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Risk Factors for Lacerations in Meatpacking

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RO1 OH 008174
2007-2012

March 12, 2012

Abstract

The U.S. animal slaughtering and processing industry employed approximately 500,000 workers in 2009 and this industry has one of the highest injury rates nationwide. Although cuts to the upper extremities are one of the most common types of occupational injuries, their causes have not been well determined. This research project investigated the causes of laceration injuries in meat processing. The project was based in two pork processing plants in Nebraska and Iowa. Over 900 cut injuries were recorded during the study period and close to 300 workers were interviewed about their injury experiences. Our study found that there were clear associations between specific events just prior to the injury and the actual risk for injury. Specifically, workers were more likely to be cut on the job right after performing unusual tasks, sharpening knives, or experiencing equipment malfunctions. Rushing, being distracted, or being tired were not found to be associated with the occurrence of cut injuries. Knives were not the only source of cuts, and workers were cut on a wide variety of other sharp edges found in the plants such as steel edges, blades, guards, and tools. Other studies we conducted in this occupational setting as part of this project found that injuries occurred during predictable times of day, particularly preceding break times and end of shift, and that while depressive symptoms were prevalent among workers (12% overall; 8% men and 20% women), having depressive symptoms did not appear to increase the risk of cut injuries.

These findings have critical implications for the meatpacking industry. Work structure, training, and staffing can be redesigned to reduce equipment malfunctions, having undertrained workers performing tasks they are not prepared for, and redesigning how knives are sharpened. We are now in the next phase of this work which is to use engineering principles to redesign workplaces to reduce sharpening and equipment hazards. The meatpacking industry can incorporate this risk factor analysis into work flow, timing, staffing, training, and management decisions to ultimately reduce the high rate of cut injuries in this high risk industry. Methodologically, this study produced important findings about the relevance of transient (time sensitive) risk factors in increasing injury risks and the utility of the case crossover method for studying occupational injuries.

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Final Report March 2012

Section 1.
Significant (Key) Findings:

Cut injuries are frequent in the meatpacking environment; their rates are higher than the across industry rates.

There are specific transient (i.e., time dependent and frequently changing) exposures in the meatpacking environment that increase the risk of cut injuries.

Meatpacking workers are more likely to get cut when they are sharpening their knives.
Meatpacking workers are more likely to get cut when they experience an equipment malfunction.
Meatpacking workers are more likely to get cut when they are using a work method they typically do not use.
Meatpacking workers are more likely to get cut when they are performing tasks they do not usually perform.
The results did not provide evidence that workers are more likely to get cut when they are tired, distracted on the job, or rushing on the line.

Knives are not the only source of cuts in the meatpacking work environment.
Only a third of meatpacking injuries are caused by knives. The remaining two thirds are caused by other sources of sharps that are ever present in the work environment, including other tools, edges, guards, and blades.

A case crossover design, which allows comparison between what a worker is doing right before a work injury, compared to what they typically do while working, can provide important information on transient (i.e., time dependent and frequently changing) job exposures that increase the risk for injury.

Translation of Findings:

These findings can be adapted in the workplace. Specifically:

Safety teams in meatpacking plants can identify and prevent equipment malfunctions. This can avoid workers having to perform unusual tasks, such as unjamming equipment, that lead to cut injuries.

Work configuration should be structured to avoid putting workers on to tasks they do not routinely perform. Task experience counts in terms of reducing cut injuries. Workers should gain experience over time, in modified work settings while in training, before they are put onto a job for which they are not prepared.

Safety teams in meatpacking plants can identify the multiple sources of sharp edges that are ever present in the work environment and these can be removed or modified so as not to pose a cut risk.

Sharpening was strongly associated with injury, however the cuts did not appear to happen while workers were actually sharpening their knives. Safety teams can work with mechanical engineers to design a workplace that paces the practice of sharpening, that standardizes the type and placement of sharpeners, and that frees up the workers hands while they are sharpening and while they are transitioning from one cut of meat to the next.

