Use of Employer Administrative Databases to Identify Systematic Causes of Injury in Aluminum Manufacturing

Keshia M. Pollack, PhD, MPH,[1*†] Jacqueline Agnew, RN, MPH, PhD,[2] Martin D. Slade, MPH,[3] Linda Cantley, MS,[3] Oyebode Taiwo, MD, MPH,[3] Sally Vegso, MS,[3] Kanta Sircar, PhD,[3] and Mark R. Cullen, MD[3]

Background *Employer administrative files are an underutilized source of data in epidemiologic studies of occupational injuries.*
Methods *Personnel files, occupational health surveillance data, industrial hygiene data, and a real-time incident and injury management system from a large multi-site aluminum manufacturer were linked deterministically. An ecological-level measure of physical job demand was also linked. This method successfully created a database containing over 100 variables for 9,101 hourly employees from eight geographically dispersed U.S. plants.*
Results *Between 2002 and 2004, there were 3,563 traumatic injuries to 2,495 employees. The most common injuries were sprain/strains (32%), contusions (24%), and lacerations (14%). A multivariable logistic regression model revealed that physical job demand was the strongest predictor of injury risk, in a dose dependent fashion. Other strong predictors of injury included female gender, young age, short company tenure and short time on current job.*
Conclusions *Employer administrative files are a useful source of data, as they permit the exploration of risk factors and potential confounders that are not included in many population-based surveys. The ability to link employer administrative files with injury surveillance data is a valuable analysis strategy for comprehensively studying workplace injuries, identifying salient risk factors, and targeting workforce populations disproportionately affected.* Am. J. Ind. Med. 50:676–686, 2007. *© 2007 Wiley-Liss, Inc.*

KEY WORDS: occupational injury epidemiology; workplace safety; administrative databases; data linkage; manufacturing sector

INTRODUCTION

Studies of occupational injuries rely on data sources to identify injury trends, modifiable risk factors, and to inform the development of injury prevention interventions and policies. Population-based surveys, such as those initiated by the Bureau of Labor Statistics, emergency department surveillance systems, and state worker compensation claims

[1]Department of Health Policy and Management, Center for Injury Research and Policy, The Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland
[2]Department of Environmental Health Sciences, Johns Hopkins Education and Research Center for Occupational Health and Safety, The Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland
[3]Yale Occupational and Environmental Medicine Program, Departments of Internal Medicine and Epidemiology and Public Health, Yale University School of Medicine, New Haven, Connecticut
The authors declare that there is no conflict of interest related to the work presented in this study. All of the sources of funding for this research have been revealed.
†Assistant Professor.

Contract grant sponsor: National Institutes for Health; Contract grant number: F31KD068940; Contract grant sponsor: National Institutes for Occupational Safety and Health; Contract grant number: 5-R01-OH-04040.
*Correspondence to: Keshia M. Pollack, Department of Health Policy and Management, Center for Injury Research and Policy, Johns Hopkins University Bloomberg School of Public Health, 624 N. Broadway, Room 557, Baltimore, MD 21218. E-mail: kpollack@jhsph.edu

Accepted 7 June 2007
DOI 10.1002/ajim.20493. Published online in Wiley InterScience (www.interscience.wiley.com)

are frequently the main sources of information for nonfatal occupational injury research [Layne and Pollack, 2004; Friedman and Forst, 2007; McCall and Horwitz, 2006; Mujuru et al., 2006; Wigglesworth, 2006]. While these databases are valuable sources of data, many of them lack information on key potential confounders. It is also rare that any one survey will contain all of the variables found in a comprehensive conceptual model of workplace injury risk. As a result, to obtain these desired measures, researchers must use multiple data sources which may lead to challenges for data linkage.

Company administrative files are another potential source of data. Generally speaking, administrative databases are an untapped resource for occupational epidemiology research [Johantgen et al., 2004; Cullen et al., 2006]. Linking administrative files, which contain worker and workplace information collected for non-research purposes, with injury records might provide a more complete study of workplace injury risk factors [Burdorf and Sorock, 1997; Burdof et al., 1997; Forst et al., 1999; Mueller, 2001; Cullen et al., 2006]. Their use may also minimize challenges faced during data linkage procedures, because theoretically, each database contains the same unique identifier given to the employee at the time of hire. Currently, only a few examples of occupational injury studies using employer administrative files exist in the published literature, with most occurring in the automotive industry [Sorock et al., 1997; Warner et al., 1998; Wong et al., 1998; Collins et al., 1999a,b]. While these studies used injury event records and some employer administrative files, there was substantial variability in the types of files utilized, included variables, and data linkage strategy. Moreover, these studies did not include injuries that resulted in first aid attention, which although relatively minor, are also extremely prevalent.

In this study, we linked a real-time injury surveillance system with occupational and environmental health surveillance and administrative databases to explore the distribution and determinants of workplace traumatic injuries. Our purpose was to show the benefits of linking injury surveillance data with employer administrative files to produce a more complete assessment of the overall workplace injury experience, and identify salient injury risk factors for subsequent study.

MATERIALS AND METHODS

Data Sources

Through a partnership that began in 1997, a university-based research group assumed responsibility for the development and implementation of corporate policies in workplace safety and occupational health at a large multi-site aluminum manufacturer. As a result of this unique academic-industry partnership, all existing company databases became available, new information was collected to expand workplace surveillance, and studies related to employee health and occupational injuries were initiated. These databases are briefly described below.

