Musculoskeletal Disorders and Traumatic Injuries Among Employees at a Poultry Processing Plant

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Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from a poultry processing plant in South Carolina. The request was required by the United States Department of Agriculture/Food Safety and Inspection Service to obtain an evisceration line speed waiver approval as part of its Salmonella Initiative Program. It was submitted to identify the potential for increase in musculoskeletal and upper extremities trauma due to the planned evisceration line speed increase. The interim report describes our evaluation of the plant before the increase.

What We Did

- We visited the poultry processing plant in May and August 2012. We focused on potential ergonomic hazards, carpal tunnel syndrome in the hands and wrists, and traumatic injuries.
- We reviewed 67 job tasks for ergonomic risk factors of repetition and force.
- We collected medical and personnel records to evaluate traumatic injuries and musculoskeletal disorders.
- We gave a questionnaire to production line employees in the Fresh Plant.
- We asked employees about work, medical history, hand and wrist symptoms, other musculoskeletal symptoms, work conditions, job training, work hours, job rotation, and participation in incentive programs.
- We did nerve conduction testing on production line employees to evaluate their median nerve function in the hands and wrists.
- We used the nerve conduction testing results and self-reported hand and wrist symptoms to determine if a person had evidence of carpal tunnel syndrome.
- We looked at medical unit data, employee records, employment histories, and logs of work-related injuries and illnesses.

We evaluated musculoskeletal disorders and traumatic injuries among employees at a poultry processing plant. We found that 42% of participants had evidence of carpal tunnel syndrome on the basis of our case definition and 41% had jobs above the American Conference of Governmental Industrial Hygienists' threshold limit value for hand activity and force. The Fresh Plant's rate of OSHA recordable injuries and illnesses was higher than the poultry processing industry average for 2009–2011. Recommendations are provided to improve work conditions and minimize exposures to factors that increase the risk for musculoskeletal disorders and traumatic injuries.

What We Found

- Most employees reported multiple musculoskeletal symptoms. The most common symptoms involved the hand or wrist.
- Forty-two percent of participants had evidence of carpal tunnel syndrome on the basis of our case definition.
- Forty-one percent of participants worked in jobs above the American Conference of Governmental Industrial Hygienists' threshold limit value for hand activity and force.
- Almost all employees knew how to report injuries at work and most had received training on how to do their job safely to prevent injury.
- The Fresh Plant's rate of OSHA recordable work-related injuries and illnesses was higher than the Bureau of Labor Statistics poultry processing industry average for 2009–2011.

- The onsite medical clinic data shows the proportion of OSHA recordable work-related injuries and illnesses to all work-related injuries and illnesses at the Fresh Plant increased from 2009–2011.
- The Fresh Plant had a decreasing rate and frequency of OSHA recordable work-related injuries and illnesses from 2009–2012.
- The work-related injuries by cause were generally "fall/slip/trip," "cut/puncture/scrape," "repetitive motion," or "caught in/under/between."

What the Employer Can Do

- Implement the OSHA Guidelines for Poultry Processing and recommendations from industry groups to prevent musculoskeletal disorders.
- Design or redesign job tasks so that they are below the American Conference of Governmental Industrial Hygienists' threshold limit value for hand activity and force.
- Until the redesign is completed, use a job rotation schedule where employees rotate to jobs that are below the American Conference of Governmental Industrial Hygienists' threshold limit value for hand activity and force.
- Ensure that employees are using sharp knives for cutting.
- Provide more than one break during the work schedule.
- Enhance reporting, screening, and medical assessment onsite to improve early intervention of musculoskeletal disorders and traumatic injuries.
- Use good housekeeping procedures (e.g., repair holes/depressions in the floor, remove poultry parts on the floor, and excess water on walking surfaces, repair drain coverings, and remove wash hoses and extension cords from walkways) to reduce fall/slip/trip injuries.

What Employees Can Do

- Report symptoms and injuries as soon as they occur to supervisors and onsite medical staff.
- Use only sharp knives for cutting.
- Make sure the standing platforms are adjusted to the correct height to do your job.
- Report potential fall/slip/trip hazards to supervisors so they can be quickly addressed.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
AL	Action Limit
BLS	Bureau of Labor Statistics
CFR	Code of Federal Regulations
DSI	Design Systems Inc.
FSIS	Food Safety and Inspection Service
FTE	Full-time equivalent
HAL	Hand activity level
IPM	Intelligent portion machines
ms	Milliseconds
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
STS	Standard threshold shift
TLV®	Threshold limit value
TWA	Time-weighted average
USDA	United States Department of Agriculture

Introduction

The Health Hazard Evaluation Program received a request from a poultry processing plant in South Carolina in April 2012. Managers at the plant submitted the request as part of a United States Department of Agriculture Food Safety and Inspection Service (USDA/FSIS) requirement to receive an evisceration line speed waiver under the Salmonella Initiative Program [9 CFR 381.3(b)]. In the request, the managers asked NIOSH to identify the potential for increase in musculoskeletal and upper extremities trauma due to a planned evisceration line speed increase. This report describes our evaluation of the plant before the increase.

We made an initial (familiarization) visit to the plant in May 2012 to observe work processes and practices, coordinate data collection plans, and hold confidential employee medical interviews. We sent a letter with our initial findings, recommendations, and plans to management and employee representatives in June 2012. On the basis of information we gathered during the familiarization visit, our review of the scientific literature, and consultation with members of the NIOSH Work Related Musculoskeletal Research Consortium,[1] we developed an evaluation protocol to assess carpal tunnel syndrome and traumatic injuries among employees. The protocol was internally and externally reviewed by scientific experts.

In August 2012, we made a second (baseline) visit to the plant to collect information for determining the prevalence of carpal tunnel syndrome and traumatic injuries before changes were made to the evisceration line speed. This visit included an ergonomic assessment, questionnaire, and nerve conduction tests. We collected Occupational Safety and Health Administration (OSHA) 300 Form Logs of Work-Related Injuries and Illnesses (2009–2012)[2], daily medical unit logs (2009–2012), and 1 month (July 2012) of electronic database records for employee records. In September 2012, we sent a letter to management and employee representatives that summarized this visit and provided additional recommendations.

In February 2013, we sent a letter to the employees who participated in the nerve conduction tests to inform them of their results. We recommended that participants share their results with their physician and seek medical evaluation if they had concerns about their health. We also sent a letter to the company and employee representatives that summarized the nerve conduction test results (without personal identifiers).

[1] A Work Related Musculoskeletal Disorder (WMSD) Research Consortium with the National Institute for Occupational Safety and Health (NIOSH) was formed in 2001 to address the impact of WMSD. Consortium membership includes 11 research groups across the United States.

[2] Recordable cases include work-related injuries and illnesses that result in one or more of the following: death, loss of consciousness, days away from work, restricted work activity or job transfer, medical treatment (beyond first aid), significant work-related injuries or illnesses that are diagnosed by a physician or other licensed heath care professional (these include any work-related case involving cancer, chronic irreversible disease, a fracture or cracked bone, or a punctured eardrum); additional criteria include any needle-stick injury or cut from a sharp object that is contaminated with another person's blood or other potentially infectious material, any case requiring an employee to be medically removed under the requirements of an OSHA health standard, tuberculosis infection as evidenced by a positive skin test or diagnosis by a physician or other licensed health care professional after exposure to a known case of active tuberculosis.

