

Laceration Injuries Among Workers at Meat Packing Plants

Chunbo Cai, MD, MPH,^{1,2} Melissa J. Perry, ScD, MHS,^{1*} Gary S. Sorock, MS, PhD,³
Russ Hauser, MD, ScD, MPH,¹ Kathleen J. Spanjer, MA,⁴
Murray A. Mittleman, MD, DrPH,^{1,5,6} and Terry L. Stentz, PhD, MPH, CPE⁴

Background Employees in meat packing experience one of the highest occupational laceration injury rates in the US.

Method A retrospective study was conducted using OSHA 200 injury and illness logs and First Reports of Injury from two large US meat packing plants from 1998 to 2000. The total workers observed during the study period ranged between 2,449 and 2,682 per year.

Results Laceration injury incidence rates in Plant 1 were 14.0 injuries per 200,000 person hours (per 100 workers per year) in 1998, 11.5 in 1999, and 8.3 in 2000, whereas in Plant 2 the overall incidence rate was 3.7 in 1998, 4.8 in 1999, and 3.0 in 2000. Laceration injury rates in Plant 2 were close to the expected OSHA recordable laceration injury rate in 1999 (3.0 per 100 workers per year), but Plant 1 was considerably higher. Plant 1 had a kill support department, and removed animal hides whereas Plant 2 did not. Handheld non-powered tools were the most common contact objects whereas the slaughter department had the highest number of injuries. Finger injuries from a handheld non-powered tool were the most frequent.

Conclusions Findings confirm the high rate of injury from laceration in this industry and indicate hazard varies across time into shift, task being performed, and type of tool being used. Am. J. Ind. Med. 47:403–410, 2005. © 2005 Wiley-Liss, Inc.

KEY WORDS: lacerations; meat packing; occupational injury; OSHA logs; shift work; traumatic injury; injury epidemiology

INTRODUCTION

Meat packing plants (SIC 2011) had a non-fatal injury and illness incidence rate of 20.0 (95% CI 18.0, 22.0) per 100 workers (equivalent to 200,000 person-hours) in 2001 [Bureau of Labor Statistics, 2004]. The meat packing injury and illness rate was 3.5 times higher than the total injury and illness rate (5.7; 95% CI 5.6, 5.8) for all US private industries in 2001, and ranked third among all industry sectors.

The Bureau of Labor Statistics captures detailed nature of injury data (e.g., cuts and punctures) only on cases involving at least 1 day away from work (DAW). These DAW cases are approximately a 20% sub-set of all recordable cases according to the Occupational Safety and Health Administration (OSHA) guidelines. The cut/puncture nature of injury category includes lacerations. Amputation cases, including

¹Harvard School of Public Health, Boston, Massachusetts

²Lahey Clinic Medical Center, Burlington, Massachusetts

³Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

⁴University of Nebraska, Lincoln, Nebraska

⁵Beth Israel Deaconess Medical Center, Boston, Massachusetts

⁶Harvard Medical School, Boston, Massachusetts

M.J.P.'s institution at the time of the research.

Contract grant sponsor: Liberty Mutual Harvard Program in Occupational Safety and Health (pilot grant).

*Correspondence to: Melissa J. Perry, ScD, MHS, Occupational Health Program, Harvard School of Public Health, 665 Huntington Avenue, Bldg. 1-1413, Boston, MA 02115.

E-mail: mperry@hsph.harvard.edu

Accepted 3 February 2005

DOI 10.1002/ajim.20157. Published online in Wiley InterScience (www.interscience.wiley.com)

finger-tip lacerations, are classified separately from lacerations and were not captured in this study. Hereafter all cuts, punctures, and lacerations will be referred to collectively as lacerations. The incidence rate of DAW laceration injury cases in meat packing plants (SIC 2011) was 0.63 in 1998, 0.56 in 1999, and 0.46 in 2000 per 100 workers per year.