Human resources

This database contains personnel records for all employees, regardless of present work status. Employee files are initiated once employment begins. Each file contains complete information on job history, including job change or changes in level within that job. Other fields included in this database are job category (hourly or salary), job title, department, plant, employment status (active or retired), date of entry or leave, and disability leave and date of re-entry.

Real-time incident management system (IMS)

This database, established in 1989 and modified over time, contains information on work-related injuries and illnesses for all employees and directly supervised contractors. All environmental health and safety incidents are recorded. The IMS system is considered real-time since incidents are recorded soon after an incident occurs, depending on the level of severity. The initial point for entering the surveillance system is the plant safety manager or the onsite health clinic. Besides the injury case classification, other recorded variables include job position, activity and circumstances of the injury, whether a tool was being used, nature of injury, body part injured, and where applicable, the date lost- or restricted-work time began. A narrative field that describes the injury event and a category to record near-misses is also present; however these are not systematically recorded. To minimize inter-plant variability in recording IMS events, training is provided for clinic staff and safety managers, and guidelines are available on the company intranet, which explicitly state the procedures for determining the classification and coding of work-related injuries and illnesses.

Occupational health screening

This database provides information on all employees who participated in various fitness-for-work evaluations and medical surveillance programs. All of the employees in this study participated in at least one medical screening program, including pulmonary function testing, chest radiograph, and audiometry testing. The type of screenings that an employee receives is based on his or her job. Also included in this database are health-related variables collected during medical record abstraction that began in 2002. During this time, a number of measures, including smoking status, height, weight, cholesterol, and blood pressure were collected.

Industrial hygiene

This database, first developed in the mid-1970s, contains industrial hygiene exposure measurements, such as ambient air sampling, by job and department that were collected through routine surveillance. Job classification has been standardized across the various plants through a multi-pronged approach. In 2000, the company senior Industrial Hygiene Manager, with over 25 years of work experience, aggregated and standardized the job titles based on the various databases. Researchers matched the standardized occupations, devised by the company industrial hygienist, with those listed in the human resources database. Although there are potential limitations to the development of a uniform job dictionary, re-occurring evaluation and observational methods have been conducted to validate job coding. The result of this extensive effort was the creation of standardized job titles for hourly employees across all plants.

Job physical demand

This new database was first established by the investigators in 2001. It contains information on physical demands of occupations held by hourly employees. The demand score for each job was determined by a single expert rater at each plant who rated the demand of each job, by department. The raters were safety and health mangers who prior to the data collection received training on the criteria to rate each job. The physical demand question is a previously validated measure that was developed by the Department of Labor [United States Department of Labor Employment and Training Administration, 1986]. It rates the degree of physical activity required for job. Irrespective of gender, the physical demand required for each job is classified as sedentary, light, medium, heavy, or very heavy.

Data Linkage

The data linkage strategy for this study was deterministic, which meant that a single identifier was used to link across databases [Mueller, 2001]. An encrypted uniform unique identifier was created for each employee to ensure human subject privacy. After data cleaning, human resources files, industrial hygiene data, occupational health screening data, and IMS system were linked by employee ID number. A separate procedure was used to link the physical demand data. As previously mentioned, the demand of the job was rated by plant and department, so groups of employees in the same job and department, by plant, received the same rating. An employee's occupation was obtained from the human resources file and classified at baseline. This job was linked by plant and department to the job demand survey. The initial linkage of the physical demand ratings successfully matched for 70% of the sample. At the next iteration, each individual job that was not matched to the physical demand survey was identified and all cases were corrected for data entry errors and were re-matched. This iteration of processes occurred for each plant individually.

Study Sample

Although this data collection effort began with 13 U.S. plants, data from eight plants were used for the present study; five plants were excluded because of curtailed production or plant closures during the study period. All full time hourly employees between 18 and 65 years of age, on the payroll during 2002 were eligible for study inclusion. Of the eligible employees, files were not linkable for 329 employees; thus, the final study sample consisted of 9,101 hourly employees. There were no significant differences for demographic, workplace, and injury-related variables between the employees who could not be linked and the final sample.

Variables

This cross-sectional analysis used all traumatic injury events from the IMS system that occurred between January 1, 2002, and December 31, 2004. Nonfatal injuries included those that warranted first aid attention along with those required for the Occupational Safety and Health Administration (OSHA recordable). OSHA recordable injuries are injury events that result in medical treatment, lost work time, restricted work time, loss of consciousness or death.

Events from the IMS system related to cumulative trauma, hearing loss, any illness, for example, poisoning, nausea, skin conditions, respiratory conditions, or pain, were excluded since they did not result from a sudden exchange of mechanical energy as with traumatic injuries. All injuries classified as an abrasion, amputation, bite/sting, blisters, burn, contusion, dislocation, electric shock, eye injuries (irritations from contusions), foreign body, fracture, laceration, musculoskeletal disorders instantaneous-sprain or strain (sprains or strains), and puncture were analyzed. Traumatic injuries were evaluated separately as first aid or OSHA recordable and together as any traumatic injury. Information on the primary body part injured in each event was also obtained from the IMS system.

Demographic variables included sex, race, education, and age. Race was classified as Black, White, Hispanic, and Asian Americans and Native Americans were combined as "Other." Education was dichotomized and all those with no more than a high school diploma were grouped and compared with employees with at least some college. Smoking was classified as current smoker, former smoker, or never smoked. Tenure was examined with two variables from the human resources database. Time since hire in years and time in current job in months were both calculated from January 1, 2002. Time since hire in years was categorized as: <1, $1 \leq X < 2$, $2 \leq X < 3$, $3 \leq X < 5$, and ≥ 5. Current job (as of January 1, 2002) was identified and the total time in months was calculated and classified as: <3, $3 \leq X < 6$, $6 \leq X < 12$, and ≥ 12. Indicator variables were created for the plant location and type of plant processes to account for the inter-plant differences.