Outcomes/Impact:
These are the first findings on causes of cut injuries in meatpacking. If the above recommendations are adapted in meatpacking plants, potential outcomes are the reductions in cut injuries to workers. Meatpacking plants can incorporate these changes immediately; however they should be evaluated by tracking cut injuries so that reductions can be measured. An intermediate outcome of this work is we have used these findings to design a corrective action plan and a workplace engineering design plan that can be implemented in the meatpacking environment to reduce and ultimately remove these specific sources of cut injuries. These plans are ready for adoption by plants, and we were are currently working on strategies for implementation in the workplace.

Section 2.
The specific aims of this study were to:
1.) Evaluate associations between upper extremity (UE) laceration injuries sustained by meatpacking workers and transient worker-related factors, such as:
a) personal protective equipment use; b) rushing, distraction, and working on an unfamiliar task; and c) UE pain.

2.) Evaluate associations between UE laceration injuries sustained by meatpacking workers and ergonomic/job design factors, such as:
a) staffing level; b) work with dull knives; and c) safety training.

Detailed below is a description of the work accomplished on the aims of the project.

Settings and Plant Description. This study was conducted at two pork-processing plants in Nebraska and Iowa with occupational health and safety (OHS) clinics and on-site nurses. The Nebraska plant had approximately 1,400 employees and processed 10,000 hogs per day. The Iowa plant had approximately 1,300 employees and processed 9,200 hogs per day. Both plants had two production shifts, with major cut/kill operations conducted during the first shift. 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 was similar in both plants. Hogs were 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 used an overhead chain line. Animals move through the line hung vertically head down. Work was chain line paced. The carcasses were scraped, cut open, clipped, gutted, trimmed, cleaned, and split into two halves in a single long, fast-moving process (approximate rate 4.5 seconds per task per hog). Prepared hanging carcasses were moved into walk-in coolers for overnight cooling and conditioning necessary for the cut process.

Data collection. All workers reporting to the plant OHS clinic for treatment of a "cut" injury were considered eligible to participate. After providing treatment, clinic personnel recorded the nature of injury in our study treatment log and then a study recruiter extended the opportunity to participate in the study. Once recruited, an English or Spanish speaking interviewer called the worker at home within 14 days of injury using a structured questionnaire. The worker was considered unreachable after 5 call-backs. Interviewers were trained by individual instruction, detailed questionnaire review, and by administering telephone interviews with a senior researcher posing as an injured worker. The completed questionnaire was then reviewed and the interviewer was provided feedback. Practice interviews were repeated as necessary. In addition, interviewers toured one of the plants to become familiar with the setting and different work processes.

Prior to interviewing, research personnel answered any outstanding questions, emphasized confidentiality, and verified the date, time, and nature of injury. The interview collected information on fixed characteristics of the worker and the work-site, as well as the occurrence of fixed and transient exposures that may have contributed to the injury. The selection of fixed exposure variables was modeled after a previous case-control study of occupational hand injury (Hertz and Emmett, 1986) and a cross-sectional study of hand lacerations and job design in line-paced assembly (Bell and MacDonald, 2003). The selection of transient exposure variables was modeled after previous studies of transient risk factors for hand injury. These studies taken together served as the empirical basis for selecting candidate fixed and transient risk factors.

Case Crossover Results from Final Analyses of Transient Risk Factors (Lander et al., Occ Environ Med, in press).

A total of 936 meatpacking workers experienced laceration injuries during the study period and 295 injured workers (32%) were interviewed (Table 1).

Table 1. Characteristics of 295 meatpacking workers with a laceration injury at two Midwestern pork-processing plants, U.S. 2006-2009

Characteristic	Value
Age, years, mean (SD)	36.6 (11.2)
Education, years, mean (SD)	11.1 (6.1)
Grade school (1-8 years), n (%)	76 (26)
High school (9-12 years), n (%)	149 (51)
University (≥13 years), n (%)	65 (22)
Gender, female, n (%)	75 (25.4)
Race/Ethnicity, n (%)	
Hispanic	140 (47.5)
White, non-Hispanic	134 (45.4)
Black	12 (4.1)
American Indian/ Alaskan Native	1 (0.3)
Asian	4 (1)
Refused/ Other	4 (1)
Upper extremity pain, numbness, tingling, n (%)	50 (17.1)
Job experience, n (%)	
≤1 year	88 (30)
1 – 4 years	76 (25.8)
> 4 years	96 (32.5)
Safety Training	
None	30 (10.2)
Classroom only	21 (7.1)
On the job only	100 (33.9)
Both classroom and on the job	93 (31.5)
Other	20 (6.8)

* Totals do not add up to 295 due to missing data.