Plant Description

The poultry plant consisted of the Fresh Plant and the Further Processing Plant. The Fresh Plant involved First Processing (receiving through chilling) and Second Processing (post-chilling, deboning, and cut-up). The Further Processing Plant prepared poultry products that involved cooking, marinating, and seasoning. We focused our evaluation on the Fresh Plant because USDA/FSIS staff confirmed the employer's statement that Further Processing Plant operations would not be affected by the proposed change in the evisceration line speed.

During the baseline visit, the plant processed approximately 159,000 birds per day over a 5-day workweek, or approximately 800,000 birds that week. The plant processed birds over 8 pounds in size. Approximately 1,560 full-time employees worked at the plant; 730 worked in the Fresh Plant over two shifts. All Fresh Plant employees typically worked 8-hour shifts with one 45-minute break per 8-hour shift and occasional overtime.

During the baseline visit, First Processing operated two evisceration lines across two shifts. The two evisceration lines were running at 90 birds per minute, less than the maximum speed of 140 birds per minute allowed by USDA/FSIS for a facility of this type. Many of the First Processing job tasks, such as slaughter and evisceration, were automated and involved few employees; exceptions included the live hang area, vent opening, final trim, USDA/FSIS inspector helpers, and the paws (feet) department. Each evisceration line had five live hang contract employees, one backup killer, one vent opener, and two final trim employees. Each evisceration line had four inspector helpers, one for each USDA/FSIS inspector. The vent opener, final trim employees, and inspector helpers rotated every 2 hours. The paws department graded/sorted, bagged, and shipped the chicken feet.

Most Second Processing jobs included hand-intensive, repetitive tasks such as deboning and cut-up. Birds were manually rehung on one of two lines, each running at 35 birds per minute. Four employees worked on each rehang line. The birds were then mechanically separated into the front half (breasts and wings) and back half (thighs and legs).

The front halves were transported to the cone lines for deboning. During our baseline visit, each of five cone lines ran at 35 birds per minute. The cone line tasks included hanger, first cut, wing roller, wing saw, bone checker, breast trimmer, tender cutter, tender clipper, and tender puller. Breast and tender pieces were additionally processed mechanically by either Design Systems Inc. (DSI) machines or Intelligent Portion Machines (IPM). However, these machines required manual loading and grading (product sort). Excess breast and tender pieces were manually cut into nuggets. Employees in the DSI area rotated every 2 hours.

The back halves of the chicken were mechanically separated; legs were packed for shipment, and thighs were deboned. During our baseline visit, thighs were either manually deboned by 15 trimmers or mechanically deboned by 3 machine loaders and 6 trimmers. The thigh trimmers used a Whizard® knife, an air-powered circular trimmer designed for meat cutting.

At the time of our baseline visit, the company had incentive programs for employees in certain jobs. The cone line had a voluntary incentive program where participants in certain skilled jobs (such as first cut) did not rotate to other jobs and received a higher hourly wage. Employees on the cone line, except for those participating in an incentive program, rotated to other jobs on the cone line. The thigh debone incentive was also voluntary and did not include job rotation.

However, incentive pay was based on individual and departmental production rates and product quality. Thigh trimmers were each timed to calculate individual production rates.

Assessment

Ergonomic and Epidemiological Assessment of Carpal Tunnel Syndrome

Ergonomic Assessment

Because we focused our evaluation to address employee concerns of hand and wrist symptoms, we focused our job assessments on ergonomic risk factors based on hand or wrist activity. On the baseline visit, we used the information we had obtained from the familiarization visit to help us to classify jobs based on a combination of repetitive and forceful movements, extreme or awkward postures, and tool use. We identified the more hand-intensive and tool-oriented job tasks and further evaluated those jobs. We used the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV) to determine levels of hand activity and force [ACGIH 2012]. This TLV was validated on carpal tunnel syndrome by Bonfiglioli et al. (2013) who found a dose-response relationship between the TLV classification and risk of CTS. We used the following approach for the selected jobs:

- Hand activity level (HAL): Two NIOSH ergonomists used the HAL scale to rate repetitiveness for right and left hands during at least five complete work cycles. We independently rated each job task. When the ratings differed between the NIOSH ergonomists, we discussed our observations, and came to a joint decision.
- Force: The two ergonomists also rated exertion of the right and left hands using the modified Borg CR-10 scale [Borg 1982]. Similar to the HAL evaluation, we rated the jobs independently, discussed differences, and reached a joint decision.

We used the HAL and force ratings to calculate a ratio using the following formula [Eastman Kodak Company 2004]:

$$\text{Ratio} = \text{Force} / (10 - \text{HAL})$$

If the ratios for the hands were different, we used the more protective (higher) ratio. We used the calculated ratio to determine an exposure value for each job task for comparison to the ACGIH reference values. We classified job tasks by exposure values into the following three groups:

- Ratios below 0.56 were below the Action Limit (exposure Group 1),
- Ratios 0.56–0.78 were above the Action Limit to the TLV (exposure Group 2), and
- Ratios above 0.78 were above the TLV (exposure Group 3).

Epidemiologic Assessment of Carpal Tunnel Syndrome

We invited all first shift Fresh Plant production employees and all first shift contract live hang employees to participate. We developed the case definition for carpal tunnel syndrome on the basis of medical literature [Katz 1990, Rosecrance and Douphrate 2010] and analyses from NIOSH ergonomic musculoskeletal disorders consortium studies [Burt et al. 2011].
To be considered a carpal tunnel syndrome case in our evaluation, participants had to fulfill all of the following criteria:

- Answered "yes" on a questionnaire to pain, numbness, burning, or tingling in the hands or wrist, occurring more than three times **or** lasting 7 days or longer in the past 12 months (since August 2011)

- Marked or shaded the location of their symptoms in the median nerve distribution area on a modified Katz hand symptom diagram
- Had abnormal median nerve conduction (median mononeuropathy) in the affected hand as determined by neurologist-interpreted nerve conduction study.

Questionnaires

Employees gave written informed consent and participation was voluntary. We verbally administered a questionnaire to participants; four requested and were provided Spanish interpretation. The questionnaire provided information on employees' demographics, work history and duties, relevant medical history, neuropathic symptom (pain, burning, numbness or tingling in their hands or wrists) frequency and duration, other musculoskeletal symptoms, and other factors such as training, work hours, job rotation, and incentive programs.

Participants who reported pain, burning, numbness, or tingling in their hands or wrists in the past 12 months on the questionnaire also completed a hand symptom diagram adapted from Katz et al. [1990]. Participants indicated the location of their hand or wrist symptoms by marking or shading areas on the diagrams. These diagrams were used to identify symptoms associated with a classic median nerve distribution. Results from the diagram were classified into four categories: positive right hand, positive left hand, positive for both hands, or negative for both hands. Two NIOSH medical officers independently scored the hand diagrams; a third medical officer resolved the discordant results.

