of injury events had multiple records (up to 4), most commonly because several hospitals reported the same injury due to transfers of care.

## Measures

For detailed information about each WTR field, the reader is referred to the WTR data dictionary.[28] In general, where data varied by report within an injury event, we assumed that the most comprehensive trauma care hospital (ie, highest trauma designation level) provided the most reliable report, per the advice of WTR staff. Missing data were filled in using other reports when feasible. However, for some variables, data from all reports for an injury event were consolidated. For example, an injury was considered work related if any of the related reports were indicated as being work related. Payer, race/ethnicity, pre-existing conditions, amputation, traumatic brain injury (TBI) and fatalities (either dead on arrival or in-hospital) were handled in a similar fashion. Conflicting information about race was resolved using this default order: Native American, Asian/Pacific Islander, Black, other, white, and missing. Hospital charges were summed across hospitals for each injury event. Total length of stay for the injury event was calculated from the arrival date for the first report to the discharge date of the last report in a series. We categorized ISS using the standard scheme of minor (1 to 8), moderate (9 to 15), and major (16 to 75). We classified amputations as the presence of any ICD-9-CM code of 885 to 887 or 895 to 897. For TBI, we followed the CDC case definition: the presence of any ICD-9-CM code of 801, 803 –to 804, 850 to 854, 950.1, 950.2, 950.3, or 959.01.[29] We defined external cause of injury based on ICD-9-CM E-codes rather than relying on the WTR mechanism of injury field, to facilitate comparison with previous related work in Illinois (refer to citation for categorization scheme).[6] To assign calendar years, we used the ED arrival year of the first report for each distinct injury event (for the fewer than 1% of cases where injury year and ED arrival year did not match exactly, injury dates were either missing, were within a few days of the ED arrival date, or appeared to be data entry errors).

## Data Analysis

We report descriptive summaries for all work-related injury reports from 1998 through 2008. We report trends in reported traumatic injuries for the years 2003 through 2008, overall and by sex, age, ethnicity, and injury type. The reader will note numerous similarities to previous work by Friedman and Forst in Illinois; we have intentionally facilitated comparison with their study of Illinois Trauma Registry data that indicated no significant declines in severe occupational injuries between 1995 and 2003 (in contrast with reports

 

**TABLE 1.** Number and Severity of Traumatic Injuries* Reported to the WTR by Year, 1998–2008

| | Reporting Hospitals | Work-Related Injuries | | Other Injuries | | All Injuries | |
|---|---|---|---|---|---|---|---|
| Year | *N* | *N* (%) | Mean ISS† | *N* (%) | Mean ISS | *N* | Mean ISS |
| 1998 | 75 | 698 (8.8) | 8.9 | 7,202 (91.2) | 10.7 | 7,900 | 10.5 |
| 1999 | 75 | 770 (9.6) | 8.8 | 7,270 (90.4) | 10.6 | 8,040 | 10.4 |
| 2000 | 79 | 823 (8.3) | 8.9 | 9,044 (91.7) | 10.1 | 9,867 | 10.0 |
| 2001 | 78 | 813 (7.3) | 9.3 | 10,310 (92.7) | 9.9 | 11,123 | 9.8 |
| 2002 | 79 | 838 (7.6) | 9.2 | 10,161 (92.4) | 9.9 | 10,999 | 9.9 |
| 2003 | 80 | 819 (7.2) | 9.1 | 10,631 (92.9) | 10.0 | 11,450 | 10.0 |
| 2004 | 81 | 815 (6.7) | 9.2 | 11,427 (93.3) | 10.2 | 12,242 | 10.1 |
| 2005 | 81 | 818 (6.5) | 11.4 | 11,865 (93.6) | 11.7 | 12,683 | 11.6 |
| 2006 | 81 | 932 (6.8) | 12.5 | 12,797 (93.2) | 12.0 | 13,729 | 12.1 |
| 2007 | 81 | 995 (7.3) | 11.8 | 12,719 (92.7) | 11.8 | 13,714 | 11.8 |
| 2008 | 80 | 864 (6.2) | 11.4 | 13,014 (93.8) | 11.7 | 13,878 | 11.7 |
| All years | 82 | 9,185 (7.3) | 10.2 | 116,440 (92.7) | 10.9 | 125,625 | 10.8 |

*Unduplicated injury events.
†Injury Severity Score scoring range: 1 to 75.
Note: There were changes to the inclusion criteria effective May 6, 2000, and January 31, 2002 that may have affected the number and severity of traumatic injury reports.
WTR indicates Washington State Trauma Registry; ISS, Injury Severity Score.

based on national surveillance data).[6] Analyses were performed using Stata/SE 11.2 for Windows (StataCorp LP, College Station, TX).