Since there were nearly 200 jobs present, the physical demand scores were utilized as a single standard metric of physicality for this analysis rather than job title. The inter-rater reliability was evaluated using the Kappa statistic to determine the proportion of agreement for physical demand scores between the eight raters (one per plant) from the plants included in this study. Ten jobs were selected (five from primary manufacturing plants and five from secondary manufacturing plants) and Kappa scores ranged from 0.43 to 0.65 for all pairwise combinations. Scores were then tested against the hypothesis that the agreement is only predicted by chance. In all cases, the Kappa statistic was found to have significant agreement above chance.

Statistical Analysis

Descriptive statistics were conducted using frequencies and percentages for each demographic variable. Since women represented approximately 9% of the sample, sample demographics are presented for all workers and by sex. Injuries during the study period are reported as the number of injured persons (all employees) and the number of injury events. Unless noted, injury estimates include both OSHA recordable and first aid injuries. Cross tabulations were created for nature of injury by body part injured and for injury type (first aid, medical treatment, lost work time, or restricted work time) by nature of injury.

Single and multivariable logistic regression models were used to measure the association between the covariates and the odds of having a traumatic injury during the study period. We also repeated the multivariable logistic regression model to measure the odds of having only an OSHA recordable injury. The variables included in both regression analyses were age, sex, race, education, smoking, time employed with the company and time in the current job, physical demand of job, and plant. Smoking was not significantly associated with traumatic injury and was thus excluded from the regression analysis. During exploratory data analysis, the risk of injury was found to be similar for all months in one's current job up to 1 year. Thus, for the logistic regression model, the time in current job was dichotomized as employed in current job for less than 1 year or greater than 1 year. Odds ratios from the logistic regression are presented along with corresponding 95% confidence intervals. All analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC).

The entire study was approved by the Institutional Review Boards at both Yale University School of Medicine and the Johns Hopkins Bloomberg School of Public Health.

RESULTS

Sample

There were 9,101 employees in this study. Females comprised 9.6% of all hourly employees (Table I). By race, most of the employees were classified as White, although a larger percentage of females were Black than of the males. Based on the available education data, roughly 20% of male and female employees had attended at least some college. The percentage of current smokers was similar between males and females, 25%, but there was a lower percentage of females categorized as never smoked and ever smoked than males. Female employees had a mean tenure with the company of 13 years (SD 9.2) while males had a mean tenure of 18 years (SD 11.9). More women were employed at secondary smelters (63.4) than at primary smelters (36.6), while for men the opposite was true, 44.9 and 55.1, respectively.

A larger percentage of females than males were employed in jobs that were rated as sedentary or light (27.4 vs. 21.1) and medium (46.1 vs. 42.3). Roughly 28% of males were in the heavy jobs while only 18% of females were in the heavy jobs. A substantially larger percentage of males were also in the most physically demanding jobs—very heavy. Almost 5% of males were in the very heavy jobs, as compared with less than 1% of females.

Injury Analysis

There were 3,563 injury events during the study period. Twenty-seven percent of the sample ($N = 2{,}495$) experienced at least one injury during the follow-up period (Table II). The most prevalent injuries were sprains or strains (32%), contusions (24%), lacerations (14%) and burn injuries (10%) (Table III). A substantially large percentage of injuries were to the hand, wrist, or finger (31%), followed by 18% to the head, face, and neck area, 13% to the leg or knee, and 11% to the back. Among all possible injury and body combinations, the most frequent injuries were sprains and strains to the back (10%), and contusions or lacerations to the hand, wrist or finger (18%).

The majority of injured workers (70%) sustained a first aid injury only (Fig. 1). Irrespective of the nature of the injury, a very small percentage of injuries resulted in lost work time. For dislocations ($n = 6$), amputations ($n = 4$) and fractures ($n = 121$), all potentially severe injuries, only 17%, 25%, and 13%, respectively resulted in at least 1 day of lost

TABLE I. Baseline Demographic Characteristics of 9,101 Hourly Employees, in Eight Metal Manufacturing Plants, U.S., 2002*