Nerve Conduction Tests

Participants again gave written informed consent. Nerve conduction tests were not conducted on all questionnaire participants because of logistical issues and employee availability. Because we were not able to conduct nerve conduction tests on all questionnaire participants, we used job title and employee description of work tasks to be sure that each job task was represented by some participants. An electrodiagnostic technologist certified by the American Association of Electrodiagnostic Technologists performed nerve conduction tests following established guidelines [American Association of Electrodiagnostic Medicine 1992, 2002]. The technologist did not know the participant's job title, medical information, or questionnaire responses. Participants' hands were warmed to 32 degrees Celsius with a radiant lamp, and median and ulnar orthodromic motor and sensory studies were performed. We measured each nerve conduction test participant's height and weight to calculate body mass index according to the following formula:

$$\text{body mass index} = \text{weight (in pounds)} \times 703 / [\text{height (in inches)}]^2$$

Two board-certified neurologists independently reviewed the nerve conduction test tracings and interpreted results as either normal or abnormal based on established criteria as shown in Appendix A, Table A1 [Burt et al. 2011]. Any discrepancies in interpreted results were resolved by discussion of the two neurologists after the independent readings. Abnormal median nerve conduction was defined as a slowed latency or a decreased amplitude in the median nerve and either (1) normal distal ulnar nerve latency and amplitude or (2) distal median nerve latency greater than ulnar nerve latency.

Traumatic Injuries

We included specific questions related to traumatic injury, safety training, and incident reporting procedures on the questionnaire. We reviewed the plant's OSHA Logs, daily medical unit logs (2009–2012), and 1 month (July 2012) of electronic employee database records. We requested employee database records from the company for 2009–2012, but they were not provided.

Data Analysis

Descriptive data for demographic, occupational, and non-occupational variables are reported as means, frequencies, and percentages. Frequencies and prevalences are reported for carpal tunnel syndrome cases for each exposure group. Prevalence of the individual components that made up the carpal tunnel case definition was also calculated.

Statistical analyses of ergonomic and musculoskeletal-related data were performed using SAS Version 9.3 (SAS Institute Inc., Cary, NC). We used log-binomial regression with the copy method [Deddens et al. 2003] to evaluate the relationship between carpal tunnel syndrome and the exposure groups after adjusting for potential confounders: age, sex, diabetes mellitus, and body mass index. We reported prevalence ratios and 95% confidence intervals. Ninety-five percent confidence intervals that did not include the null value (1) were considered statistically significant.

Onsite medical unit data were analyzed using R statistical software [R Development Core Team 2011].

Results

Ergonomic Assessment

The two ergonomists assessed 67 job tasks in the plant. All HAL and force ratings assessed were within one point of each other on each rating scale. A full list of the assessed job tasks in each group is provided in Appendix A, Table A2. A list of the jobs tasks with assigned exposure values based on our observations during the familiarization visit and previous ergonomic studies [Lipscomb et al. 2008; Cartwright et al. 2012] is provided in Appendix A, Table A3.

Although the ACGIH TLV for hand activity and force is intended for individual jobs, the TLV Documentation states that it can be extended to multi-task jobs by using time-weighted exposures [ACGIH 2012]. On the questionnaire, 130 (41%) employees reported that they rotated job tasks at the plant. We calculated the time-weighted exposures using job task rotation information provided by each employee for an average day. Although some participants indicated that they worked overtime, we did not know what jobs were performed so overtime was not included in the time-weighted exposures. Participants were then grouped into exposure categories using the ACGIH reference values (the Action Limit and threshold limit value). Table 1 shows the distribution of participants by exposure group.

Table 1. Distribution of questionnaire participants by exposure groups (n=318)

Exposure groups	No. (%)
Group 1 (< AL*)	139 (44)
Group 2 (AL– TLV†)	49 (15)
Group 3 (> TLV)	130 (41)

*AL = Action Limit for the ACGIH TLV for hand activity and force

†TLV = ACGIH threshold limit value for hand activity and force

Epidemiologic Assessment of Carpal Tunnel Syndrome

Among the 375 eligible Fresh Plant first shift production employees and live hang contractors, 318 (85%) completed the administered questionnaire. Two hundred eighty four completed nerve conduction tests; one of these nerve conduction tests was not interpretable.

Table 2 shows the demographics and personal characteristics for the participants. The average age was 39 (range: 19–73), and participants were predominantly black or African American (94%). A total of 77 (24%) reported being a current smoker, and 85 (27%) reported using alcohol. A total of 68 (21%) reported regularly doing hand-intensive tasks outside of their job, such as working at home, doing hobbies, playing sports, or working at a second job. Out of 284 participants, 143 (50%) had a body mass index ≥30, which is considered 'obese' [WHO 2009]. Eighteen women reported being pregnant.

Table 2. Demographics and personal characteristics of participants (n=318)

Age (years)	Mean 39 (range:19–73)
	No. (%)
Sex	
Male	95 (30)
Female	223 (70)
Currently pregnant*	18 (9)
Race	
White	13 (4)
Black or African American	298 (94)
Other	7 (2)
Body mass index†	
< 25	62 (22)
25 up to 30	79 (28)
≥ 30	143 (50)
Hand-intensive tasks at home, hobbies, sports, or second job	68 (21)
Hands/wrists	

Ever had an accident or injury	41 (13)
Ever had surgery	22 (7)

*Out of 210 responding females
†Out of 284 measured participants

Table 3 shows the physician-diagnosed medical conditions as reported by participants. Out of 318 participants, 32 (10%) reported that a physician diagnosed them with carpal tunnel syndrome and 1 (0.3%) reported that a physician diagnosed them with kidney failure.

Table 3. Physician-diagnosed medical conditions as reported by participants (n=318)

	No. (%)
Carpal tunnel syndrome	32 (10)
Hand/wrist tendonitis	27 (8)
Thyroid problems	18 (6)
Diabetes mellitus	17 (5)
Trigger finger	14 (4)
Ganglion cyst	8 (3)
Kidney failure	1 (0.3)

Table 4 shows the workplace characteristics of participants such as length of employment, hours worked, hands used most at work, overtime, participation in rotation/incentive programs, and tool use. About 50% of participants used mostly their right hand at work, and about 43% used mostly both hands at work. The participants worked for a mean of 38 hours the week prior to our visit and had been at the plant or any poultry plant for a mean of 9 years. Of 150 (47%) employees who usually worked some overtime, the amount of overtime hours worked ranged from 0.3–18 hours per week with a mean of 7 hours per week.