The mean age of the workers was 36.6 years (SD 11.2). The majority of workers had a high school education (51%), and 75% were male. The percentages of White, non-Hispanic and of Hispanic workers were similar: 48% and 45%, respectively. The percentage of workers with tenure of less than one year was similar to that of workers with tenure of more than four years, 30% vs. 33%, respectively. Approximately 34% of workers reported having only on-the-job training; 7% had only classroom training; and 32% had both classroom and on-the-job training.

Sixty workers (20%) were recruited from the hot production side, 179 (61%) from the cold production side, 23 (8%) from the maintenance department, and 16 (5%) from quality assurance and/or sanitation. A specific work location was not given for 17 workers.

Workers were asked to report all PPE items worn when the injury occurred and whether those items were required for their specific jobs (Table 2).

Table 2. Type of personal protective equipment required and used at time of injury by 295 workers at two Midwestern pork-processing plants, 2006-2009.

Personal protective equipment (PPE) item	**Number of workers required to wear PPE items for their specific jobs/tasks N (%)***	**Number of workers who used the required PPE items at injury time N (%)****
Reusable gloves†	96 (32.5)	71 (74.0)
Disposable gloves†	105 (35.6)	81 (77.1)
Metal mesh gloves	107 (36.3)	64 (59.8)
Cotton gloves	147 (49.8)	104 (70.7)
Plastic arm guard	66 (22.4)	43 (65.2)
Metal mesh apron	28 (9.5)	22 (78.6)
Rubber apron	52 (17.6)	38 (73.1)

* Percent of workers who were required to wear each PPE item was calculated from the total number of workers (n=295). Workers are required to wear more than one type of PPE so these percentages total to more than 100%.
** Percent of workers who used each PPE item at the time of injury was calculated from the total number of workers required to wear each item.
† Disposable gloves are similar to standard surgical gloves. Reusable gloves are made from thicker rubber and are similar to household cleaning gloves.

For example, 147 workers (50%) were required to wear cotton gloves; of these, 104 (71%) wore them at the time of injury. Twenty-eight workers (10%) were required to wear a metal mesh apron for torso protection; of these, 22 (79%) wore it at the time of injury. Among the workers required to wear specific PPE items, reported usage ranged from 79% of workers wearing the metal mesh apron to 60% wearing metal mesh gloves when the injury occurred (Table 2). These metal mesh gloves were the least utilized required item at the time of injury. Glove use was not examined as a transient risk factor in the case-crossover analyses because the majority of workers wore them while working; thus the exposure remained fixed between the hazard and control periods.

Sharpening (RR 5.3, 95% CI:3.8-7.4) and equipment malfunction (RR 5.3, 95% CI:3.9-7.3) were associated with the highest relative risks for laceration injury, followed by using an unusual work method to accomplish a task (RR 4.1, 95% CI:2.6-6.4) and performing an unusual task (RR 2.3, 95% CI:1.8-3.0) (Table 3).

Table 3. Number of workers exposed to each transient risk factor, the number of hours exposed and the estimated relative risks of laceration injury of 295 workers at two Midwestern pork-processing plants, 2006-2009

Exposure	Number of subjects exposed just before the injury N (%)	Number of hours exposed in week prior to injury Mean (SD)*	RR (95% CI)**
Sharpening†	44 (15.0)	2.1 (6.7)	5.3 (3.8 - 7.4)
Equipment malfunction	26 (8.8)	1.1 (5.6)	5.3 (3.9 – 7.3)
Using unusual work method	16 (5.4)	1.0 (5.6)	4.1 (2.6 – 6.4)
Performing unusual task	45 (15.3)	3.6 (9.2)	2.3 (1.8 – 3.0)
Being tired	25 (8.5)	3.5 (8.5)	1.2 (0.8 – 1.8)
Being distracted	13 (4.4)	1.9 (6.9)	1.1 (0.6 – 1.9)
Rushing	66 (22.4)	10.8 (15.6)	0.8 (0.7 – 1.1)

* The estimated average number of hours included participants who reported zero hours of each exposure.