Efforts to control laceration injury rates in the meat packing industry have focused primarily on the use of personal protective equipment (PPE) including such items as metal mesh gloves, plastic arm and belly guards, and protective eyewear [OSHA, 2004]. Work method and tool safety training have also been targeted in an attempt to reduce laceration injury risk [NIOSH, 2004]. However, injury risks remain high and progress in reducing laceration injuries has been limited by the lack of specific and current epidemiological data on risk factors for acute injury in the US meat packing industry. One of the only published studies that systematically evaluated meat packing lacerations was conducted two decades ago. Estimating US meat packing injury rates using Bureau of Labor Statistics data between 1976 and 1981, they showed an all injury incidence rate of 31.4/100 meat packing workers per year as compared to 12.2/100 manufacturing workers per year [Pezaro, 1984]. Among all injuries reported between 1976 and 1981, knives/saws were the most common source of injury (22.6%); stuck by an object was the most frequent type of injury (24.8%); finger was the most common body part injured (24%); and sprain/strain and cut/laceration were the most frequent nature of injury (31.1% and 30.5%, respectively).

A study of the Canadian meat packing industry published over a decade ago [Novek et al., 1990] reported the number and rate of upper limb injuries, including acute and cumulative trauma cases, increased from 12.7 per 100 workers per year in 1982 to 14.7 per 100 workers per year in 1986. Data available from only one plant showed 20% of all injuries were musculoskeletal injuries to the hands, fingers and wrists, whereas lacerations to the same body parts comprised almost 15% of all injuries. Industry-wide data showed mechanization and line speed increases had increased output per person hour from 83.6 pounds in 1980 to 102.8 pounds in 1986 and Novek et al. [1990] posited that output increases were contributing to the observed injury rate increases.

A New Zealand (NZ) study used hospital discharge data 1979–1988 from NZ public hospitals to identify meat workers with fractures, dislocations, open wounds, amputations, contusions, superficial crushing injuries, and sprains/strains of the forearm, wrist and hand [Laing et al., 1997]. Number and rate of hospitalized meat workers increased from 97 (3.3 per 1,000) in 1979 to 135 (5.3 per 1,000) in 1988. Workforce size decreased from 29,481 (1979) to 25,585 (1988). Of the hospitalized cases, 72% were due to cutting or piercing instruments and 20% were machinery related. Open

wound was most common in 88% of cases. 65% of injury records in the three plants involved the fingers, and or/lower arm. Chain mesh gloves and plastic arm guards were the PPE most often required.

Descriptive studies characterizing meat packing laceration injury rates in the US, coupled with measures of effectiveness and economic feasibility of novel intervention techniques, could be of considerable economic and occupational health value in light of the hazardous nature of meat cutting work. This study focused on quantifying laceration injury incidence rates and describing types and sources of laceration injuries to provide up to date data on laceration injuries in the US meatpacking industry.

METHODS

Study Design and Population

The objective of this retrospective study was to determine laceration injury rates and to identify potential risk factors for laceration injuries among meat packing employees. The study involved the voluntary participation of two meat packing plants in the Midwest, specializing in pork processing. The University of Nebraska—Lincoln Institutional Review Board approved the protection of human subjects protocol used in the study. The plants provided copies of the OSHA 200 injury and illness logs, and First Reports of Injury for a 3-year period, 1998, 1999, and 2000. An OSHA log entry and a First Report of Injury for a laceration was initiated if the injury required more than first aid. If an employee had to have a butterfly bandage or any type of suture applied, or if prescription medications were required, the case would be considered OSHA recordable. Only a subset of these recordable injuries results in a full lost day from work and thus are not directly comparable with day-away-from work laceration cases. The database included any employee who had sustained a laceration injury in the 3-year period, including cut or puncture. On average 6,500–8,500 hogs were processed per day in each of the two plants. For this study, only injured employees from first shift were analyzed because the majority of production line employees worked first shift (65% in Plant 1 and 76% in Plant 2).

The bulk of first shift operations in the two plants occurred in three production departments: kill/slaughter, kill/support, and cut. The kill/slaughter department is similar in both plants. Hogs are herded into the production line single file from holding pens, stunned, shackled by the hind leg and hung vertically, bled, and prepared for further processing. Most of the production processes use an overhead chain line. Animals move through the line hung vertically head down. Work is chain line paced. The carcasses are scraped, cut open, clipped, gutted, trimmed, cleaned, and split into two halves in a single long, fast-moving process (approximate rate 4.5 s per

task per hog). Prepared hanging carcasses are moved into walk-in coolers for overnight cooling and conditioning necessary for the cut process.