Years prior to 2003 were excluded from trend assessments due to changes in WTR inclusion criteria. We also excluded minor injuries from trend assessments (those with an ISS under 9) to focus on the more severe injuries that the WTR was designed to capture and limit various sources of inter- and intrafacility variation in reporting practices that we expected would be exaggerated for more minor injuries (described further in the Discussion section). Because there had been some changes in coding practices and the reporting software in use, we ran sensitivity analyses using an alternative ISS as the basis for the inclusion cutpoint, to provide more consistency across hospitals and over time. We generated the alternative ISS for all records using the ICDMAP-90 software program (developed by the Center for Injury Research and Policy of the Johns Hopkins Bloomberg School of Public Health and Tri-Analytics, Inc.). This approach had little impact on our findings and we defaulted to the more accurate ISS reported by the trauma registrars. Reporting hospitals both entered and left the system during 2003 to 2008, potentially affecting total reported trauma volume, so we developed adjustment weights; however, these weights made negligible difference to either the magnitude or significance of our findings and they were not included in the analyses presented here.

Trends in reported moderate and major traumatic injuries are presented as rates based on annual ACS employed population denominators. We present rates because, in so doing, we can adjust for age and for changes in the employed population over time, and to allow for comparison with related work in other states. These rates should not be interpreted as absolute, because not all work-related moderate and major trauma is treated at designated trauma facilities, some injuries occurring in Washington may be treated in other states, and many severe work-related injuries will not meet the WTR inclusion criteria. In addition, capture of severe injuries may exhibit regional variation related to whether the transporting EMS is permitted to diagnose a death or is required to route to a hospital for that purpose.

Age adjustment was conducted using the Stata user-written program -distrate- to implement direct standardization with gamma confidence intervals (CI)[30] based on year 2000 US standard working population weights.[31] Incidence rate ratios (IRR) and annual trends in injury rates were estimated using Poisson regression models.[32]

## RESULTS

### Work-Related Traumatic Injury Reports, 1998 to 2008

For the 11 years studied, the WTR contained a total of 145,891 reports for 125,625 unduplicated injury events. There were 82 distinct reporting hospitals during that time, though not all were reporting for the entire time period. Table 1 presents the number and average severity of traumatic injuries reported to the WTR for each year from 1998 through 2008, broken out by work-related versus other injuries. In 2000, and again in 2002, there were changes to the WTR inclusion criteria that may have affected the number and severity of traumatic injury reports. Therefore, the annual figures in Table 1 should not be interpreted as a smooth series. On average, injury severity was slightly lower for work-related injuries compared with other injuries (mean ISS of 10.2 vs 10.9; $P < 0.001$). Mean length of stay for reported work-related injuries was 6.4 days compared with 6.1 days for other injuries ($P = 0.01$). These are small differences, and a number of factors likely contributed to the longer average length of stay for work-related injuries despite the lower average ISS, including demographics, payer, pre-existing conditions, and differential survival. Mean unadjusted hospital charges were $32,850 for work-related injuries compared with $31,571 for other injuries (difference not significant).

Men accounted for 88% of work-related injury reports, and injury characteristics varied by sex. Table 2 presents a summary of demographic and injury characteristics, broken out by sex, for the 7.3% of WTR injuries that were work-related ($N = 9185$) for all 11 years combined. Latino/Hispanic workers accounted for 13.6% of injuries (Latinos/Hispanics comprised 7.5% of the Washington population in 2000 and 8.9% in 2006[33]). The Washington State Department of Labor & Industries (responsible for managing the vast majority of WC claims in the state) was noted as payer for 72.6% of reported injuries. Nearly 16% were either specifically noted as having no insurance or had no payer information at all.

On the basis of the ISS, 45.2% of reported work-related traumatic injuries were minor (ISS = 1 to 8), 35.0% were moderate

 