Table 4. Workplace characteristics of participants (n = 313–318)

Years worked at any poultry plant	Mean 9 (range: 0.008–45)
Years worked at this poultry plant	Mean 9 (range: 0.008–42)
Hours worked last week	Mean 38 (range: 0–56)
	No. (%)
Hand used most to work	
Right	160 (50)
Left	22 (7)
Both	136 (43)
Usually work any overtime per week	150 (47)

Rotate from main job to different job tasks	130 (41)
Participate in an incentive program in main job	185 (58)
Use knife, scissors, Whizard® or other cutting tool in any job	52 (17)

The number of participating employees meeting the case definition for carpal tunnel syndrome was 126 of 301 (42%). We used 301 as our group of workers at risk (denominator) for this calculation. This denominator included all participants with sufficient questionnaire **or** nerve conduction test results to be classified according to the multipart case definition (Appendix B; Figure B1 *Defining a Case of Carpal Tunnel Syndrome among Poultry Employees* provides a more complete explanation). Table 5 shows the prevalence of carpal tunnel syndrome cases among participants by exposure group. Prevalence increased with increasing exposure, rising from 36% in the lowest exposure group to 48% in the highest exposure group.

Table 5. Prevalence of carpal tunnel syndrome among participants by exposure groups (n=301)

Exposure groups	Carpal tunnel syndrome cases No. (%)
Group 1 (< AL*)	48 (36%)
Group 2 (AL–TLV†)	20 (43%)
Group 3 (> TLV)	58 (48%)

* AL = Action Limit for the ACGIH TLV for hand activity and force

† TLV = ACGIH threshold limit value for hand activity and force

We examined several variables found in other studies to be associated with carpal tunnel syndrome. Reporting a physician diagnosis of thyroid problems was not significantly associated with carpal tunnel syndrome (p-value = 0.65). Only one person reported kidney failure; they did not have carpal tunnel syndrome. Reporting having hand-intensive tasks outside of their job (working at home, doing hobbies, playing sports, or working at a second job) was not found to be statistically significantly related to carpal tunnel syndrome (p-value = 0.17).

Table 6. Carpal tunnel syndrome prevalence by exposure group* (n=282)

Exposure groups	Adjusted prevalence	Prevalence ratio	95% Confidence interval
Group 1 (< AL‡)	34%	1	
Group 2 (AL−TLV§)	38%	1.13†	(0.74, 1.57)
Group 3 (> TLV)	54%	1.59†	(1.19, 2.15)

*Adjusted for sex, age, body mass index, and diabetes mellitus
†Group 1 was considered the referent group
‡ AL = Action Limit for the ACGIH TLV for hand activity and force
§ TLV = ACGIH threshold limit value for hand activity and force

Table 6 shows the results from our binomial log-regression model adjusted for sex, age, body mass index, and diabetes mellitus, independent variables known to be associated with carpal tunnel syndrome. The adjusted prevalence of carpal tunnel syndrome in exposure Group 3 was significantly higher than that for Group 1 (PR= 1.59, 95% CI= (1.19, 2.15).

Of 212 participants who had pain, burning, numbness, or tingling in the last 12 months (localized or not localized to median nerve), 150 (71%) reported having these symptoms in the last 7 days. Of those with symptoms within 7 days of our visit, 98 (72%) met the case definition for carpal tunnel syndrome.

Two-hundred and thirteen participants reported pain, burning, numbness or tingling in their hands or wrists in the past 12 months. Of these 213, 143 (67%) participants reported awakening from sleep because of these symptoms. On average, participants who reported these symptoms rated their worst level of discomfort on a scale of 0−10 to be an 8; 62 (29%) rated their worst level of discomfort as a 10. A total of 92 of 212 (43%) reported visiting the plant's medical unit because of these hand or wrist symptoms. Because of these hand or wrist symptoms, 32 (15%) reported missing work, 33 (15%) reported temporary work restrictions, and 7 (3%) reported a permanent change of job.

Of 317 participants who provided sufficient information, 176 (56%) had aching or stiffness in their hands or wrists **and** classic symptoms for carpal tunnel syndrome of pain, burning, numbness, or tingling in hands or wrists. Twenty-nine (9%) participants without classic symptoms for carpal tunnel syndrome reported aching or stiffness.

Of those 27 participants with a previous diagnosis of carpal tunnel syndrome, 17 (63%) met the carpal tunnel syndrome case definition. Of those 21 individuals who reported ever having hand surgery, 11 (52%) met the carpal tunnel syndrome case definition. Of those 64 individuals who reported doing hand-intensive tasks at home, doing hobbies, playing sports, or at a second job, 22 (34%) met the carpal tunnel syndrome case definition.

In addition to hand or wrist symptoms, we also collected information on other musculoskeletal symptoms. The prevalences are shown in Table 7. The prevalence of hand or wrist symptoms was the highest at 213 (67%) with the prevalence of back symptoms following at 185 (58%).

Table 7. Prevalence of musculoskeletal symptoms (n=318)

Body Part	No. (%)
Hands or wrists*	213 (67)
Back†	185 (58)
Shoulders†	160 (50)
Ankles or feet†	124 (39)
Neck†	112 (35)
Knees†	89 (28)
Elbows†	35 (11)
Hips†	31 (10)

*Pain, burning, numbness, or tingling in hands or wrists in the past 12 months

†Pain, aching, or stiffness in the past 12 months

Traumatic Injuries

We asked participants questions about being injured at work (not all participants answered every question, so the denominators vary slightly). When asked if they had been injured at work in this plant during the past 12 months; 22 of 318 (7%) answered yes. When asked about all potential outcomes for work injury responses, 5 (24%) indicated their injury kept them away from work more than a day, 6 (29%) replied their injury led to a work restriction or transfer to another job, and 10 (48%) reported their injury needed medical treatment beyond first aid, one did not provide information on the injury. Two reported they required hospitalization or more than an emergency room visit and one reported loss of consciousness. Twenty-one respondents reported their injury to the employer.

All but one participant indicated they knew how to report an injury at work. When asked about all potential sources of learning about reporting injuries, 198 (63%) learned this at new employee orientation, 204 (65%) learned this from their supervisor, 196 (62%) learned this from safety meetings, and 29 (9%) learned this from another source (e.g., line leader, lead or lead person, co-worker, or other personnel). There were 307 participants (97%) who indicated they knew they were supposed to report injuries to their supervisor. Ten (3%) reported they were supposed to report injuries to the onsite clinic, 3 (1%) replied they were supposed to report injuries to the safety team and 63 (20%) reported “Other” (e.g., lead, lead person, team leader).

When asked about all potential sources for safety training, 287 (90%) reported they received training to do the job safely to prevent injuries. Of those who received training, 174 (61%) indicated they received training at employee orientation when hired, 205 (71%) reported they received training when they first started a new job task, 219 (76%) reported receiving training from their supervisor, 232 (81%) reported they received training at safety meetings and 43 (15%) reported another source of training. Of these 43, 30 (70%) responded that training was received from their lead person or other supervisor.

Table 8 shows that the total OSHA recordable industry-wide poultry processing illness and injury rate for 2011 was 5.8 cases per 100 full-time equivalent (FTE) per year, a unit that indicates the workload of an employed person, down slightly from 5.9 in 2010, but higher than the 5.5 per 100 FTE in 2009 [Bureau of Labor Statistics 2009, 2010, 2011]. The Fresh Plant OSHA recordable

injury rates were higher than the industry-wide rates in all years but 2012. In July 2012, the employee records data indicated 106,848.5 hours worked (regular hours + overtime hours, excluding vacation and holiday hours). Assuming this was similar for all 12 months in 2012, the full-year estimate would be 1,282,182 hours in the year 2012 or 6.41 per 100 FTEs. Rates in 2009, 2010 and 2011 were based on this estimate of hours worked of 6.41 per 100 FTEs.