Referred to as the “hot side,” the kill/slaughter work environment is noisy, bloody and slippery. Noise levels above 95 dB are common. Production line employees wear hearing protection, hard hats, steel mesh gloves and clothing, rubber gloves, eye protection, plastic arm guards, rubber aprons, heavy plastic belly guards, and rubber boots. Workers stand 2–4 feet apart, many on elevated metal grate platforms as hanging carcasses or product move in front of them along the chain line. The concrete and tile floors are slippery. Ambient air temperature can range from 75 to 100°F depending on the season. Processing tools and equipment include manual knives, powered knives, saws, hydraulic clippers and pullers. Some jobs do not utilize tools, and all grasping, pulling, stripping, and tearing is accomplished with gloved hands and fingers.

In Plant 1 the kill/support department performed further processing by cutting and skinning the hide from the animal by means of handheld powered knives and hydraulic hide-pullers while the animal hangs in a vertical position on the chain line. Plant 2 did not remove the hides from the animals. Therefore, there was no kill/support department in Plant 2.

Both Plants 1 and 2 had a cut department or “cold side.” Cooled and conditioned hanging carcasses are removed from coolers and cut into various types of meat including loins, butts, ribs, hams, and chops. Initial cutting is accomplished with powered saws. A variety of handheld powered and non-powered knives are used to make finer, more intricate cuts. Fat trimming is a major operation using powered rotating blade knives, stationary skinning machines, and handheld knives. Ambient room temperature can range from 38 to 42°F. Workers wear similar kinds of PPE as in the “hot side” with the addition of heavier insulating clothing, hoods, gloves, and boots. The concrete and tile floors are slippery from water, meat, and fat scraps that fall to the floor or overflow from conveyor belts and product tubs. Most workers stand elbow to elbow on metal grate platforms, on both sides of fast-moving horizontal conveyor belt lines. Work is conveyor line paced.

Study Variables

Each plant provided the number of employees by gender, department, and the number of person-hours worked on first shift for each of the 3 years, 1998, 1999, and 2000. Information was taken from the OSHA logs and First Reports of Injury and categorized into the following variables: age, gender, plant site, date of injury, time of injury, start time, first break, lunch time, and anatomical injury location. Each OSHA laceration injury was treated as a separate event.

Job task information was grouped into larger department categories as follows: slaughter: duties related to driving and slaughtering hogs, removing all product from hog. Kill/support: jobs related to the kill floor such as removing/scalding and processing of the hide. Cut: basic dissection and boning of cleaned, chilled carcass into individual pieces of meat. Injury object information was grouped into larger contact object categories as follows: handheld non-powered knife/tool: any handheld knife or tool not mechanized such as straight knife, chisel, box cutter, or pry bar. Stationary powered equipment: floor-mounted powered equipment. Handheld powered knife/tool: mechanized tools including air knife, scribe saw, grinder and wizard knife. Miscellaneous protrusion/edge: metal, wood, poly-vinyl chloride (PVC) pipe, or other sharp objects.

Statistical Methods

The characteristics of the injured workers are presented as mean and standard deviations (SD) or summarized as percentages. Descriptive analyses were used to identify tools involved in injuries and most frequently injured body parts. The rate of laceration injury per 200,000 person-hours (equivalent to injuries per 100 full-time workers per year) was calculated by dividing the number of laceration injuries by the number of hours worked and then multiplying by 200,000; [OSHA Incidence Rate = $(N/EH) \times 200,000$] where: N = number of injury cases in the first shift; EH = total hours worked by all employees in the first shift; and 200,000 was based on 100 equivalent full-time workers (40 hr, 50 weeks per year). These analyses were conducted using SAS version 8.0 [2002].

The calculated rates were stratified by gender, department, and year of observation for each plant. Statistical differences in incidence rates by gender and by department were calculated with a Chi-square test ($\alpha = 0.05$) using STATA v.8.0 [2003]. Rate ratios and their 95% confidence intervals were also calculated using STATA. The timing of laceration injury was evaluated throughout the shift by plotting the number of injuries by the hour into the shift.