**TABLE 2.** Work-Related Injuries Reported to the WTR, 1998–2008 ($N = 9{,}185$*)

| Characteristic | Total *N* (%) | Men *N* (%) | Women *N* (%) |
|---|---|---|---|
| Sex | | | |
| Men | 8,086 (88.0) | n/a | n/a |
| Women | 1,098 (12.0) | n/a | n/a |
| Age, yr | | | |
| 16–24 | 1,351 (14.7) | 1,223 (15.1) | 128 (11.7) |
| 25–34 | 2,002 (21.8) | 1,851 (22.9) | 151 (13.8) |
| 35–44 | 2,221 (24.2) | 1,986 (24.6) | 234 (21.3) |
| 45–54 | 2,064 (22.5) | 1,776 (22.0) | 288 (26.2) |
| 55–64 | 1,125 (12.3) | 943 (11.7) | 182 (16.6) |
| 65 and older | 422 (4.6) | 307 (3.8) | 115 (10.5) |
| Race/ethnicity | | | |
| White | 6,078 (66.2) | 5,375 (66.5) | 703 (64.0) |
| Latino/Hispanic (any race) | 1,253 (13.6) | 1,143 (14.1) | 110 (10.0) |
| Black/African American | 194 (2.1) | 168 (2.1) | 26 (2.4) |
| Asian/Pacific Islander | 221 (2.4) | 184 (2.3) | 37 (3.4) |
| Native American | 65 (0.7) | 55 (0.7) | 10 (0.9) |
| Other | 116 (1.3) | 102 (1.3) | 14 (1.3) |
| Unknown | 1,258 (13.7) | 1,059 (13.1) | 198 (18.0) |
| Payer (categories not mutually exclusive) | | | |
| Labor & Industries | 6,665 (72.6) | 5,930 (73.3) | 734 (66.9) |
| Medicare | 278 (3.0) | 207 (2.6) | 71 (6.5) |
| Medicaid/DSHS/Healthy Options | 355 (3.9) | 305 (3.8) | 50 (4.6) |
| Other insurance (government/private) | 2,073 (22.6) | 1,737 (21.5) | 336 (30.6) |
| None (self-pay, charity) | 1,148 (12.5) | 1,012 (12.5) | 136 (12.4) |
| No insurance information | 281 (3.1) | 252 (3.1) | 29 (2.6) |
| Pre-existing conditions (selected) | | | |
| Previous trauma | 452 (5.8) | 402 (5.9) | 50 (5.4) |
| Hypertension | 919 (11.9) | 757 (11.1) | 162 (17.4) |
| Cardiac | 362 (4.7) | 291 (4.3) | 71 (7.6) |
| Diabetes | 388 (5.0) | 325 (4.8) | 63 (6.8) |
| Respiratory | 336 (4.3) | 267 (3.9) | 69 (7.4) |
| Psychiatric | 194 (2.5) | 143 (2.1) | 51 (5.5) |
| Drug abuse | 187 (2.4) | 177 (2.6) | 10 (1.1) |
| Alcohol abuse | 209 (2.7) | 198 (2.9) | 11 (1.2) |
| Tobacco use | 1,299 (16.8) | 1,203 (17.7) | 96 (10.3) |
| Injury Severity Score | | | |
| Minor (1–8) | 4,133 (45.2) | 3,578 (44.5) | 554 (50.6) |
| Moderate (9–15) | 3,195 (35.0) | 2,791 (34.7) | 404 (36.9) |
| Major (16–75) | 1,814 (19.8) | 1,676 (20.8) | 138 (12.6) |
| Injury involved an amputation | 587 (6.4) | 531 (6.6) | 56 (5.1) |
| Traumatic brain injury | 1,910 (20.8) | 1,718 (21.3) | 192 (17.5) |
| Fatality (dead on arrival or in-hospital) | 247 (2.7) | 236 (2.9) | 11 (1.0) |
| External cause of injury | | | |
| Falls | 3,507 (38.2) | 2,978 (36.8) | 529 (48.2) |
| Machinery | 1,225 (13.3) | 1,113 (13.8) | 112 (10.2) |
| Motor vehicle traffic | 835 (9.1) | 683 (8.5) | 152 (13.8) |
| Cutting/piercing objects | 444 (4.8) | 419 (5.2) | 25 (2.3) |
| Struck by object | 1,132 (12.3) | 1,080 (13.4) | 51 (4.6) |
| Caught between objects | 382 (4.2) | 361 (4.5) | 21 (1.9) |
| Electrocution | 143 (1.6) | 137 (1.7) | 6 (0.6) |
| Corrosive material/steam | 286 (3.1) | 241 (3.0) | 45 (4.1) |
| Homicide/assault | 147 (1.6) | 117 (1.5) | 30 (2.7) |
| Overexertion/movement-related | 68 (0.7) | 46 (0.6) | 22 (2.0) |
| Fire/flames | 182 (2.0) | 173 (2.1) | 9 (0.8) |
| Explosive materials | 52 (0.6) | 48 (0.6) | 4 (0.4) |
| Animal bites | 68 (0.7) | 49 (0.6) | 19 (1.7) |
| Other specified | 707 (7.7) | 636 (7.9) | 71 (6.5) |
| Missing/Unspecified | 7 (0.1) | 5 (0.1) | 2 (0.2) |
| Place of injury | | | |
| Home | 524 (5.7) | 418 (5.2) | 106 (9.7) |
| Farm | 456 (5.0) | 387 (4.8) | 69 (6.3) |
| Mine/quarry | 27 (0.3) | 23 (0.3) | 4 (0.4) |
| Industrial | 5,040 (54.9) | 4,617 (57.1) | 423 (38.5) |
| Sports/recreation | 153 (1.7) | 129 (1.6) | 24 (2.2) |
| Street/highway | 883 (9.6) | 723 (8.9) | 160 (14.6) |
| Public building | 361 (3.9) | 232 (2.9) | 129 (11.8) |
| Residential institution | 101 (1.1) | 68 (0.8) | 33 (3.0) |
| Other specified | 904 (9.8) | 809 (10.0) | 95 (8.7) |
| Missing/Unspecified | 736 (8.0) | 680 (8.4) | 55 (5.0) |

*Categories for some characteristics do not sum to 9,185 due to missing data.
WTR indicates Washington State Trauma Registry; n/a, not applicable; DSHS, Washington Department of Social and Health Services.