Table 8. OSHA's Form 300 logs of work-related injuries and illnesses

Year	Fresh Plant injuries and illnesses	Fresh Plant FTE*	Fresh Plant Rate per 100 FTE[3]	Industry-wide Recordable Injury Rate per 100 FTE[§]	Rate ratio
2009	66	6.41	10.29	5.5	1.87
2010	52	6.41	8.11	5.9	1.37
2011	40	6.41	6.24	5.8	1.07
2012†	29	6.41	4.52	5.8‡	0.78

*Extrapolated from the employee records data for July 2012

†24 injuries and illnesses reported by October 27, 2012 (300 days or 82% of the year). Projected = 24* (365/300) = 29

‡2012 BLS industry-wide (poultry processing) data not available; used 2011 data

[§]BLS, 2009, 2010, 2011

Table 9 shows that in 2009, sprain, strain, soreness, and inflammation were the most common "Type" of OSHA recordable injury. In 2010, "hand pain" and "Contusion/abrasion" were the most common types of recordable injury. In 2011, "hand pain" was the most common type of injury and in 2012. "Hearing Loss Standard Threshold Shift (STS)" was the most common type of injury reported on the OSHA Logs.

Table 9. OSHA's Form 300 logs of work-related injuries and illnesses entries by type for years 2009–2012

Type	2009	2010	2011	2012*
Sprain, strain, soreness, inflammation	29	9	0	2
Hand pain	12	12	9	0
Head injury	0	0	1	0
Laceration	11	8	8	5
Contusion/abrasion	9	12	5	1
Fracture	0	3	7	1
Amputation	0	0	1	1
Avulsion	0	0	0	1
Burn	2	1	0	1
Foreign body	1	1	2	0
Hearing loss (STS†)	1	2	6	7

Slips, falls	0	3	1	1
Repetitive - trigger thumb	1	0	0	2
CTS‡	1	0	0	1
Chemical splash to eyes	0	1	0	1
Total entries	67	52	40	24

*Up to November 21, 2012
†STS = standard threshold shift
‡CTS = carpal tunnel syndrome

The onsite medical clinic personnel captured visits to their clinic in an electronic data file. We reviewed only the Fresh Plant visits. This file was current as of July 25, 2012. The "Type," "Cause," "Nature," "Body Part," "Injury Degree Status," and whether the visit was an OSHA recordable injury were captured. These data also indicated decreasing injury reports over the time period studied.

The hand and fingers were the most frequently reported Body Part sustaining an injury except for 2012 when ear(s) was the most frequently injured body part (most likely from hearing loss). The next most frequently reported were finger(s), thumb, and hand (Appendix A, Table A4). "Strains," "cut/puncture/scrape," "fall/slip/trip" and "struck by" or "caught in/under/between" were the most frequently reported Type of injury across all years studied (Appendix A, Table A5). The most frequent Cause of injury was "cut/puncture/scrape," "repetitive motion," or "fall/slip/trip" for 2009–2011 (Appendix A, Table A6). For 2012 it was "cut/puncture/scrape," "cumulative," "caught in/under/between," or "hand tool or machine in use." The Nature of injury was generally "contusions/bruise," "sprain/strain," or "laceration/cut" for 2009–2011 but for 2012 it was "pain," "hearing loss," or "laceration/cut" (Appendix A, Table A7). The Injury Degree Status was identified as generally being "first aid occupational health staff," "medical only," or "lost time" for all years (Appendix A, Table A8). In 2012 "near miss" was the second most frequently reported outcome; in 2010 "near miss" was tied for the third place ranking with "lost time." The injuries treated and recorded by the medical clinic that were identified as OSHA recordable injuries increased from 38% in 2009 to 68% in 2012 (Appendix A, Table A9).

Discussion

Poultry processing involves a combination of highly repetitive and forceful movements and places employees at an increased risk for upper extremity work-related musculoskeletal disorders [Lipscomb et al. 2008; Cartwright et al. 2012]. Approximately 41% of the participants at this plant were performing job tasks that were above the ACGIH TLV for hand activity and force. The ACGIH TLV for levels of hand activity and force was validated and has been shown to predict a dose-response relationship for the incidence of carpal tunnel syndrome [Bonfiglioli et al. 2013]. Additionally, Chiang et al. [1993] found a significant relationship between increasing exposure to repetition and force and increasing prevalence of carpal tunnel syndrome.

We found 42% of participants met the carpal tunnel syndrome case definition. Although the prevalence is higher in this evaluation than that reported in other poultry industry studies, a similarly high prevalence of carpal tunnel syndrome has been reported in other highly repetitive and forceful manual operations [Bonfiglioli et al. 2006; Rosecrance and Douphrate 2010]. Cartwright et al. [2012] recently reported on results of carpal tunnel syndrome among poultry processing workers and other manual labor occupations. Cartwright categorized positive carpal

tunnel syndrome results as “possible carpal tunnel syndrome” or “carpal tunnel syndrome.” Both categories would be included in our carpal tunnel syndrome case definition as Cartwright’s categories were based on a scoring system using similar criteria. Adding both of Cartwright’s categories together would give a prevalence of 48%, which is similar to the 42% prevalence in our evaluation. Because early detection and aggressive treatment is key to averting problems and possibly disabling injuries [Poultry Safety and Health Committee Task Force 1986; Dokuztug et al. 2006], we chose a more sensitive (inclusive) case definition for carpal tunnel syndrome than that chosen by Cartwright.

In evaluating other highly repetitive, forceful manual occupations, one can find a similarly high prevalence of carpal tunnel syndrome. A carpal tunnel syndrome prevalence of 74% was found among meat and fish processing plant employees [Kim et al. 2004] and a carpal tunnel syndrome prevalence of 43% was found among assembly workers [Bonfiglioli et al. 2006] using case definitions similar to ours.

Because of the work required in processing chickens, many workers must use their dominant and non-dominant hands. Therefore, the risk of work-related musculoskeletal disorders is not limited to the dominant hand. In our evaluation, of those with carpal tunnel syndrome in either hand, we found bilateral carpal tunnel syndrome in 83 (66%) of 126 individuals. This is similar to a previous finding of bilateral carpal tunnel syndrome in 58% of patients [Stevens 1997].

Although a strong relationship exists between specific work factors and carpal tunnel syndrome [National Research Council 2001], non-occupational factors need to be considered. Medical conditions such as obesity, diabetes mellitus, and thyroid disease have been associated with carpal tunnel syndrome [Becker et al. 2002; Karpitskaya et al. 2002]. Advanced age and being female also have been associated with carpal tunnel syndrome risk. In our analysis, we adjusted for sex, age, body mass index, and diabetes mellitus; we found that work factors (force and repetition) were still significantly associated with carpal tunnel syndrome.