		Sex	
Characteristic	**All employees (N = 9,101)**	**Male (N = 8,266)**	**Female (N = 835)**
Mean age, years (SD)	45.0 (9.8)	45.0 (9.8)	44.3 (9.6)
Age category, N (%)			
18–24	235 (2.6)	209 (2.5)	26 (3.1)
25–34	1,349 (14.8)	1,236 (15.0)	113 (13.5)
35–44	2,341 (25.7)	2,083 (25.2)	258 (30.9)
45–54	3,561 (39.1)	3,254 (39.4)	307 (36.8)
55–64	1,615 (17.8)	1,484 (18.0)	131 (15.7)
Race/ethnicity, N (%)			
White	7,581 (83.3)	6,982 (84.5)	595 (71.3)
Black	936 (10.3)	752 (9.1)	184 (22.0)
Hispanic	310 (3.4)	290 (3.5)	20 (2.4)
Other[a]	69 (0.8)	59 (0.7)	10 (1.2)
Education,[b] N (%)			
Some college or more	1,874 (20.6)	1,698 (20.5)	176 (21.1)
HS graduate or less	5,632 (61.9)	5,207 (63.0)	425 (50.9)
Smoking status,[c] N (%)			
Current smoker	2,290 (25.2)	2,071 (25.1)	219 (26.2)
Ever smoked	1,702 (18.7)	1,591 (19.3)	111 (13.3)
Never smoked	2,904 (31.9)	2,554 (32.2)	240 (28.7)
Plant type, N (%)[d]			
Primary smelter	4,014 (44.1)	3,708 (44.9)	306 (36.7)
Secondary smelter	5,087 (55.9)	4,558 (55.1)	529 (63.4)
Mean years since hire (SD)	17.2 (11.8)	17.6 (11.9)	13.0 (9.2)
Plant location[e]			
1	2,112 (23.2)	1,889 (22.9)	223 (26.7)
2	854 (9.4)	734 (8.9)	120 (14.4)
3	855 (9.4)	818 (9.9)	37 (4.4)
4	1,266 (13.9)	1,117 (13.5)	149 (17.8)
5	1,213 (13.3)	1,139 (13.8)	74 (8.9)
6	869 (9.6)	784 (9.5)	85 (10.2)
7	359 (3.9)	337 (4.1)	22 (2.6)
8	1,573 (17.3)	1,448 (17.5)	125 (15.0)
Physical demand of job,[f] N (%)			
(1) Sedentary	298 (3.3)	265 (3.2)	33 (3.9)
(2) Light	1,673 (18.4)	1,477 (17.9)	196 (23.5)
(3) Medium	3,882 (42.7)	3,497 (42.3)	385 (46.1)
(4) Heavy	2,505 (27.5)	2,349 (28.4)	156 (18.7)
(5) Very heavy	396 (4.4)	389 (4.7)	7 (0.84)

*All employees are those on the payroll during calendar year 2002, including 388 newly hired employees. Employees age, years since hire, and job demand classification were calculated as of January 1, 2002 or at time of hire for newly employed workers.
[a]Other includes American Indian and Asian/Pacific Islander. Race is missing 2% of all workers (2% of males and 3% of females).
[b]Percentages do not add up to 100 because education is missing for 18% of all employees (17% of males and 28% of females).
[c]Percentages do not add up to 100 because smoking is missing for 24% of all employees (23% of males and 32% of females).
[d]The four plants with a smelter are considered primary smelting locations and the remaining four production plants are considered secondary smelter plants.
[e]Plant locations 1–4 are secondary manufacturing plants and plants 5–8 are primary manufacturing plants.
[f]Physical demand missing for 3.9% of all employees (4% of males and 9% of females).

TABLE II. Frequency of All Traumatic Injuries, by Metal Manufacturing Plant, U.S. 2002–2004*

Plants	N[a]	No. of people injured (%)[b]	No. of injuries
1	1,573	563 (36)	872
2	359	66 (18)	100
3	869	260 (30)	362
4	1,213	352 (29)	497
5	1,266	256 (20)	341
6	855	218 (25)	306
7	854	263 (31)	418
8	2,112	517 (25)	667
Total	9,101	2,495 (27)	3,563

*Plant locations 1–4 are primary smelters and plants 5–8 are secondary smelters.
[a]Total number of employees on the payroll during 2002.
[b]Percentages are for the row—percent injured workers are out of the total employees per plant.

work time. However, over 50% of these same injuries resulted in restricted work time.

The results from the univariable regression, shown in Table IV, revealed significant associations between injury and sex, age, tenure, physical demand, race (Hispanic only), plant type, and plant. The multivariable model, also in Table IV, showed increased odds of injury for females when compared to males (OR = 1.57, 1.14–1.85), and highest odds of injury for the younger age categories. By race, the only significant increased risk of injury was for Hispanic workers compared with Whites (OR = 1.50, 1.17–1.93).

The odds ratios for physical demand of job ranged from 2.14 (1.44–3.18) for those in jobs classified as light, up to 4.34 (2.75–6.86) for those in very heavy jobs. As time employed with the company increased, the odds ratios for injury decreased. Workers employed for less than a year were nearly two times as likely to be injured as those with the company for five or more years. Time in current job was also a strong predictor of injury; if an employee was in their present job for less than 1 year, their risk of injury was 2.6 times as those in their job for greater than or equal to 1 year.

The multivariable model was repeated with only the OSHA recordable injuries (Table V). The odds ratios that resulted when using only the recordable injuries were of similar magnitude and in the same direction as those from the model which included the first aid injuries. While in some instances the odds ratios for only the recordable injuries were even more pronounced, the confidence intervals, consistent with the smaller sample size, were generally wider than those from the model that included only the first aid injuries.

DISCUSSION

There have been many descriptive studies of workplace injuries; the data presented in this study are not novel.

TABLE III. All Acute Traumatic Injuries Among Hourly Employees by Injury Type and Body Part, 2002–2004*,**

	Body part injured								
Type of injury	Toe/foot/ankle	Hand/wrist/finger	Forearm/elbow	Head/face/neck	Leg/knee	Back	Shoulder	Trunk	Total N (%)
Sprain/strain[a]	122	113	82	60	160	360	180	53	1,131 (31.8)
Contusion[b]	62	314	90	79	171	25	37	58	837 (23.5)
Laceration	2	337	51	81	20	—	2	—	493 (13.9)
Burn	21	133	41	118	34	4	8	6	366 (10.3)
Abrasion	7	44	36	53	75	6	6	9	236 (6.6)
Foreign body	1	37	1	147	2	—	—	1	189 (5.3)
Fracture	15	85	6	2	6	1	—	6	121 (3.4)
Eye injury[c]	—	—	—	73	—	—	—	—	73 (2.1)
Puncture	4	31	5	1	5	—	—	1	46 (1.3)
Bite/sting	—	7	5	12	2	2	4	1	33 (0.9)
Electrical shock	—	5	—	—	1	—	—	—	15 (0.4)
Blisters (friction)	4	4	2	—	—	—	—	—	10 (0.3)
Dislocation	1	2	—	—	—	—	3	—	6 (0.2)
Amputation	—	4	—	—	—	—	—	—	4 (0.1)
Total N (%)	239 (6.7)	1,116 (31.4)	318 (8.9)	626 (17.6)	476 (13.4)	398 (11.2)	240 (6.7)	135 (3.8)	3,560 (100)