(ISS = 9 to 15), and 19.8% were major (ISS = 16 to 75). An amputation was present in 6.4% of reported injuries and TBI was present in 20.8%. There was a history of previous trauma for 5.8% of these work injuries. Pre-existing hypertension was documented for 11.9% of reported injuries, and diabetes for 5.0%. There were 247 work-related fatalities identified in the WTR.

Falls were the most common cause of work-related injury, accounting for 38.2% of WTR reports. Being struck by, caught between or cut or pierced by objects accounted for 21.3%, machinery accounted for 13.3%, and motor vehicle traffic for 9.1%; a variety of causes accounted for the remaining 18%. Overall, 54.9% of injuries occurred in an industrial setting, 9.6% on a street or highway, 5.0% on a farm, 5.7% at home, and 3.9% in a public building. Another 12.9% occurred in a variety of specified locations, and 8% occurred at unspecified locations.

To get a rough idea of the amount of serious work-related injuries captured by the WTR, we compared the raw number of work-related trauma reports involving fatalities, burns, TBI, and amputations with other available sources. There were 247 work-related fatalities identified in the WTR from 1998 through 2008, compared with 942 identified by the Fatality Assessment and Control Evaluation program, run by the Washington State Department of Labor and Industries Safety and Health Assessment and Research for Prevention Program, and 991 identified by the Census of Fatal Occupational Injuries during the same years. The WTR therefore captured about a quarter of the work-related fatalities occurring in Washington (a study in Illinois reported an estimate of about 20% for that state[6]). Trauma registries would be expected to capture only a fraction of the fatalities captured by death registries because work-related deaths can occur in any setting. Many work-related trauma deaths occur in the field; a medical examiner or EMS personnel may

**TABLE 3.** Trends in Moderate and Major Traumatic Injury Reports* by Demographic Characteristics, Adjusted for Changes in Employed Population (Crude, Age-Adjusted and Age-Specific Incidence Rates per 100,000 Workers†)

| Characteristic | *N* | 2003 Rate (CI) | 2004 Rate (CI) | 2005 Rate (CI) | 2006 Rate (CI) | 2007 Rate (CI) | 2008 Rate (CI) | Mean Annual % Change | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Overall, crude‡ | 3,093 | 14.6 (13.3–16.1) | 14.2 (12.8–15.6) | 16.7 (15.2–18.2) | 19.5 (18.0–21.1) | 19.8 (18.3–21.4) | 17.2 (15.8–18.7) | +5.5 | <0.001 |
| Overall, age-adjusted§ | 3,093 | 16.5 (15.1–18.1) | 15.7 (14.2–17.2) | 19.3 (17.7–20.9) | 22.6 (20.9–24.3) | 22.5 (20.9–24.2) | 19.0 (17.5–20.5) | +5.3 | <0.001 |
| Sex§ | | | | | | | | | |
| Men | 2,745 | 25.5 (23.0–28.2) | 24.9 (22.5–27.5) | 28.8 (26.2–31.5) | 34.5 (31.7–37.4) | 34.3 (31.5–37.2) | 29.8 (27.3–32.5) | +5.4 | <0.001 |
| Women | 348 | 6.6 (5.3–8.1) | 4.6 (3.6–6.0) | 7.9 (6.5–9.5) | 8.6 (7.2–10.3) | 8.8 (7.4–10.5) | 6.6 (5.4–8.0) | +5.0 | 0.04 |
| Ethnicity§‖ | | | | | | | | | |
| Latino | 490 | 28.2 (21.4–36.5) | 22.8 (16.9–30.0) | 29.0 (22.5–36.9) | 38.8 (31.4–47.5) | 46.6 (38.6–55.7) | 45.5 (37.8–54.2) | +14.8 | <0.001 |
| Non-Latino | 2,097 | 10.8 (9.6–12.2) | 11.1 (9.9–12.5) | 12.9 (11.6–14.3) | 14.9 (13.5–16.4) | 14.5 (13.2–16.0) | 13.1 (11.9–14.5) | +5.3 | <0.001 |
| Age-specific | | | | | | | | | |
| 16–24 | 418 | 14.0 (10.6–18.3) | 16.0 (12.3–20.4) | 16.0 (12.4–20.3) | 21.0 (16.8–25.9) | 19.1 (15.1–23.8) | 16.1 (12.5–20.4) | +4.1 | 0.16 |
| 25–34 | 611 | 10.9 (8.5–13.9) | 13.8 (11.0–17.1) | 16.3 (13.3–19.7) | 18.3 (15.2–21.9) | 16.7 (13.8–20.1) | 17.9 (14.9–21.3) | +8.6 | 0.001 |
| 35–44 | 679 | 14.9 (12.2–18.0) | 10.7 (8.5–13.4) | 16.7 (13.8–19.9) | 17.4 (14.5–20.7) | 20.0 (16.9–23.6) | 13.7 (11.1–16.6) | +4.2 | 0.07 |
| 45–54 | 771 | 15.1 (12.3–18.2) | 15.6 (12.8–18.8) | 15.5 (12.7–18.6) | 20.5 (17.4–24.0) | 20.0 (17.0–23.4) | 17.6 (14.8–20.8) | +5.1 | 0.02 |
| 55–64 | 432 | 17.8 (13.6–22.8) | 14.4 (10.8–18.8) | 16.2 (12.5–20.7) | 17.2 (13.5–21.6) | 19.9 (16.0–24.5) | 18.6 (15.0–22.9) | +3.8 | 0.19 |
| 65 or older | 182 | 28.4 (17.6–43.3) | 24.6 (15.2–37.6) | 35.5 (24.0–50.7) | 41.5 (29.2–57.2) | 40.0 (28.4–54.7) | 31.8 (22.0–44.5) | +5.5 | 0.22 |