RESULTS

In years 1998 through 2000, Plant 1 employed a mean of 1,188, 1,273, and 1,366 workers, respectively, whereas Plant 2 employed a mean of 1,261, 1,273, and 1,316 workers, respectively. In the 3-year period, 599 laceration injury cases were reported in the OSHA 200 logs and First Reports of Injury on the first shift in the two plants combined. Because all injuries were entered as separate log entries, this total includes individuals experiencing more than one injury and individuals who were injured on different occasions. The demographic and occupational characteristics of the injured

TABLE I. Demographic and Occupational Characteristics of Laceration Cases Among Workers in Pork Processing Plants (1998–2000)

Characteristic	n = 599 (%) ^a
Age (years) mean ± SD (35 ± 9.68)	
<25	94 (15.7)
25–34	194 (32.4)
35–44	215 (35.9)
45–54	78 (13.0)
55+	13 (3.0)
Gender	
Male	476 (79.5)
Female	123 (20.1)
Regular job	
No	62 (10.0)
Yes	537 (90.0)
Time of injury	
Before 12:15 p.m.	347 (63.0)
After 12:15 p.m.	177 (37.0)
First break (15 min)	
8–9 a.m.	177 (31.7)
9–10 a.m.	381 (67.5)
Other	5 (0.8)
Lunch break (30 min)	
11:00 a.m.–12:15 p.m.	552 (98.4)
Other	9 (1.6)
Employment	
Duration mean ± SD (weeks) 65 ± 85.82	
≤6 months	158 (26.4)
>6 months, ≤1 year	58 (9.7)
>1 year, ≤5 years	183 (30.6)
>5–39 years	199 (33.3)

n, number of injuries.

%, % of total injuries.

^aTotals may not sum to 599 due to missing data for some variables.

cases are presented in Table I. Injured workers' ages ranged from 18 to 67 years and the mean age was 35 years (SD, 9.68). There were 444 cases from Plant 1 and 155 from Plant 2. The mean duration of employment was 65 months (SD, 85.82 weeks). Five hundred thirty-seven cases (90%) were injured performing their regular job, whereas 62 (10%) were injured performing a non-regular job. Five hundred sixty-five (95.3%) cases started the shift between 6:00 and 7:15 a.m. Each worker took a 15-min break in the morning. Three hundred eighty-one cases (67.5%) took their first break between 9 and 10 a.m., 177 (31.7%) between 8 and 9 a.m., 5 (0.8%) at a later time and there were no data available on the first break for 33 injured workers. Typically, a 30-min mass relief lunch break was scheduled for workers between 11:00 a.m. and 12:15 p.m. (n = 552, 98.4%), with nine workers (1.6%) having their lunch break at a later time. No

TABLE II. Laceration Injury Incidence Rates* by Year, Plant, Gender and Major Departments Among Workers in Two Pork Processing Plants

Year	1998		1999		2000	
Plant number	1	2	1	2	1	2
Gender ^a						
Male	16.6	3.7	12.8	5.3	10.5	3.1
Female	18.7	3.8	8.4	3.0	4.2	2.7
Department						
Slaughter	40.0	7.1	36.4	7.7	18.4	6.6
Kill/support	38.4	—	50.1	—	18.2	—
Cut	12.8	4.0	3.3	6.5	10.5	3.1

*Rates per 100 full-time workers per year (200,000 hr).

^aMale and female incidence rates differ significantly ($P < 0.05$) in Plant 1 in all 3 years and only in 1999 in Plant 2.

data were available on lunch break time for 38 injured workers. The workforce included a variety of racial/ethnic backgrounds, including Caucasian (non-Hispanic white; 40%), Hispanic (30%), Vietnamese (25%), Bosnian (2%), Laotian (1%), and Russian (1%) (data not shown; percentages are approximate).