On the basis of high prevalence of carpal tunnel syndrome in the lowest exposure category (Group 1), job task rotation alone is unlikely to be sufficient for controlling musculoskeletal disorders in this plant. We identified carpal tunnel syndrome cases in all three exposure categories, with a significantly higher prevalence of carpal tunnel syndrome in the higher exposure group as compared to the lower exposure group. It is possible that some cases in the lower exposure groups (below the ACGIH Action Limit, and below the ACGIH TLV) were a result of employees having worked in jobs or performed job tasks in the higher exposure category in the past, or other factors were involved that we could not identify in this cross sectional evaluation. Also, a review of the rotation logs showed that, although 41% of participants reported rotating to different job tasks, the rotation was usually from one high exposure job task (Group 3) to another high exposure job task (Group 3) or from one lower exposure job task (Group 1) to another lower exposure job task (Group 1). Rotation among job tasks of similar exposure risk has not been found to reduce the risk of developing musculoskeletal disorders [Jonsson 1988]. Job rotation should allow employees with job duties with a higher exposure (on the basis of the ACGIH TLV) to rotate to duties of lesser exposure to reduce ergonomic risk factors. Job rotation should reduce fatigue and stress of muscles and tendons by rotating employees to job tasks that use different muscle-tendon groups [OSHA 1993]. Rotating from higher exposure tasks to lower exposure tasks has been found to result in less fatigue and improved performance [Raina and Dickerson 2009]. Job rotation decisions should include evaluating jobs using the ACGIH TLV. When the Action Limit is exceeded, other ergonomic controls should be employed.

OSHA has guidelines for preventing musculoskeletal disorders in the poultry industry [OSHA 2004]. Early recognition, reporting, and intervention of musculoskeletal disorders can limit injury severity, improve the effectiveness of treatment, minimize the likelihood of a disability or permanent damage, and reduce the rate of workers' compensation claims [OSHA 2004]. The National Chicken Council and the Poultry and Egg Institute have published recommendations encouraging companies to address workplace safety concerns such as ergonomics, injury, and noise [National Chicken Council 2008; The Poultry & Egg Institute 2013]. Some of the recommendations and best practices include employee training, onsite wellness centers for timely medical attention, additional automation as technology becomes available, and full-time safety managers and registered nurses to monitor health and safety concerns. We agree with the American Meat Institute 2009 recommendations for an effective medical management program, which calls for a physician or occupational health nurse with training in the prevention of musculoskeletal disorders supervising the program. The American Meat Institute recommends that each work shift have access to health care providers to facilitate treatment, medical surveillance, and the recording of information. Specifically, the medical management program should address the following issues:

- Injury and illness record keeping
- Early recognition and reporting
- Systematic evaluation and referral
- Conservative treatment
- Conservative return to work
- Systematic monitoring
- Adequate staffing and facilities.

Upon hire, employees at this plant received a letter from the Occupational Health Manager that provided recommended exercises and the use of medication to help with the discomfort associated with the adjustment to the job. Although there was a recommendation to see their healthcare provider before taking any medication, we observed a medicine dispenser in the cafeteria which sold pain relievers. The ready availability of this dispenser may make it easier for employees to bypass this recommendation.

Since 1986, the Poultry Safety and Health Committee Task Force [1986] has recognized the importance of early medical intervention in preventing the onset of serious musculoskeletal disorders. Early detection and aggressive treatment of musculoskeletal disorders was described as key to averting problems and possibly disabling injuries [Poultry Safety and Health Committee Task Force 1986]. Medical intervention, however, must be combined with job improvement to reduce the risk of work-related carpal tunnel syndrome. Silverstein reported that carpal tunnel syndrome is unlikely to go away in a year without implementing such measures [Silverstein et al. 2010].

We noted that employees had only one regularly scheduled rest break per day. Employees rotating between different Group 3 jobs would be unlikely to receive sufficient break time to relieve muscle fatigue. Tucker et al. [2003] found that limiting continuous work to less than 2 hours reduced risk of injury. Dababneh et al. [2001] found that hourly 9-minute breaks did not negatively affect productivity and improved employee discomfort ratings.

We found the majority of participants knew how to report an injury at work and to whom to report the injury. Among the Fresh Plant participants, self-reported injuries indicated an injury prevalence of 7%. The OSHA Log rates for this plant were higher in comparison to national poultry processing injury rates in 3 of the 4 years studied. However, there was a decreasing injury rate and frequency over these years for the Fresh Plant, which could have implications for

assessing whether an increase in evisceration line speed affects injury. Because decreasing injury rates were noted prior to any change in evisceration line speed, assessing the true effect of increased evisceration line speed on worker injury in this plant may be difficult.

Between 2009 and 2012, the number of reported injuries decreased and the most frequently reported injured body part changed. Few "hand" and no "wrist" or "wrist(s) and hand(s)" injuries were reported; however, participants reported a high prevalence of hand or wrist symptoms on the questionnaire. The decrease in hand pain to 0 in 2012 could be due to (1) a full year of data not being available (but data was extrapolated to the end of the year), (2) a change in reporting procedures or some other aspect that may have inadvertently affected the results, or (3) underreporting. In general, strain, cut/puncture/scrape, fall/slip/trip, struck by injuries, and caught in/under/between were the leading type of injuries reported. While the injuries decreased from 2009–2012, it was notable that the proportion of injuries which were OSHA recordable increased over most years.

In May 2012, we identified unsafe walking surfaces (with poultry product or pieces of product, excess water, holes and depressions, and drain coverings) and poor housekeeping practices (with the presence of wash hoses and extension cords in walkways). These conditions increased the risk of traumatic injuries. Our analysis of the onsite medical clinic data indicated that "fall/slip/trip" injuries were the leading "Type" and "Cause" of injury in 2011.

We observed dust exposures in the Further Processing Plant (Breading Area) during our walk-throughs of the plant. While we did not evaluate these exposures, we noted them previously to plant managers.

Strengths and Limitations

We had very good participation, with 85% of eligible first shift Fresh Plant employees and first shift live hang contractors completing the questionnaire. We based the carpal tunnel syndrome case definition on well accepted and recognized criteria using objective nerve conduction measurements. The use of two independent board-certified neurologists strengthened the interpretation of the nerve conduction test results. The high participation rate allowed us to examine employees across many job duties. Our ergonomic assessment evaluated a wide range of job tasks using standardized and validated assessment tools. The two independent ergonomists' ratings showed strong inter-rater agreement.

The following four possible limitations regarding our evaluation of musculoskeletal disorders warrant noting:

- This is a cross-sectional study, which measures health outcomes and exposures at a single point in time. Selection bias was unlikely because of the high response rates. Inherent in this type of study is the potential for "survivor bias," not including people who may have left their jobs because of carpal tunnel syndrome or injuries. This may result in an underestimation of the prevalence of carpal tunnel syndrome.

- The carpal tunnel prevalence rates were partially determined by self-reported symptoms from questionnaires: this may either overestimate or underestimate carpal tunnel syndrome.

- This study did not fully address the impact of non-work-related variables and their possible associations with carpal tunnel syndrome. For example, we did not have

information about third trimester pregnancy, which may have had some impact on carpal tunnel syndrome.

- Some exposure misclassification may have occurred because our exposure assessment was based on current job and did not account for overtime work.