*Body part missing for N = 3 cases.
**The 12 injury events to the whole body were excluded from this table. The type of injury was contusion (n = 1), electric shock (n = 9), sprain/strain (n = 1), and burn (n = 1).
[a]Sprain/strain are injuries that were categorized as "Instantaneous Musculoskeletal Disorders-acute."
[b]Contusion (bruise)—a impact injury caused by a blow or contact.
[c]Consists of eye irritations or contusion to the eye.

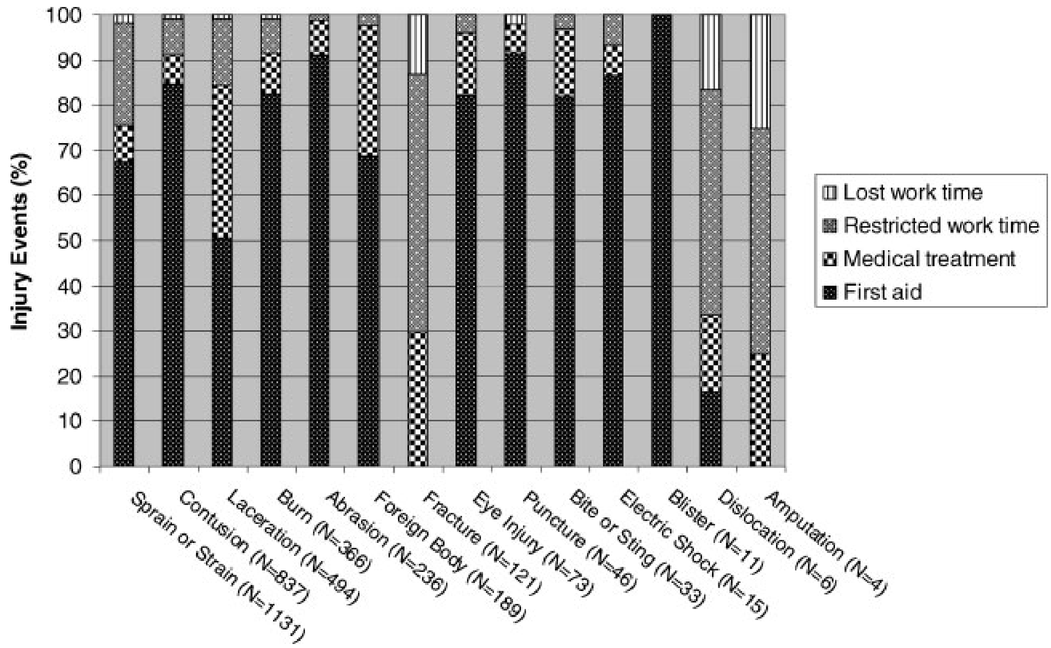

FIGURE 1. Distribution of traumatic injury events by case code and nature of injury, N = 3,563, 2002–2004.

However, the method used to obtain the injury estimates is novel, and after searching the published literature, the first assemblage of its type. Not only did we investigate injuries using a company real-time incident surveillance system, but also we linked it to occupational and environmental surveillance data and administrative files, which contained key individual and ecological level measures. This process created a dataset that contained many variables that are often not present in any one population-based survey. While there are challenges with using administrative databases and linkage, such as lack of a common identifier across databases, data availability, and coding/key entry errors, we believe that the benefits of using these data outweigh the limitations.

Due to the company's longstanding investment in having complete injury records, we were able to explore both first aid and OSHA recordable injuries; prior studies have tended to focus on the latter. We included these minor injuries not only because of their prevalence, but also to show that by having access to the first aid data, a more detailed yet unbiased exploration of the recordable injuries can be achieved. The comparison of adjusted odds ratios with and without the first aid events showed that by including the first aid events, study power increased, the confidence intervals narrowed, and sub-analyses by demographics were conducted, all the while not distorting the patterns of the more serious injuries. Although the first aid events distribute similarly to the more serious recordable injuries, these first aid events are an important aspect of the injury experience. In our study, approximately 70% of all traumatic injuries were first aid. This estimate is consistent with prior work that shows that the majority of traumatic injuries are the least severe [Segui-Gomez and MacKenzie, 2003].

Injuries to the hand, wrist, and finger were very common in this study. Despite prior research that showed a high prevalence of injuries to the extremities in this injury, we were still surprised by this finding because personal protective equipment (PPE) for these body parts is required [Schoemaker et al., 2000]. Future studies are planned that explore the availability, use, and workplace policies that govern PPE. In those instances where PPE use is lower than expected, it may be necessary to explore additional engineering and behavioral interventions to reduce injury [Lipscomb, 2000; Lombardi et al., 2005].