** RR, relative risk; CI, confidence interval.

† The duration of each episode was assumed to last 10 seconds.

The reasons for malfunctioning equipment reported by 32 workers in the narrative text sections of the interview included new equipment (n=5); jammed (n=6); dull knives, blades, or hooks (n=6); product fell or stuck (n=2); sharp edges (n=2); door or lid malfunction (n=3); no gloves or machine guard (n=2); and other (n=6). Seventeen workers reported using unusual work methods; these included malfunctioning or new equipment (n=3), difficulties keeping up with line speed (n=3), different equipment or location on the line (n=3), being new at the job (n=2), using a non-dominant hand (n=2), feeding product into machine differently (n=1), product harder to process (n=1), and cleaning or other (n=2).

Sixty-six workers (22%) reported that they were rushing just before the laceration injury occurred. Rushing was also the most frequently reported exposure independent of the hazard period prior to injury; workers reported rushing an average of 10.8 hours per week (SD 15.6). Because rushing was frequently reported during both the control and hazard periods, it was not significantly associated with the incidence rate of laceration injury (RR 0.8, 95% CI:0.7-1.1). Self-reported reasons for rushing (reported by 104 workers, including those not rushing at injury time), included line speed (n=46), preparing to go home or on break (n=15), pressure from supervisor and/or coworkers (n=12), general rushing (n=12), setting up the line or cleanup (n=9), performing an unfamiliar task, unjamming, or line delay (n=7), understaffing (n=3), and inexperience with work (n=3).

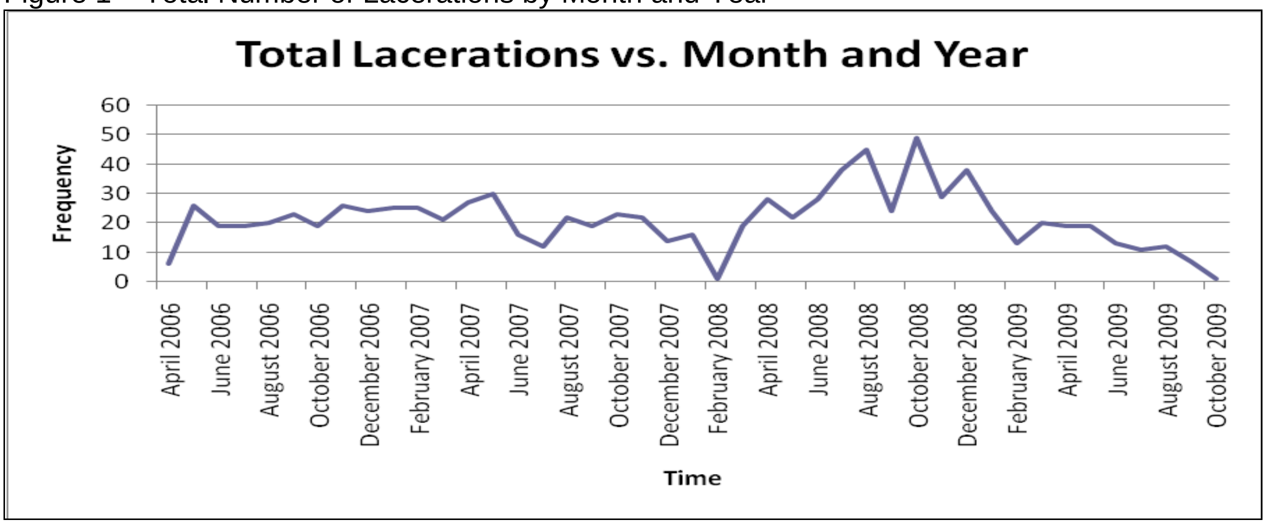
Following rushing, performing an unusual task (45 workers, 15%, RR 2.3, 95% CI:1.8-3.0) and tool sharpening (44 workers, 15%, RR 5.3, 95% CI:3.8-7.4) were the most frequently reported exposures just before the injury. Unusual tasks were reported by 43 workers and included machinery maintenance or repair, (n=7), unjamming (n=6), job rotation or replacing another employee (n=6), using a different machine or tool (n=5), pushing or pulling product or containers (n=5), cutting or sorting (n=4), changing blades (n=3), new task, job, or training another employee (n=2), housekeeping (n=2), and other (n=3).