Table II details laceration injury incidence rates by gender and major department. Overall incidence rate of laceration injury in Plant 1 was 14.0 injuries per 100 workers in 1998, 11.5 in 1999, and 8.3 in 2000. The overall incidence rate in Plant 2 was 3.7 in 1998, 4.8 in 1999, and 3.0 in 2000. The overall incidence rates in Plant 1 were higher than Plant 2 for all years combined: 11.1 versus 3.8 per 100 workers, rate ratio of 2.9 (95% CI 2.4–3.5, $P < 0.0001$). A downward trend was seen in rates over the 3-year-time period for Plant 1 but not for Plant 2. Male and female incidence rates differed significantly in Plant 1 in all 3 years ($P < 0.05$) and only in 1999 in Plant 2 ($P < 0.05$).

Table III details the distribution of laceration injuries by major department, injury location and contact object. Handheld non-powered tools were the most common contact objects whereas the slaughter department had the highest number of injuries. Finger injuries from a handheld non-powered tool were the most frequent.

The number of laceration injuries occurring in each hour of the first shift is shown in Figure 1. The mean duration into the shift at the time of injury was 4.6 hr (SD, 2.8). The total number of hourly injuries peaked between the 4th and 5th hr and peaked again between the 7th and 8th hr into the shift. The decrease between the 6th and 7th hr corresponds with the lunch break time. There appeared to be some variability in the timing of these injuries across departments. For example, the number of laceration injuries in the kill/support department peaked only slightly at the 4th hr then showed a large increase between the 8th and 9th hr.

TABLE III. Laceration Injuries by Contact Object, Major Department and Location Among Workers in Two Pork Processing Plants (1998–2000)

	Contact object n (column %)				Total n (% of total) ^b
	Handheld nonpowered knife/tool	Stationary powered equipment	Handheld powered knife/tool	Miscellaneous protrusion/edge	
Department (n = 463) ^a					
Slaughter	187 (56.1)	19 (37.2)	12 (22.2)	6 (24.0)	224 (48.3)
Kill	57 (17.1)	7 (13.7)	34 (62.9)	15 (6.0)	113 (24.4)
Cut	89 (26.7)	25 (49)	8 (14.8)	4 (16.0)	126 (27.2)
Total	333	51	54	25	463
Injury location (n = 549) ^c					
Finger	215 (58.4)	55 (64.7)	45 (83.3)	19 (44.1)	334 (60.8)
Hand	50 (13.5)	11 (13.0)	5 (9.2)	5 (11.6)	71 (12.9)
Lower arm	70 (19.0)	6 (7.1)	3 (5.5)	2 (4.6)	81 (14.7)
Head	12 (3.2)	9 (10.7)	0 (0)	12 (27.9)	33 (6.0)
Lower extremity	21 (5.7)	3 (3.5)	1 (1.8)	5 (11.6)	30 (5.4)
Total	368	84	54	43	549

n, number of injuries.
 %, % of total injuries.
^aTotal injuries for which department data were available.
^bDoes not add to 100% due to rounding.
^cTotal injuries for which location data were available.