We were also surprised to find relatively few cases of lost work time for even amputations, dislocations and fractures. As suggested by Ruser [1999] this finding may be due to increasing financial and legal incentives that encourage employers to improve the safety of workplaces, create more restricted work positions and employ newer methods of injury follow-up such as managed care. Or, it may have been that we did not have enough cases, and thus power, to find differences between specific types of injury and its association with lost work time as seen in recent studies [Baldwin and Butler, 2006; Kines et al., 2007]. Our future work will benefit from the use of data from additional plants and years. The addition of data will allow for exploration of multiple injuries to workers, prior injury, and the calculation of risk estimates for various injury severity categories. We are also planning to investigate the work experience of injured employees once they return to work. With the pressure to return employees to work, further occupational injury studies

TABLE IV. Univariable and Multivariable Logistic Regression for All Traumatic Injury Among Hourly Manufacturing Workers, N = 9,101

	Univariable OR (95% CI)[a]	Multivariable OR (95% CI)[b]
Sex		
Female	1.33 (1.14–1.55)	1.57 (1.33–1.85)
Male	1.00	1.00
Age category*		
18–24	1.96 (1.46–2.64)	1.35 (0.95–1.91)
25–34	1.88 (1.60–2.22)	1.76 (1.45–2.14)
35–44	1.47 (1.26–1.70)	1.57 (1.33–1.85)
45–54	1.52 (1.32–1.75)	1.46 (1.26–1.69)
55–64	1.00	1.00
Education		
Some college or more	0.91 (0.81–1.03)	0.90 (0.79–1.02)
HS graduate or less	1.00	1.00
Time since hire*		
Less than 1 year	1.98 (1.59–2.46)	1.73 (1.22–2.47)
1–2 years	1.88 (1.54–2.31)	1.52 (1.20–1.92)
2–3 years	1.30 (0.99–1.72)	1.27 (0.95–1.71)
3–5 years	1.49 (1.26–1.76)	1.28 (1.07–1.54)
5+ years	1.00	1.00
Time in current job		
0–12 months	1.96 (1.66–2.31)	2.62 (2.10–3.27)
12 + months	1.00	1.00
Physical demand*		
Very heavy	5.18 (3.41–7.87)	4.34 (2.75–6.86)
Heavy	4.19 (2.88–6.11)	3.77 (2.52–5.64)
Medium	2.95 (2.03–4.34)	2.62 (1.77–3.87)
Light	2.56 (1.74–3.76)	2.14 (1.44–3.18)
Sedentary	1.00	1.00
Race		
Black	0.88 (0.75–1.03)	1.02 (0.86–1.22)
Hispanic	1.48 (1.17–1.88)	1.50 (1.17–1.93)
Other	0.95 (0.55–1.63)	0.78 (0.45–1.37)
White	1.00	1.00
Plant type		
Primary smelter	1.00	1.00
Secondary smelter	0.73 (0.66–0.80)	0.85 (0.77–0.95)

[a]*Note*: OR, odds ratio; CI, confidence interval. Odds ratio of 1.00 denotes the reference group.
[b]Full model which includes sex, age, education, race, location, time since hire, time in current job, and physical demand score.
**P* value (homogeneity) <0.001.

TABLE V. Multivariable Logistic Regression for Only OSHA Recordable Injuries Among Hourly Manufacturing Workers, N = 7,387*

	Multivariable odds ratios	95% confidence interval[a]
Sex		
Female	1.72	1.34–2.20
Male	1.00	
Age category		
18–24	1.88	1.12–3.17
25–34	1.73	1.26–2.37
35–44	1.47	1.12–1.92
45–54	1.47	1.15–1.87
55–64	1.00	
Education		
Some college or more	0.91	0.75–1.10
HS graduate or less	1.00	
Time since hire		
Less than 1 year	2.30	1.40–3.78
1–2 years	1.62	1.15–2.90
2–3 years	1.38	0.91–2.09
3–5 years	1.03	0.76–1.39
5+ years	1.00	
Time in current job		
0–12 months	2.73	1.91–3.90
12+ months	1.00	
Physical demand		
Very heavy	4.14	2.13–8.06
Heavy	3.69	2.09–6.51
Medium	2.23	1.28–3.86
Light	1.58	0.91–2.76
Sedentary	1.00	
Race		
Black	0.85	0.64–1.12
Hispanic	1.30	0.88–1.93
Other	1.13	0.52–2.46
White	1.00	
Plant type		
Primary smelter	0.81	0.44–1.51
Secondary smelter	1.00	

*The total N excludes all of the workers who had first aid injuries.
[a]Full model which includes sex, age, education, race, location, time since hire, time in current job, and physical demand score. Smoking was not statistically significant and was not included in the final model.

are needed to explore the impact on injured workers who remain in the workforce and the impact on productivity, employee well-being, and presenteeism, that is, the phenomenon whereby workers report to work but cannot function at their full capacity.

We found that time since hire and time in current job were both important risk factors for injury. This is consistent with prior studies that found an association between injury and job tenure. However, prior studies have mainly explored either duration of employment or time in job, rather than multiple levels of job tenure in the same model [Collins et al., 1999a,b; Schoemaker et al., 2000; Oh and Shin, 2003; Breslin and Smith, 2006]. We found that the odds ratio for injury occurrence was greater if an employee was employed in his or current job for less than 1 year, independent of the total amount of time employed with the company. This finding indicates that employee training may need to be at the point of job change, in addition to at the start of employment. More research is needed to corroborate this finding and to explore potential effective interventions aimed at job tenure, in addition to company tenure.