Being distracted was not significantly associated with the incidence rate of laceration injury (RR 1.1, 95% CI: 0.6-1.9). Reasons for being distracted were reported by 27 workers and included line speed (n=3), external factors such as looking around or noise (n=7), talking with coworkers (n=7), internal reasons such as thinking or being tired (n=9), and removing gloves (n=1).

Slipping was associated with an over 100-fold increase in the risk of laceration injury, and falling was associated with an over 5000-fold increase in the risk of laceration injury (data not shown). Because both of these events occurred very infrequently (at injury time, 3% of workers reported slipping and 3% reported falling), the confidence intervals for these estimates were very wide. Reasons for slipping or falling were reported by 15 workers and included floor conditions such as fat or water (n=5), working or walking (n=4); ladder or scaffolding (n=3), rushing (n=2), and losing awareness (n=1).

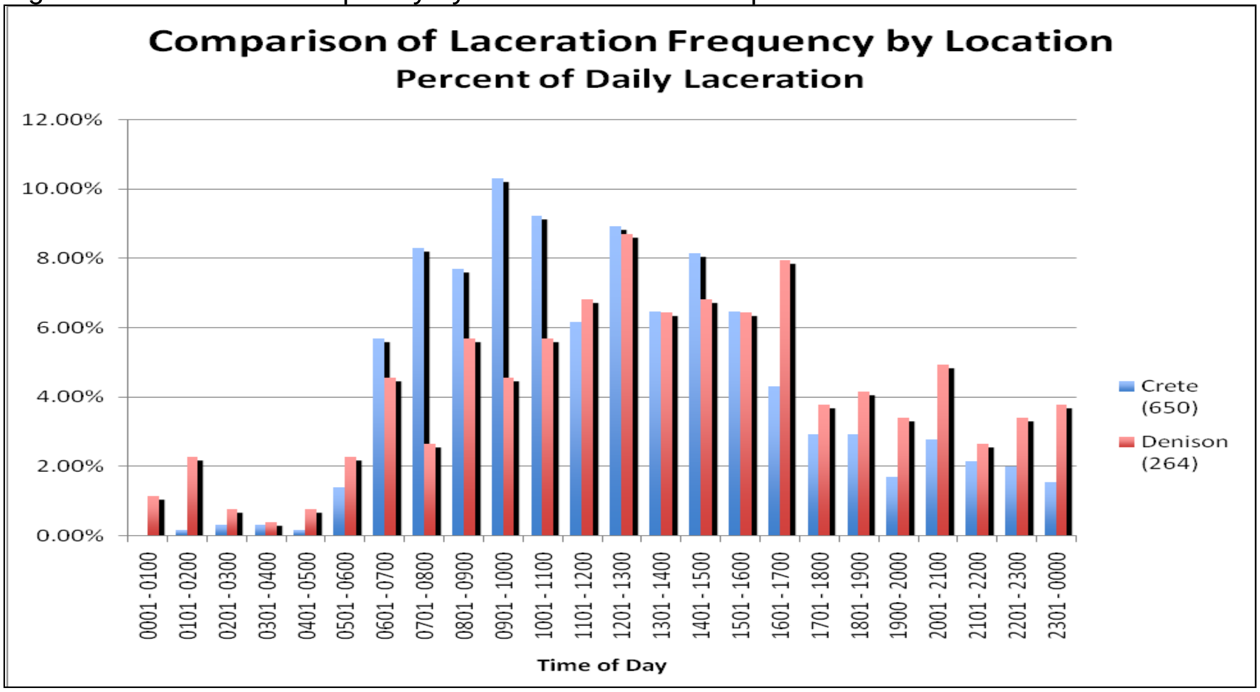
Results from Analyses of Time Trends for Lacerations Injuries (*Herstein et al., under review*). Collection of data on over 900 laceration injuries has allowed for systematic analysis of injury patterns including month and year, time of day and break time analysis. Lag-time models using time series analysis is being applied to determine whether there are predictable times of the month, year, or day or whether there are critical risk periods during which injuries are more likely to occur.
An ARMA model was used to describe the time series of total lacerations occurrences for both plants compared to month and year. Further analysis of these models revealed an ARMA(p,q) model for Plant 1 an ARMA(p,q) model for Plant 2, and an ARMA(p,q) model for the total number of lacerations (Figure 1).