Distribution of Laceration Injuries by Hours into Shift

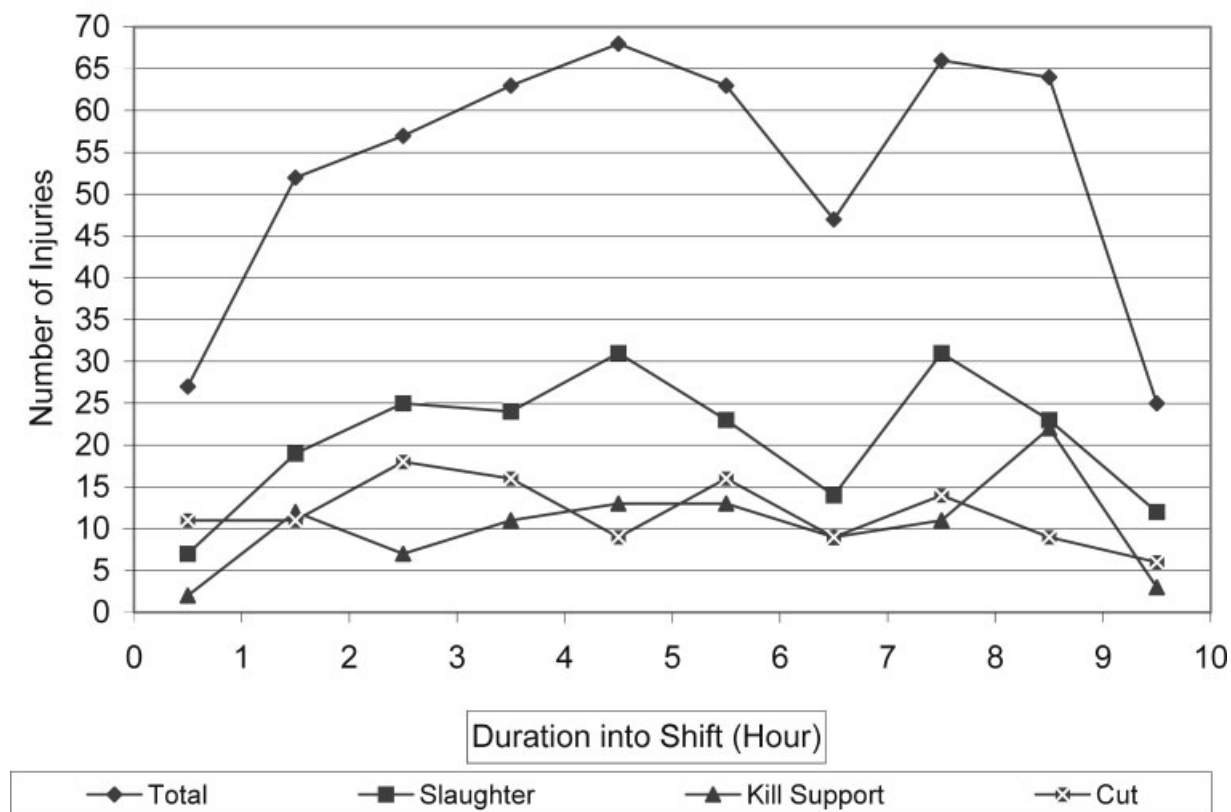


FIGURE 1. Distribution of laceration injuries by hours into the work shift among pork processing workers (N = 599) 1998–2000.

DISCUSSION

During the 3-year study period covered by this report (1998–2000), the rates of all reported laceration injuries were much higher (ranging from 3 to 50 per 100 workers) than previously reported industry averages (0.6 days-away-from work (DAW) cases per 100 workers in 1999). A large part of the difference in rates in the present report is due to case definition differences. Bureau of Labor Statistics (BLS) data only provide details on nature of injury for those cases with one or more lost work-days. Only about 20% of all OSHA recorded cases in meatpacking in 1999 resulted in lost workdays. Assuming the same percentage holds for laceration injuries (20%), the expected rate would be at most 3.0 laceration injuries per 100 workers per year in this study. The rates for Plant 2 were about what would be expected (3.8 per 100) based on national data for meatpacking, whereas the rates for Plant 1 were considerably higher (11.1 per 100).

Incidence rates were significantly lower in Plant 2 than Plant 1 throughout the 3-year period. One possible explanation for this difference is that Plant 2 did not have a kill support department, which had the highest laceration incidence rate in Plant 1. However, the incidence rates in Plant 2 were also lower in other departments as compared to the corresponding departments in Plant 1. Information provided by the plants indicated Plant 2 had a longer history of an active safety program than Plant 1. Plant 1 management reported they had experienced a staff shortage during at least one point in the observation period. Unfortunately systematic data were not kept on these events when they occurred during the observation period, which prevented more detailed study of the effect these events may have had on the injury rates observed.

It may be that the BLS rates are not necessarily the appropriate standards to use in comparing these particular plants. Meat-processing plants across the country have different configurations of their work-units depending upon the plants' products. The industry average rates were calculated by pooling the person-hours and number of injuries from the entire industry. This method does not provide information on major differences across plants in terms of product type, capacity, scale of operation, production demands, degree of automation and safety programming. The BLS incidence data are not parsed finely enough to provide information on the many differences across this hazardous, yet diverse industry.