*Restricted to injuries with Injury Severity Score≥9 to limit intra- and inter-facility reporting variation.
†Denominators based on American Community Survey estimates of employed population/subpopulations.
‡Crude estimates include 95% Poisson exact confidence intervals.
§Age-adjusted using year 2000 US standard working population weights; 95% gamma confidence intervals.
‖Counts too low to meaningfully test age-adjusted trends for other categories.
CI indicates confidence interval.

declare death and the worker may never arrive at a reporting hospital. We identified 409 hospitalized work-related burns in the WTR from 2003 to 2008, compared with 502 identified by Safety and Health Assessment and Research for Prevention Program's hospitalized work-related burn surveillance program during the same years (case definitions were roughly comparable though hospital coverage differed). We identified 712 cases of work-related TBI in the WTR from 1998 to 2002, compared with 797 cases identified by a different study using WC data during the same years[34] (the case definitions and available populations were somewhat different). TBI is an injury type that might more often involve EMS transfer, trauma team activation, and/or extended hospital observation time and thus be quite likely to be reported to the WTR compared with other injury types. According to national estimates, 16% of those treated in an ED for TBI are hospitalized and another 3% die.[29] We identified 434 work-related amputations, including 55 upper extremity amputations and 19 lower extremity amputations in the WTR from 1998 to 2005, compared with 2528 total work-related amputations, 45 upper extremity amputations, and 22 lower extremity amputations identified by a different study using WC data from 1997 to 2005 (identified using ANSI Z16 codes).[35] Again, the case definitions and available populations were somewhat different. As would be expected based on severity, the counts of upper extremity and lower extremity amputations were much more similar across WTR and WC data sources than were the counts for all amputations, many of which may not require hospitalization (eg, fingertip amputations).

## Trends in Work-Related Traumatic Injury Reports, 2003 to 2008

For the years 2003 through 2008 combined, the incidence of work-related traumatic injury reports (any severity level) was 4 times higher for men than women (age-adjusted IRR: 4.34; $P < 0.001$; 95% CI: 4.05 to 4.66). The incidence of work-related traumatic injury reports was lower for Black/African American workers than for white workers (age-adjusted IRR: 0.76; $P = 0.004$; 95% CI: 0.63 to 0.92). The incidence of work-related traumatic injury reports was more than twice as high for Latinos compared with non-Latinos (age-adjusted IRR: 2.60; $P < 0.001$; 95% CI: 2.40 to 2.82).

Significant upward trends in unadjusted moderate and major traumatic injury reports were observed for all sex, ethnicity, and age categories, with the exception of age-specific rates for ages 16 to 24 years, for the timeframe from 2003 through 2008 (data not presented). After age adjusting and controlling for changes in the underlying employed population, upward trends were more consistent between subgroups, with most ranging from a 4% to 9% mean annual increase (Table 3). Upward trends remained statistically significant in most subgroups, with the exception of several age categories. The 14.8% mean annual increase in injury reports for Latinos was the largest upward trend observed for any subgroup.

We also assessed trends by external cause of injury. We observed significant upward trends in unadjusted traumatic injury reports for falls, machinery, cutting/piercing objects, and corrosive material/steam (data not presented). There was no evidence of significant trends for motor vehicle traffic, struck by object, caught between object, or homicide/assault. A similar picture remained after age adjusting and controlling for changes in the underlying employed population, except that the apparent upward trend in cutting/piercing objects was no longer statistically significant (Table 4).