Figure 1 – Total Number of Lacerations by Month and Year



A comparison between the two plants showed that the Nebraska plant had higher lacerations between 7-11am whereas the Iowa plant had higher frequencies at noon and 4-5pm, indicative of break and shift transition times. Based on the model, the system was found to be asymptotically stable or have the ability to recover from disturbances after approximately 50 weeks. Findings also indicate an increased risk for laceration injury during the summer months when many pork processing plant employees take advantage of vacation time. The model was further analyzed in terms of the spring-mass-damper system to find that injuries will decrease if the amount of time given to complete tasks is increased. These findings indicate that changes in task speed can potentially decrease meatpacking lacerations injuries.

Figure 2 – Laceration Frequency by time of date for each plant



Results from Analyses examining depressive symptoms among pork processing workers (Lander et al., under review). Depressive symptoms were assessed using the Burnam screening tool (6 items from the Center for Epidemiologic Studies Depression Scale and 2 items from the Diagnostic Interview Schedule). Matched case-control analyses were conducted among 142 workers to evaluate the effect of depression on the risk for laceration injury. A total of 404 workers were interviewed (70% male, 44% Hispanic) in two plants. Depressive symptoms were found in 11.9% (n=48) workers: 8% men and 20% women (OR 2.87, 95%CI:1.56-5.29, p<0.01). Hispanic ethnicity was not significantly associated with the presence of depressive symptoms: 19 (11%) Hispanic workers and 29 (14%) non-Hispanic workers reported depressive symptoms (OR 0.74, 95%CI:0.40-1.38, p-value 0.35). Working for more than 35 months (median) was associated with depressive symptoms (16% vs. 8%, OR 2.03, 95%CI:1.08-3.80, p-value 0.027). Presence of depressive symptoms (CESD score $\geq$ 5) was not associated with lacerations: among workers who experienced lacerations, 12% (15) reported presence of depressive symptoms compared to 13% (16) among workers who did not experience such injury (OR 0.81 (0.39-1.69), p-value 0.87; Table 4). Adjusting for age, gender, ethnicity, and job tenure did not change the results.

Table 4: Comparison of injured and non-injured meatpacking workers in Nebraska and Iowa plants, 2005-2008.*

Characteristic	**Injured workers (n=121)**	**Non-injured workers (n=121)**	**P-value‡**
Gender			**0.038**
Male	82 (68%)	67 (55%)	
Female	38 (32%)	54 (45%)	
Age, years, mean (SD)	36 (11)	40 (11)	**0.010**
Education, years, mean (SD)	11 (3.6)	11 (3.5)	0.70
Race/Ethnicity, N (%)			
Caucasian	72 (82%)	72 (84%)	0.71
Black	6 (7%)	3 (3%)	
Other/Unknown	10 (11%)	11 (13%)	
Hispanic, N (%)	58 (48%)	54 (46%)	0.69
Hours per work week, mean (SD)	46 (10)	47 (10)	0.53
Months on the job, mean (SD)	41 (63)	50 (72)	0.37
Sharp object hours, mean (SD)	4.9 (3.9)	5.4 (3.9)	0.29§
Smoker, N (%)	34 (29%)	28 (23%)	0.36
Smoking years, mean (SD)	16 (12%)	16 (11%)	0.89
BMI, mean (SD)	28 (4.7)	28 (5.2)	0.31
Overweight, N (%)	8 (7%)	13 (12%)	0.23
Sleep, hours, mean (SD)	7.3 (1.1)	6.9 (1.0)	0.0006
CESD6 depression score $\geq$ 5	15 (12%)	16 (13%)	0.87

* Non-injured workers were matched to injured workers on work day and plant. For example, if a Nebraska plant worker was injured on Tuesday, June 5, 2007 at 10a.m.; control was recruited in the Nebraska plant and interviewed up to one month after the injury occurred (July 5, 2007). The control was asked about Tuesday at 10 a.m. in the previous work week.

† Odds ratios and corresponding 95% confidence intervals were calculated using univariate logistic regression comparing demographic factors stratified by case status. Controls were the comparison group.