Overall, the injury rates were higher in males than in females. While no data are available specific to US meatpacking, prior data on upper extremity lacerations by gender show that men have almost fifty percent higher rates (per 100 person workyears) of emergency department-treated occupational finger injuries (1.0 in men) than women (0.6) [CDC, 1983]. This difference may be related to

differential task assignment with higher inherent laceration risk although this could not be evaluated in our study. Detailed characterization of job tasks by gender should lend insight into the gender differences in injury rates observed here. Additionally, because the slaughter and cut departments generated high incidence rates overall, further department-level study may highlight work environment-specific risk factors in those departments, and how they may be differentially distributed across gender.

Sixty-three percent of injuries occurred in the morning and peaked twice during the first shift. The first peak was 4–5 hr into the shift, while the second peak occurred 7–8 hr into the shift and was smaller than the first peak. Associations between temporal factors and occupational injury patterns have been reported in other industries. Hamelin [1987] examined lorry drivers' accident risk as a function of how much time had elapsed since their last rest break. It was noted that the risk in the first 4 hr was higher than in all subsequent hours unless the drivers had been working for more than 12 hr. Wojtczak-Jaroszowa and Jarosz [1987] studied glass factory and steel plant workers and found clear hourly fluctuations in the frequency of accidents in both plants with a peak just before noon, which corresponded with the lunch break. After the break, the accident frequency rose again, followed by a gradual drop throughout the afternoon and evening. Authors reported a direct relationship between number of accidents and level of activity in the plants. Ong et al. [1987] reported two injury peaks, the major one between 9 and 10 a.m. and the minor one between 2 and 3 p.m. during a 7 a.m.–3 p.m. work shift in an iron and steel mill. Folkard [1997] observed that injury risk peaked between 2 and 4 hrs into a task and referred to this time on task effect as "black times." Hanecke et al. [1998] reported injury increases between 6 and 11 a.m. and again between 2 and 7 p.m. in 12 hr shifts with the majority of the workers starting work between 6 and 8 a.m. A decrease in accident frequencies at common work break times was observed at 9 a.m. and between 12 and 1 p.m. They also showed a strong interaction effect for hours at work by time of day. With later starting times, the relative accident risk increased beyond the 8th hr at work. Oginski et al. [2000] have reported that internal factors such as fatigue, and external factors such as physical environment, influenced time-related injury risk in continuous shift work. Despite this information available from prior descriptive studies, the underlying causes of such increases in risk remain unclear.

This study's finding that finger injury was the most frequent injury location is consistent with reports from other industries. It has been reported that the hand is the most common anatomical site to be injured at work in the iron and steel industries [Ong et al., 1987]. Sorock et al. [2002] reported that laceration injury was the most common type of hand injury at work across a wide variety of industries and the distal part of the finger (the finger tip) was the body part most

often lacerated [Sorock et al., 2004]. Innovations in personal protective equipment for meat cutters to reduce the risk of both hand laceration and cumulative trauma should be the focus of new research. Additionally, ways in which meat packing tasks and tools can be redesigned to reduce laceration risk need evaluation.

The OSHA 200 log or First Report of Injury is an underestimate of the total number of cases, as has been demonstrated for work-related musculoskeletal disorders in automobile manufacturing [Silverstein et al., 1997]. Underreporting of lacerations in this industry may be less likely because the injury is clearly work-related and cut workers are required to leave the line so that blood-borne contamination of the product (or vice versa) does not occur. Nonetheless, it remains possible that workers do not report minor cuts and punctures and therefore the rates reported may be an underestimate of the true laceration rates in the plants.

Because denominators were not available to calculate rates for some of the exposures of interest, we were only able to report the frequency of injuries according to these factors. For instance, the number of workers using non-powered handheld tools at the plants was not available to calculate an injury rate specific to this type of tool. It remains unclear whether these types of tools inherently increase risk of injury.

Department specific information was not available on variation in job assignment, tool use, break time, finish time, work loads, nor time to put on and take off PPE. Therefore these factors could not be taken into account in this report and results should be interpreted with this limitation in mind. Another note of caution concerns the categorizations used to group department job tasks and contact objects from the log reports. Categorization was based largely on ease of interpretation, and these categories need to be applied to other meat packing settings to determine their applicability across the industry.

Concerning injuries during the course of the work shift, the number of workers on the job was assumed to remain constant throughout the shift based on their reported break times which did not vary widely among workers (e.g., 98% reported taking lunch break between 11 a.m. and 12:15 p.m.). However, this number could not be tracked precisely and therefore some possibility remains that fluctuations in staffing during the shift could have contributed to the injury patterns observed.