As a reminder, the rates presented in Tables 3 and 4 should be interpreted with caution. As discussed earlier, they do not represent the absolute incidence of any category of work-related injuries.

In addition, we assessed trends for two specific injury types, amputations and traumatic brain injuries (TBI), controlling for changes in the underlying employed population. There was a significant upward trend observed for both, with a 21.3% mean annual increase for amputations ($P < 0.001$; 95% CI: +9.8% to +34.0%),

 

**TABLE 4.** Trends in Moderate and Major Traumatic Injury Reports* by Most Common External Causes, Adjusted for Changes in Employed Population (Crude Incidence Rates per 100,000 Workers†)

| External Cause of Injury‡ | *N* | 2003 Rate (SE§) | 2004 Rate (SE) | 2005 Rate (SE) | 2006 Rate (SE) | 2007 Rate (SE) | 2008 Rate (SE) | Mean Annual% Change | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Falls | 1,412 | 7.14 (0.50) | 6.13 (0.46) | 7.07 (0.49) | 8.43 (0.52) | 9.02 (0.54) | 8.73 (0.52) | +6.8 | <0.001 |
| Machinery | 314 | 1.16 (0.20) | 1.33 (0.22) | 1.78 (0.25) | 1.98 (0.25) | 2.36 (0.27) | 1.71 (0.23) | +10.2 | 0.004 |
| Motor vehicle traffic | 309 | 1.51 (0.23) | 1.86 (0.26) | 1.62 (0.23) | 1.95 (0.25) | 1.82 (0.24) | 1.49 (0.22) | +0.01 | >0.99 |
| Cutting/piercing objects | 61 | 0.25 (0.09) | 0.11 (0.06) | 0.40 (0.12) | 0.49 (0.13) | 0.32 (0.10) | 0.43 (0.12) | +15.2 | 0.07 |
| Struck by object | 388 | 1.65 (0.24) | 2.03 (0.27) | 2.59 (0.30) | 2.53 (0.29) | 2.33 (0.27) | 1.71 (0.23) | +1.1 | 0.71 |
| Caught between objects | 143 | 0.84 (0.17) | 0.98 (0.19) | 0.77 (0.16) | 0.81 (0.16) | 0.73 (0.15) | 0.62 (0.14) | –6.4 | 0.17 |
| Corrosive material/steam | 54 | 0.18 (0.08) | 0.11 (0.06) | 0.17 (0.08) | 0.49 (0.13) | 0.45 (0.12) | 0.37 (0.11) | +25.9 | 0.006 |
| Homicide/assault | 64 | 0.39 (0.12) | 0.28 (0.10) | 0.30 (0.10) | 0.68 (0.15) | 0.19 (0.08) | 0.28 (0.09) | –3.7 | 0.61 |

*Restricted to injuries with Injury Severity Score≥9 to limit intra- and interfacility reporting variation.
†Denominators based on American Community Survey estimates of employed population.
‡External cause of injury based on ICD-9-CM codes; table limited to causes resulting in more than 50 injuries.
§Standard errors assume Poisson distribution.
SE indicates standard error.

and a 7.4% mean annual increase for TBI ($P < 0.001$; 95% CI: + 3.5% to + 11.4%).

## DISCUSSION

In summary, we observed significant upward trends in moderate and major traumatic injury reports for all sex, ethnicity, and age categories for the timeframe from 2003 through 2008, most of which persisted after we adjusted for age and changes in the underlying employed population. We also observed significant upward trends for several external causes (falls, machinery, and corrosive material/steam), and for amputations and traumatic brain injuries, which also persisted after adjusting for changes in the underlying employed population.

A previous study using Illinois Trauma Registry data found no significant declines in severe occupational injuries between 1995 and 2003[6] (in contrast with reports from national surveillance data), but neither did they observe upward trends as we did. There were several important differences between our study and theirs, aside from the states involved. First, the timeframes of the two studies only overlap by 1 year. However, the downward injury trends seen in the national employer-based Survey of Occupational Injuries and Illnesses (SOII) data have continued over both study timeframes for both states (for Washington, there was a nearly monotonic decline from 6.5 nonfatal injuries per 100 full-time workers in 2003 to 5.4 in 2008, a 17% overall drop).[36] There have also been monotonic downward trends in the number of compensable WC claims in Washington State during this time period, from 2.3 to 1.9 claims per 100 full-time workers, also a 17% overall drop (unpublished data). Trauma registry inclusion criteria differ between the states in several ways. For example, Illinois includes those admitted for at least 12 hours compared with 48 hours in Washington, Illinois includes dead on arrival and ED deaths whereas Washington includes all inpatient deaths occurring during the trauma-related hospital stay as well as dead on arrival and ED deaths, and only Level I & II facilities report in Illinois whereas all designation levels, I through V, report in Washington. However, although these differences would be expected to affect observed rates, they should not affect observed trends. We used ACS-based denominators for adjustment whereas the Illinois study used Current Population Survey-based denominators; however, we ran a sensitivity analysis using both sources and differences were negligible. We also assessed the impact on our findings of (1) controlling for changes in the number and volume of reporting hospitals over the study timeframe and (2) excluding fatalities; both alternative approaches had negligible effect.