‡ P-values for all continuous variables were calculated using a pooled t-test of statistical significance between the cases and controls. P-values for all categorical or binary variables were calculated using a chi-squared test of significance between cases and controls. Fisher’s exact test was used for strata with 5 or fewer observations.

§ Sharp object hours variable was a response to the question “How many **hours per day** on average do you use a sharp knife /tool/object on your job or work with this equipment?”

We found there was a high prevalence of depressive symptoms among the workers, however these are likely to be non-representative prevalence estimates because the sample was not selected based on having an equal risk for depression. Most importantly, depression was not shown to be a risk factor for occupational laceration injuries. Evaluation of depressive symptom causes among meatpacking plants workers is needed to elucidate prevention and treatment strategies.

Publications

Lander L, Sorock S, Stentz T, Eisen E, Mittleman M, Hauser R, Perry MJ. Validation of self-reported occupational exposures in meatpacking workers. Am J Ind Med 2009 52:707-715.

Lander L, Sorock GS, Stentz TL, Eisen EA, Mittleman M, Hauser R, Perry MJ. A case-crossover study of occupational laceration injuries in pork processing: methods and preliminary findings. Occup Environ Med 2010; 67(10):686-692.

Lander L, Sorock G, Stentz T, Smith LM, Mittleman M, Perry MJ. Transient factors associated with laceration injuries in meatpacking. Occ Enviro Med (in press).

Under Review:

Herstein K, Stentz T, Rajukar P, Lander L, Sorock G, Mittleman M, Perry MJ. A time series analysis of laceration injuries among workers at meat packing plants (under review).

Kim SS, Lander L, Parasam V, Stentz TL, Mittleman MA, Perry MJ. Identifying causes of laceration injuries in meatpacking operations: a mixed method (under review).

Lander L, Sorock G, Stentz TL, Euler M, Herstein K, Mittleman M, Hauser R, Perry MJ. Depressive symptoms among pork processing workers (under review).

Presentations:

Lander L, Sorock G, Stentz TL, Eisen EA, Mittleman M, Hauser R, Perry MJ. A case-crossover study of occupational laceration injuries in pork processing. Presented at 138th American Public Health Association Annual Meeting & Exposition, Denver, CO, November 2010.

Lander L, Sorock G, Stentz TL, Euler M, Herstein K, Mittleman M, Perry MJ. Depressive symptoms among pork processing workers. Presented at 138th American Public Health Association Annual Meeting & Exposition, Denver, CO, November 2010.

Perry MJ, Lander L, Stentz TL, Sorock G, Mittleman MA, Smith LM. A case-control study: Job demand and control, and lacerations among pork-processing workers in the Midwest. Presented at 139th American Public Health Association Annual Meeting & Exposition, Washington, D.C., November 2011.

Lander L, Sorock G, Stentz TL, Herstein K, Smith LM, Mittleman MA, Perry MJ. A case-control study of risk factors for laceration injury among pork-processing workers in the Midwest. Presented at 139th American Public Health Association Annual Meeting & Exposition, Washington, D.C., November 2011.

In Preparation:

Lander L, Sorock S, Stentz T, Mittleman M, Smith LM, Kim SS, Perry MJ. A case-control study of occupational laceration injuries in pork processing.

Kim SS, Lander L, Stentz TL, Sorock G, Mittleman MA, Smith LM, Perry MJ. Job demand and control, and lacerations among pork-processing workers.

Kim SS, Lander L, Stentz TL, Sorock G, Mittleman MA, Smith LM, Perry MJ. The role of rushing in risks for laceration injuries in meatpacking: a mixed methods analysis.

SIGNIFICANCE

Significance of the project is over 900 meatpacking laceration injuries were studied; multiple risk factors for lacerations have been quantified; and now an empirical base exists so that risk factors can be targeted for preventive interventions to reduce the burden of injuries in the high risk occupational industry.

PROJECT-GENERATED RESOURCES

Structured questionnaires, an extensive data base of laceration injury data, and multiple original research reports have been generated from this study.

INVENTIONS AND PATENTS

None

References:

Bell JL, MacDonald LA. Hand lacerations and job design characteristics in line-paced assembly. J Occup Environ Med 2003; 45:848-856.

Hertz RP, Emmett EA. Risk factors for occupational hand injury. J Occ Med 1986; 28:36-41.