Since we used the physical demand measure rather than the job title, no job specific analyses were performed. An employee's job was defined according to a company-level standardized classification system, which allowed for comparisons across plants. However, this system may raise questions about our ability to make comparisons between our data and other studies that have used widely available measures such as the Bureau of Labor Statistics Standardized Occupational Codes (BLS SOC). At its most broad level, the job titles are directly comparable to the BLS SOC. The added benefit yielded by use of these data is the ability to move beyond general classifications to more refined and detailed description of jobs, down to the level of the grade of the job. This information is very useful in highlighting not only the most risky jobs according to job title titles, but also whether risk of injury relates to the grade within the job. These types of analyses are more challenging to conduct with population-based survey data for which detailed job information is unavailable.

Differences in risk of injury were noted for specific workers. The odds ratios for injury were greater for females than for males, even after statistically adjusting for potential confounders. Although research supports increased risk of injury for women in manufacturing, the explanation for the difference is not clear [Warner et al., 1998; McCurdy et al., 1989; Islam et al., 2001]. Future studies of the magnitude and causes of disparities in occupational injuries by sex are planned, with particular attention to job demands. The influence of the distribution by sex among physical demands has been shown as an important confounder in previous research [Smith and Mustard, 2004]. The distribution of women in jobs by demand was different than that for men, and the risk of injury varied by gender when we controlled for job demand. We are currently working to refine our measure of demand and we are planning to study how psychosocial stress impacts injury, with attention to gender differences.

The odds ratio for injury in the multivariable model was also significantly higher for Hispanic employees when compared with White employees. Prior research supports higher injury rates for Hispanic and Latino employees, especially in construction and agriculture [McCurdy et al., 2003; Brunette, 2004; Brunette, 2005]. We are currently expanding our collection of data on race and ethnicity and studies of differences by sociodemographic factors are planned.

Study limitations

While we were able to successfully create a database by linking various company databases, there are some limitations to our use of this method. First, with a heavy reliance on administrative files, issues related to data quality are a concern, especially reporting quality generally; the resulting database is only as good as the separate parts used to build it. Each of the databases used are subject to routine audits by company personnel in which completeness of injury and event reporting is emphasized and rated. Although routine audits and checks occur to ensure accuracy and completeness of data, possible key entry errors or other inaccuracies may complicate linking multiple databases. These concerns must be recognized as further studies seeking to use company datasets are conducted.

As with studies using existing data, missing data are a concern. We do believe that the injury files were complete, and since we explored all injuries we captured even those that may have been downgraded in terms of severity (e.g., deciding to provide first aid over medical treatment for a laceration). Although the personnel and injury files were complete, we were missing data for variables collected during the medical record abstraction. Our analysis of the missing data did not yield patterns supporting systematic differences that warranted concern.

There were a number of variables that we did not include in the present analysis because they were either not available for all of the included plants or because of concerns related to statistical power. We did not include any information about the injury experience prior to the study period because injury surveillance data were not available during this time for all of the plants in this research. Since research shows that injury history is an import predictor of injury, the risk estimates in this study may actually be underestimates of the true odds of injury. As more data becomes available, we intend to look at history of injury on the risk of subsequent injury.

Lastly, we did not explore job change during the study period. For this analysis, a worker's job was classified at only one time point. Thus, it is possible that an employee changed jobs and the job that the injury occurred in was not the same job recorded as baseline. Concerns regarding job change is however minimal, since close review of the data in the human resources indicated that many employees may have changed grade for a particular job, but the job title remained the same. Nevertheless, the issue of job change in relation to injury needs further examination, especially as time on the job is, itself, an apparent risk factor for injury.

SUMMARY

In conclusion, occupational injury surveillance systems can further injury prevention by illuminating the distribution and frequency of injuries, identifying high-risk groups, and evaluating the effectiveness of occupational injury interventions. However, by itself, injury surveillance systems are narrow in terms of included measures, and the ability to explore a number of potential risk factors may be hindered. Linking injury data to employer administrative files allows assemblage of information on measures that might potentially confound an association between a particular risk factor and injury [Cullen et al., 2006]. Moreover, linkage of various files maintained by employers, such as those mentioned in this study, could also permit the multi-level analysis of individual-level and ecological-level measures on the risk of injury along with studies that distinguish job effects from plant effects.

Clearly, we benefited from the close academic and industry partnership that resulted in the opportunity to link the various databases. Since data availability to researchers is often a barrier to workplace studies, the significance of this partnership cannot be overstated. While it was time consuming to build trust, work with employer leadership and union leaders, develop data use agreements and identify the most relevant research topics and data, the benefits of such a partnership have begun to outweigh the initial start-up investment.

ACKNOWLEDGMENTS

The authors wish to acknowledge the careful review of this research and manuscript by Dr. Karen Bandeen-Roche, Dr. Gary Sorock, Professor Susan Baker, and the Alcoa Occupational and Environmental Health Advisory Committee. This study was supported by National Institutes for Health F31KD068940; the National Institutes for Occupational Safety and Health 5-R01-OH-04040; the Donaghue Foundation, the Network on Socioeconomic Status and Health of the John D. and Catherine T. MacArthur Foundation, and continuing support from Alcoa.

REFERENCES

Baldwin ML, Butler RJ. 2006. Upper extremity disorders in the workplace: Costs and outcomes beyond first return to work. J Occup Rehabil 16:303–323.

Breslin FC, Smith P. 2006. Trial by fire: A multivariate examination of the relation between job tenure and work injuries. Occup Environ Med 63:27–32.

Brunette MJ. 2004. Construction safety research in the United States: Targeting the Hispanic workforce. Injury Prev 10:244–248.