Perhaps the most important analytic difference is that we excluded minor injuries (those with an ISS under 9) from trend analyses, although the Illinois study included all injuries regardless of severity. We did this a priori, to limit inter- and intrafacility variation in reporting practices due to factors such as the highly variable skills and training among trauma registrars which can affect the accuracy and consistency of reporting decisions, financial incentives which can drive reporting, and EMS/ambulance transfers that may be related to geography and local resources but trigger inclusion regardless of severity. However, given the contrasts between our findings and those in Illinois, we also ran our adjusted analyses (Tables 3 and 4) without excluding minor injuries. In doing so, we found little evidence for upward trends, generally speaking, but no evidence for downward trends. The age adjusted mean annual percent increase for all injuries was 0.9%, but was not statistically distinguishable from zero (95% CI: –0.7% to + 2.4%). Among subgroups, most upward-appearing trends were not statistically significant, and some appeared essentially flat. A notable exception was that the upward trend for Latino workers remained significant (mean annual percent change: 7.1%; $P = 0.001$; 95% CI: + 2.8% to + 11.6%), whereas the trend for non-Latino workers was essentially flat (mean annual percent change: 0.6%; 95% CI: –1.4% to + 2.6%). There were no large or statistically significant downward trends. However, because our concerns about variation in reporting practices for minor injuries remain, we stand by our a priori decision to exclude minor injuries.

Despite these differences, the relative age-adjusted incidence rates for subpopulations (any injury severity level) were strikingly similar across the two studies. The all-year age-adjusted IRR for men compared with women was 4.34 (95% CI: 4.05 to 4.66) in Washington, and 4.31 (95% CI: 4.14 to 4.48) in Illinois. The all-year age-adjusted IRR for Black/African American workers compared with white workers was 0.76 (95% CI: 0.63 to 0.92) in Washington, and 0.71 (95% CI: 0.68 to 0.76) in Illinois. The all-year age-adjusted IRR for Latino/Hispanic workers compared with other workers was 2.60 (95% CI: 2.40 to 2.82) in Washington, and 2.44 (95% CI: 2.35 to 2.54) in Illinois. This may be attributable to the confluence of more Latino/Hispanic representation and higher injury rates in the construction and agricultural sectors (particularly for contingent and precarious employment in those sectors).[37–40] Unfortunately, we cannot test this hypothesis using WTR data due to the absence of information about industry and occupation. Although we have stressed

that the age-adjusted rates, we have produced do not represent absolute injury rates and despite several differences in trauma registry inclusion criteria, it is still worth noting that when we included all injuries regardless of severity, the observed magnitude is not overly distant from that observed in Illinois (31.9 per 100,000 workers for Washington compared with 44.4 per 100,000 workers in Illinois).

There have been significant upward trends in the overall volume of WTR trauma reports since its inception (a threefold increase from 1995-2009).[25] Reports produced by the WTR ascribe these trends to the aging population (especially falls and TBI in the elderly).[25] Because we are focused on the subset of work-related injuries, advanced age is less common and age adjustment should remove aging of the employed population as a contributor to the trends we observed. We can think of two alternative explanations for the observed upward trends. First, hospitals may be reporting increasingly higher proportions of their trauma cases over time. There is evidence that some aspects of reporting are in fact improving over time (eg, decreasing amounts of missing data in many but not all fields). However, reporting is mandatory once hospitals are designated, and most hospitals had been reporting for some time prior to the timeframe of this study. The exclusion of minor injuries should have had the effect of removing the most borderline cases, those in which reporting inconsistencies might be more likely to occur for reasons described earlier. Second, it could be that higher proportions of all traumatic injuries are being directed to designated (reporting) hospitals over time. This is a goal of Washington's trauma system, "to deliver the "right" patient to the "right" facility in the "right" amount of time."[25] However, nearly all hospitals in the state have had a trauma designation since the WTR began and there are nondesignated hospitals in only a single county (this county has a sophisticated EMS system, making misdirection unlikely). As a counterpoint to both of these alternative explanations, it did not appear that the WTR identified increasing proportions of two independently monitored indicators over this time period: (1) all Washington work-related fatalities (Census of Fatal Occupational Injuries or Fatality Assessment and Control Evaluation), or (2) all Washington work-related burn hospitalizations.