CONCLUSIONS

Laceration injuries in meat packing plants remain high despite current safety interventions, especially in work departments where job tasks include inherent risks such as knife use or fine cutting. Because the plants have already had

PPE programs implemented, this problem needs more in-depth prospective study to explore the role of temporal, transient and fixed risk factors in affecting risk of laceration injuries. An increased knowledge of modifiable risk factors will better enable the meat packing industry to develop proactive laceration injury prevention programs.

ACKNOWLEDGMENTS

The authors are thankful to Ann Backus and Rachel Pescatore for administrative support, and to all of the plant personnel for their assistance in making the data available for this study.

REFERENCES

- Bureau of Labor Statistics (BLS). 2004. web site: <http://stats.bls.gov/iif/oshwc/osh/case/ostb1038.txt>, www.bls.gov/iif/oshwc/osh/os/ostb1109.txt, www.bls.gov/iif/osh_rse.htm. and <http://stats.bls.gov/iif/oshwc/osh/os/ostb0882.pdf>. Accessed August, 2004.
- Centers for Disease Control. 1983. Occupational finger injuries-United States, 1982. *MMWR* 32(45):589-591.
- Folkard S. 1997. Black times: Temporal determinants of transport safety. *Accid Anal Prev* 29(4):417-430.
- Hamelin P. 1987. Lorry drivers' time habits in work and their involvement in traffic accidents. *Ergonomics* 30:1323-1333.
- Hanecke K, Tiefemann S, Nachreiner F, Grzech-Sukalo H. 1998. Accident risk as a function of hour at work and time of day as determined from accident data and exposure models for the German working population. *Scand J Work Environ Health* 24(Suppl 3): 43-48.
- Laing RM, Burrige JD, Marshal SW, Keast DE. 1997. Hand and lower arm injuries among New Zealand meat workers and use of protective clothing. *N Med J* 110:358-361.
- National Institute for Occupational Safety and Health (NIOSH). 2004. web site: <http://www.cdc.gov/niosh/docs/2004-135/casestudies/meat-Processing.html>. Accessed September, 2004.
- Novek J, Yassi A, Spiegel J. 1990. Mechanization, the labor process, and injury risks in the Canadian meat packing industry. *Intl J Health Serv* 20(2):281-296.
- Occupational Safety and Health Administration (OSHA). 2004. web site: <http://www.osha.gov/Publications/osha3108.pdt>. Accessed November, 2004.
- Oginski A, Oginska H, Pokorski J, Kmita W, Gozdzia R. 2000. Internal and external factors influencing time-related injury risk in continuous shift work. *Int J Occup Saf Ergon* 6:405-421.
- Ong CN, Phoon WO, Iskandar N, Chia KS. 1987. Shiftwork and work injuries in an iron and steel mill. *Appl Ergon* 18(1):51-56.
- Pezaro A. 1984. Critical review analysis for injury related research in the meatpacking industry (SIC 2011), NIOSH. Cincinnati, OH: US Department of Health and Human Services. 66p.
- Silverstein B, Stetson D, Keyserling W, Fine L. 1997. Work-related musculoskeletal disorders: Comparison of data sources for surveillance. *Am J Ind Med* 31:600-608.

- Sorock GS, Lombardi DA, Hauser RB, Herrick RF, Mittleman MA. 2002. Acute traumatic occupational hand injuries: Type, location, and severity. *J Occup Environ Med* 44(4):345–351.
- Sorock G, Lombardi D, Peng D, Hauser R, Eisen E, Herrik R, Mittleman M. 2004. Glove use and the relative risk of acute hand injury: A case-crossover study. *J Occup Environ Hygiene* 1:182–190.
- StataCorp. 2003. Stata statistical software: Release 8.0. College Station, TX: Stata Corporation.
- SAS Institute, Inc. 2002. Statistical analysis software, version 8.0. Cary, NC: SAS Institute, Inc.
- Wojtczak-Jaroszowa J, Jarosz D. 1987. Time-related distribution of occupational accidents. *J Saf Res* 18:33–41.