Brunette MJ. 2005. Development of educational and training materials on safety and health: Targeting Hispanic workers in the construction industry. Fam Community Health 28:253–266.

Burdof A, Sorock GS, Herrick RF, Courtney TK. 1997. Advancing epidemiologic studies of occupational injury—Approaches and future directions. Am J Ind Med 32:180–183.

Burdorf A, Sorock GS. 1997. Positive and negative evidence of risk factors for back disorders. Scand J Work Environ Health 23:243–256.

Collins JW, Smith GS, Baker SP, Landslittel DP, Warner M. 1999a. A case–control study of forklift and other powered industrial vehicle incidents. Am J Ind Med 36:522–531.

Collins JW, Smith GS, Baker SP, Warner M. 1999b. Injuries related to forklifts and other powered industrial vehicles in automobile manufacturing. Am J Ind Med 36:513–521.

Cullen MR, Vegso S, Cantley L, Galusha D, Rabinowitz P, Taiwo O, Fiellin M, Wennberg D, Iennaco J, Slade MD, Sircar K. 2006. Use of medical insurance claims data for occupational health research. J Occup Environ Med 48:1054–1061.

Forst LS, Hryhorczuk D, Jaros M. 1999. A state trauma registry as a tool for occupational injury surveillance. J Occup Environ Med 41:514–520.

Friedman LS, Forst L. 2007. Occupational injury surveillance of traumatic injuries in Illinois, using the Illinois trauma registry: 1995–2003. J Occup Environ Med 49:401–410.

Islam SS, Velilla AM, Doyle EJ, Ducatman AM. 2001. Gender differences in work-related injury/illness: Analysis of workers compensation claims. Am J Ind Med 38:84–91.

Johantgen M, Trinkoff A, Gray-Siracusa K, Muntaner C, Nielsen K. 2004. Using state administrative data to study nonfatal worker injuries: Challenges and opportunities. J Safety Res 25:309–315.

Kines P, Spangenberg S, Dryreborg J. 2007. Prioritizing occupational injury prevention in the construction industry: Injury severity or absence. J Safety Res 38:53–58.

Layne LA, Pollack KM. 2004. Nonfatal occupational injuries from slips, trips, and falls among older workers treated in hospital emergency departments, United States 1998. Am J Ind Med 46:32–41.

Lipscomb HJ. 2000. Effectiveness of interventions to prevent work-related eye injuries. Am J Prev Med 18:27–32.

Lombardi DA, Pannala R, Sorock GS, Wellman H, Courtney TK, Verma S, Smith GS. 2005. Welding related occupational eye injuries: A narrative analysis. Injury Prev 11:174–179.

McCall BP, Horwitz IB. 2006. An assessment and quantification of the rates, costs, and risk factors of occupational amputations: Analysis of Kentucky workers' compensation claims, 1994-2003. Am J Ind Med 49: 1031–1038.

McCurdy SA, Schenker MB, Lassiter DV. 1989. Occupational injury and illness in the semiconductor manufacturing industry. Am J Ind Med 15:499–510.

McCurdy SA, Samuels SJ, Carroll DJ, Beaumont JJ, Morrin LA. 2003. Agricultural injury in California migrant Hispanic farm workers. Am J Ind Med 44:225–235.

Mueller BA. 2001. Data linkages and using administrative and secondary databases. In: Rivara FP, Cummings P, Koepsell TD, Grossman DC, Maier RV, editors. Injury control: A guide to research and program evaluation. Cambridge: Cambridge University Press. pp 47–63.

Mujuru P, Singla L, Helmkamp J, Bell J, Hu W. 2006. Evaluation of the burden of logging injuries using West Virginia workers' compensation claims data from 1996 to 2001. Am J Ind Med 49: 1039–1045.

Oh JH, Shin EH. 2003. Inequalities in nonfatal work injury: The significance of race, human capital, and occupations. Soc Sci Med 57: 2173–2182.

Ruser JW. 1999. The changing composition of lost-workday injuries. Monthly Labor Rev Online 122:11–17.

Schoemaker MJ, Barreto SM, Swerdlow AJ, Higgins CD, Carpenter RG. 2000. Non-fatal work related injuries in a cohort of Brazilian steelworkers. Occup Environ Med 57:555–562.

Segui-Gomez M, MacKenzie EJ. 2003. Measuring the public health impact of injuries. Epidemiol Rev 25:3–19.

Smith PM, Mustard CA. 2004. Examining the associations between physical work demands and work injury rates between men and women in Ontario, 1990–2000. Occup Environ Med 61:750–756.

Sorock GS, Smith GS, Reeve GR, Dement J, Stout N, Layne L, Pastula ST. 1997. Three perspectives on work-related injury surveillance systems. Am J Ind Med 32:116–128.

United States Department of Labor Employment and Training Administration. 1986. Physical demands characteristics (PDC). In: U.S. Department of Labor Dictionary of Occupational Titles, 4th ed. Washington DC: U.S. Department of Labor Employment and Training Administration.

Warner M, Baker SP, Li G, Smith GS. 1998. Acute traumatic injuries in automotive manufacturing. American Journal of Industrial Medicine 34:351–358.

Wigglesworth E. 2006. Occupational injuries by hour of day and day of week: A 20-year study. Aust NZ J Public Health 30:505–508.

Wong TY, Lincoln A, Tielsch JM, Baker SP. 1998. The epidemiology of ocular injury in a major U.S. automobile corporation. Eye 12:870–874.