Our findings are also consistent with the possibility that rates of high-severity injuries may be increasing while rates of the more common lower severity injuries may be decreasing. SOII data do not contain severity information beyond missed workdays. In contrast to the downward trends observed for all Washington State WC claims, those involving immediate hospitalization did not display a strong or monotonic downward trend for this time period. There were 55.8 claims involving immediate hospitalization per 100,000 full-time workers in 2003 and 51.4 in 2008, an 8% overall drop; however, there were increases in some years and no significant overall trend using Poisson modeling (unpublished data). Another possible explanation for our findings might be an expansion over time in employment falling outside the scope of WC coverage and/or SOII surveys. The WTR work-related indicator is minimally defined, and identifies an unknown number of work-related injuries that may not be captured by most occupational injury data sources (eg,, injuries among self-employed workers, family farms, federal employees, household workers). Finally, we were limited to 6 years of WTR data, which is not a long timeframe for trend assessment, and the trend for WC hospitalized injury claims did appear particularly flat from 2003 to 2008 in contrast to the years before and after that time period. Going into the future, as the WTR continues to mature, it may become a stronger long-term source for occupational injury trend assessment. However, ongoing changes in WTR inclusion criteria may continue to pose challenges.

### Implications

The WTR has potential to serve as an additional source of surveillance data to more fully capture the burden of severe occupational traumatic injury in Washington State, including improved case ascertainment for severe occupational injuries, the identification of populations at high risk and the identification of new or emerging injury patterns (eg,, among temporary workers or those classified as independent contractors in construction). In addition, it has the potential to contribute valuable information to the planning, implementation and evaluation of programs related to occupational traumatic injury prevention. The WTR is well positioned to capture several types of severe high-priority work-related traumatic injuries, including motor vehicle crashes, falls, and traumatic head and brain injury. In addition, the WTR contains injury information that is not commonly available in other databases, including severity and details of initial treatment. These statements are likely true of any number of state trauma registries and we are hopeful that the use of state trauma registries for occupational injury research will continue to be explored around the country. In addition to work in Illinois, several occupational injury studies have been conducted using the Alaska Trauma Registry.[8,9,41] The Alaska Trauma Registry has the advantage of including all acute care hospitals in the state, as well as containing fields for occupation (narrative text) and industry (two-digit code for 11 identified target industries) that enable more detailed occupational injury surveillance.[8] Occupational injury researchers elsewhere have called for the addition of occupation, industry, and other work-related information to trauma registries.[5,42]

This study also provides important exploratory information for occupational health researchers anticipating a fully developed population-based national trauma registry. State trauma registries vary considerably in reporting requirements, inclusion criteria, data elements, and coding conventions.[4,24] The American College of Surgeons has made progress by developing the National Trauma Data Bank and issuing the National Trauma Data Standard, which specifies that participating trauma centers should collect occupation and occupational industry for all injuries flagged as work related (not currently available in the WTR).[43] However, the National Trauma Data Bank is currently represented as a convenience rather than population-based sample.

## CONCLUSIONS AND RECOMMENDATIONS

This study presents the first use of the WTR for surveillance of severe occupational traumatic injuries, and compares findings with a similar study conducted in Illinois. We found no evidence of a decreasing trend in work-related traumatic injuries reported to the WTR from 2003 through 2008, using either raw reports or age-adjusted rates based on employed population estimates. In fact, the evidence suggests the opposite is more likely the case, despite the various limitations inherent in using trauma registry data for surveillance. Trauma registry data may avoid some recognized reporting filters,[16] specifically whether a WC claim is filed or accepted for a particular injury or whether an employer recognizes and reports a particular injury as work-related, which may account for the differences between our findings and those based on other data sources. These reporting filters would be less likely to affect the most severe occupational injuries, and we focused on a select subset of severe traumatic injuries for trend analysis. On the contrary, the trends we observed are so strikingly different from those based on most other data sources that they raise a number of questions. It may be that trends in the incidence of the most severe injuries differ from those of less severe injuries, that there has been an expansion over time in employment falling outside the scope of WC coverage and/or SOII surveys, or that we observed these trends due to limitations inherent in using the WTR for surveillance or due to the particular years involved (there is some evidence that the downward trend in WC claims involving immediate hospitalization was unusually flat during these years). Further research will be required to understand whether rates are differentially increasing for the most severe traumatic occupational injuries, and what this might mean for occupational injury

 

prevention efforts. We hope that other researchers will extend our efforts in this regard.

The WTR presents several limitations for surveillance, including incomplete injury coverage and interhospital variation in reporting practices. However, use of WTR data could contribute to planning and evaluation of occupational injury prevention programs, improved case ascertainment for severe occupational injuries, and identification of high-risk populations and emerging injury patterns. Adding industry and occupation information to the WTR and to other state trauma registries would improve their utility for occupational injury surveillance and research.

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