- Some evidence shows that employees on later work shifts experience more injuries and, therefore, our evaluation of only the first shift may be an underestimation of the prevalence [Strong and Zimmerman 2005].

The denominator used for determining rates of injury was based upon 1 month of electronic personnel data (July 2012), which was obtained in August 2012. This 1-month period was then extrapolated for the entire year of 2012 and used for the prior years. Having the personnel data for 2009−2012 may change some of the findings for rates of injury (they may increase, decrease, or remain the same). It was noted that the plant changed length of the workweek from 32 hours per week to 40 hours per week in November 1, 2011. This change would result in 25% higher rates and correspondingly higher rate ratios prior to November 1, 2011 (4% higher in 2011). The higher rates could not be documented without the actual employee records data.

This plant may not be representative of other poultry processing plants. Furthermore, this plant may not be representative of all plants that may increase their evisceration line speed.

Conclusions

We found that 42% of participants had evidence of carpal tunnel syndrome on the basis of our case definition and that 41% of participants were working in jobs above the ACGIH TLV for hand activity and force. Moreover, the risk of carpal tunnel syndrome increased with increasing exposure to the risk factors for musculoskeletal disorders. Our evaluation was not able to clearly identify job tasks that did not pose a potential risk for developing carpal tunnel syndrome. These results suggest the need for ergonomic interventions and improvement of work processes and medical evaluation. Early recognition and medical management of musculoskeletal disorders and traumatic injuries can help limit their severity, improve the effectiveness of treatment, minimize the likelihood of a disability or permanent damage, and reduce workers' compensation claims [OSHA 2004]. We also found that the Fresh Plant's rate of OSHA Form 300 Logs of Work-Related Injuries and Illnesses was higher than the poultry processing industry average for 2009–2011 [BLS 2009, 2010, 2011].

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the poultry processing plant to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the poultry processing plant.

Our recommendations are based on an approach known as the hierarchy of controls. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install

engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment may be needed.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Design or redesign job tasks so that they are below the ACGIH TLV to minimize the risk for developing carpal tunnel syndrome.
2. Automate or semi-automate front half deboning and thigh deboning.
3. Install a tilter or dumper for bulk material in the multi-vac area to eliminate or reduce the bending required for this task. Vats with drop-down sides can help the employee get closer to the product when shoveling or lifting.
4. Provide adjustable lift tables/load levelers for palletized materials at the end of lines where pallets are used. Employees were seen bending to the floor and reaching overhead to place boxes on pallets.
5. Provide adjustable standing platforms at all workstations. Some employees in the DSI area did not have platforms and were reaching near shoulder height to sort.
6. Place sharpeners (referred to as mousetraps on cone lines) in locations that do not require reaching above the shoulder to use them.
7. Redesign the drumstick packer workstation to eliminate twisting and reaching for the label with the right hand.
8. Minimize dust exposures in the Further Processing Plant (Breading Area). A NIOSH health hazard evaluation report from another poultry processing plant where these types of exposures were evaluated in-depth is available at http://www.cdc.gov/niosh/hhe/reports/pdfs/2009-0131-3171.pdf.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Review and implement the OSHA Guidelines for Poultry Processing: Ergonomics for the Prevention of Musculoskeletal Disorders [OSHA 2004] and the recommendations of the National Chicken Council and The Egg and Poultry Institute [National Chicken Council 2008, The Poultry & Egg Institute 2013].
2. Employ a job rotation schedule in which employees rotate between jobs that use different muscle groups and are below the Action Limit of the ACGIH TLV for levels of hand activity and force.
3. Eliminate incentive programs that encourage employees to perform only one job task when that task is associated with a high level of repetitive motion.
4. Provide more than one break during the workday. Hourly 9-minute breaks may improve employee discomfort ratings without negatively affecting production.

5. Encourage employees to report musculoskeletal symptoms early to the onsite medical unit. This will provide an opportunity to evaluate the job and ensure prompt medical management as needed.
6. Provide bulletin board and safety meeting reminders and break room handouts to emphasize the importance of early reporting of possible work-related symptoms.
7. Institute a medical surveillance program for musculoskeletal disorders to monitor employee health and determine the effectiveness of exposure prevention and medical management strategies. There are several good sources for information on medical monitoring and surveillance, among them the Meat AMI.com and OSHA.com websites.
8. Remove the medicine dispenser in the cafeteria.
9. Develop procedures for employees to provide information and feedback on work equipment and procedure modifications.
10. Add specific information about working height recommendations and adjustable stands to the employee safety training. OSHA has information and pictures in their poultry processing guidelines at [http://www.osha.gov/ergonomics/guidelines/poultryprocessing/poultryprocessing.html].
11. Provide training during supervisor meetings regarding proper setup of standing platforms. For light assembly, the hands should be slightly below elbow height. For work requiring heavy force, the work surface should be below elbow height, unless close visual inspection is required.
12. Start a program to keep knives sharp so employees do not have to exert undue force to make cuts; this should reduce cuts/lacerations and reduce the risk of musculoskeletal disorders.
13. Improve maintenance/cleaning of floors and housekeeping to reduce the slip and trip hazards that were observed (e.g., holes/depressions in the floor, poultry parts on the floor, excess water on walking surfaces, drain coverings, and wash hoses or extension cords in walkways).

Appendix A: Tables

Table A1. Abnormal median nerve conduction measures [Burt et al. 2011]

Abnormal if meet Criteria A and (Criteria B or Criteria C)		
Criteria	**Indicators**	
A Slowed Latency in Median Nerve (one of the indicators present)	• wrist to index finger sensory latency **or** • mid palm to wrist sensory latency **or** • motor latency	> 3.7 ms* > 2.2 ms > 4.4 ms
B Normal Distal Ulnar Nerve Latency and Amplitude (both indicators present)	• wrist to little finger sensory amplitude **and** • wrist to little finger sensory latency	≥ 10 µV† ≤ 3.7 ms
C Distal Median Nerve Latency > Distal Ulnar Latency	• median wrist to index finger *minus* ulnar wrist to little finger latency **or** • median mid palm to wrist *minus* ulnar mid palm to wrist latency	difference > 1.0 ms difference >0.5 ms

*ms = milliseconds
†µV = microvolts

From: Burt S, Crombie K, Jin Y, Wurzelbacher S, Ramsey J, Deddens J [2011]. Workplace and individual risk factors for carpal tunnel syndrome. Occup Environ Med. *68*(12):928-33.

Table A2. Job tasks assessed for ergonomic risk

Area	Department	Exposure group 1	Exposure group 2	Exposure group 3
First processing	Evisceration	Backup killer Backup re-hanger Vent opener Reprocess vacuum USDA trimmer/helper	N/A	Final trim Reprocess salvage
	Paws	Grader (Line 1) Grader (Line 2) Bagger Box/stack	N/A	Grader (incoming product needs rework)
Second processing	Cone Lines	Bone hawk	Loader	First cut (left shoulder) First cut (right shoulder) Wing roller Wing saw Breast trimmer Tender score/cut Tender clip Tender pull
	Thigh Debone	Machine loader 1 Machine loader 2 Machine loader 3	N/A	Manual trimmer Machine trimmer
	Cut-up	Legs scale One leg saw One leg load Whole leg pack Whole leg lid/label Whole leg box maker Thigh flipper Drumstick packer Wing operation pack tips Wing operation grade/drum/midjoint	Whole leg scale Rework leg Wing operation saw	Box maker combo One leg knife Whole leg stack/strap Rehang
	Multi-vac	Loader Box pack	Bagger	Dumper Box stack
	DSI	Loader/X-ray Slitter loader DSI loader 1 DSI loader 2 DSI grader Rework/X-ray Check trim	Marriage Cut nuggets/sizing	Loader (pull meat apart with hands)
	IPM	Classifier loader Loader to index 1 Loader to index 2 Loader to index 3 Loader to index 4 Grader Cut nuggets	N/A	Pack tenders

Table A3. Job tasks assigned to exposure groups based upon observation and previous evaluations

Area	Department	Exposure group 1	Exposure group 2	Exposure group 3
First Processing	Evisceration	Utility picking Condemn/knife Chiller operator Product wash Quality control/SPC Lead	N/A	Live hang
	Paws	Lead	N/A	N/A
Second Processing	Cone Lines	Shaver Floor Quality control/SPC Lead	N/A	N/A
	Thigh debone	Timing Floor Lead Quality control/SPC High debone x-ray	N/A	N/A
	Cut-up	Whole leg lead Flex line floor Parts/product wash Wing operation floor	N/A	Whole leg stack
	Multi-vac	N/A	Scale Box Maker	N/A
	DSI	Quality control/SPC Floor Lead	N/A	N/A
	IPM	Move nuggets to tub Lead	N/A	N/A

Table A4. Onsite medical clinic visits - “Body Part” affected by year

Body Part	2009	2010	2011	2012
Hand	29	18	18	3
Finger(s)	27	12	9	4
Ear(s)	4	6	5	7
Multiple body parts	12	2	6	0
Lower back area	11	6	1	1
Thumb	5	4	4	4
Wrist	9	4	2	0
Shoulder	8	5	1	1
No physical injury	1	9	1	4
Lower arm	8	3	4	0
Foot	3	4	6	0
Knee	5	3	4	0
Upper arm	6	3	2	0
Multiple upper extremities	5	4	2	0
Eye(s)	3	4	2	2
Ankle	2	3	4	0
Wrist(s) and hand(s)	3	1	2	0
Upper back area	4	1	1	0
Multiple lower extremities	3	1	2	0
Multiple head injury	0	3	3	0
Lower leg	3	1	2	0
Other (4 or less in any one year)	25	7	8	2
Total	176	104	89	28

Table A5. Onsite medical clinic visits - “Type” of injury by year

Type	2009	2010	2011	2012
Strain/injury by	46	29	17	3
Cut/puncture/scrape injured	44	13	14	8
Miscellaneous cause	23	15	9	8
Fall/slip/trip injury	17	16	20	1
Struck/injured by	19	9	9	3
Caught in/under/between	7	11	12	2
Striking against/stepping on	13	6	5	1
Burn/scald, hot/cold contact	4	2	2	1
Motor vehicle	0	3	0	1
Rubbed or abraded by	1	0	1	0
Non-work related	1	0	0	0
Cut, puncture, scrape	1	0	0	0
Total	176	104	89	28

Table A6. Onsite medical clinic visits - “Cause” of injury by year

Cause	2009	2010	2011	2012
Cut/puncture/scrape, NOC*	39	10	12	7
Repetitive motion	21	18	11	1
Fall/slip/trip, NOC	12	10	13	1
Cumulative, NOC	10	8	5	7
Caught in/under/between, NOC	6	10	11	2
Struck or injured, NOC	10	6	4	1
Striking against/stepping on,	9	4	5	1
Other - miscellaneous, NOC	9	6	3	1
Strain/injury by, NOC	6	6	3	1
Lifting	10	2	2	0
Pushing or pulling	7	2	0	0
Object being lifted or handled	4	2	2	0
Hand tool, utensil; not powered	5	1	2	0
Slip, or trip, did not fall	0	1	3	0
On same level	3	0	1	0
Fellow worker, patient, or other	2	1	1	0
Steam or hot fluids	1	1	1	0
Stationary object	2	1	0	0
On stairs	1	0	2	0
Object being lifted and handle	0	2	0	1
Moving parts of machine	3	0	0	0
Hand tool or machine in use	0	0	1	2
From liquid or grease spills	0	3	0	0
From different level (elevation)	0	2	1	0
Foreign matter (body) in eye(s)	2	1	0	0
Falling or flying object	1	1	1	0
Collision with fixed object	0	2	0	1
Chemicals	1	1	0	1
Absorption, ingestion, or inhalation	2	0	1	0
Using tool or machinery	1	0	0	1
Machine or machinery	1	0	1	0
Holding or carrying	2	0	0	0
Wielding or throwing	0	1	0	0
Twisting	0	0	1	0
Rubbed or abraded by, NOC	0	0	1	0
Object handled	0	1	0	0
Non-occupational disease	1	0	0	0
Moving part of machine	1	0	0	0
Knives/scissors	1	0	0	0
Into openings	1	0	0	0
Hot objects or substances	1	0	0	0
Contact with, NOC	0	0	1	0
Collision or sideswipe with an object	0	1	0	0
Cold objects or substances	1	0	0	0
Total	176	104	89	28

*NOC = not otherwise classified

Table A7. Onsite medical clinic visits - “Nature” of injury by year

Nature	2009	2010	2011	2012
Contusions/bruise	32	21	20	0
Sprain/strain	34	16	12	0
Laceration/cut	33	12	12	5
Pain	12	8	6	7
Other	20	7	2	0
Hearing loss	4	6	5	7
Musculoskeletal disorders	1	12	5	0
Multiple physical injuries	10	2	6	0
None	1	7	2	4
Puncture	9	3	1	0
Inflammation/swelling	9	0	4	0
Fracture	0	4	7	1
Scratch/abrasion	2	3	0	0
Irritation	2	1	1	1
Burn	2	1	1	0
Avulsion	2	0	0	2
Foreign body	0	1	2	0
Minor first aid care	2	0	0	0
Amputation	0	0	1	1
Respiratory condition	0	0	1	0
Electric shock	0	0	1	0
Cut/laceration	1	0	0	0
Total	176	104	89	28

Table A8. Onsite medical clinic visits - “Injury Degree Status” by year

Degree Status	2009	2010	2011	2012
Medical only	56	59	38	14
First aid occupational health staff	85	30	43	4
Lost time	13	5	4	1
Near miss	1	5	0	8
First aid non-medical responder	11	1	2	0
Temporary restriction	4	4	2	1
Not indicated	5	0	0	0
Preventative restriction	1	0	0	0
Total	176	104	89	28

Table A9. Onsite medical clinic visits injury OSHA recordable status by year

OSHA recordable	2009	2010	2011	2012
No	109	53	50	9
Yes	67	51	39	19
Column (%)	(38)	(49)	(44)	(68)

Appendix B: Figure

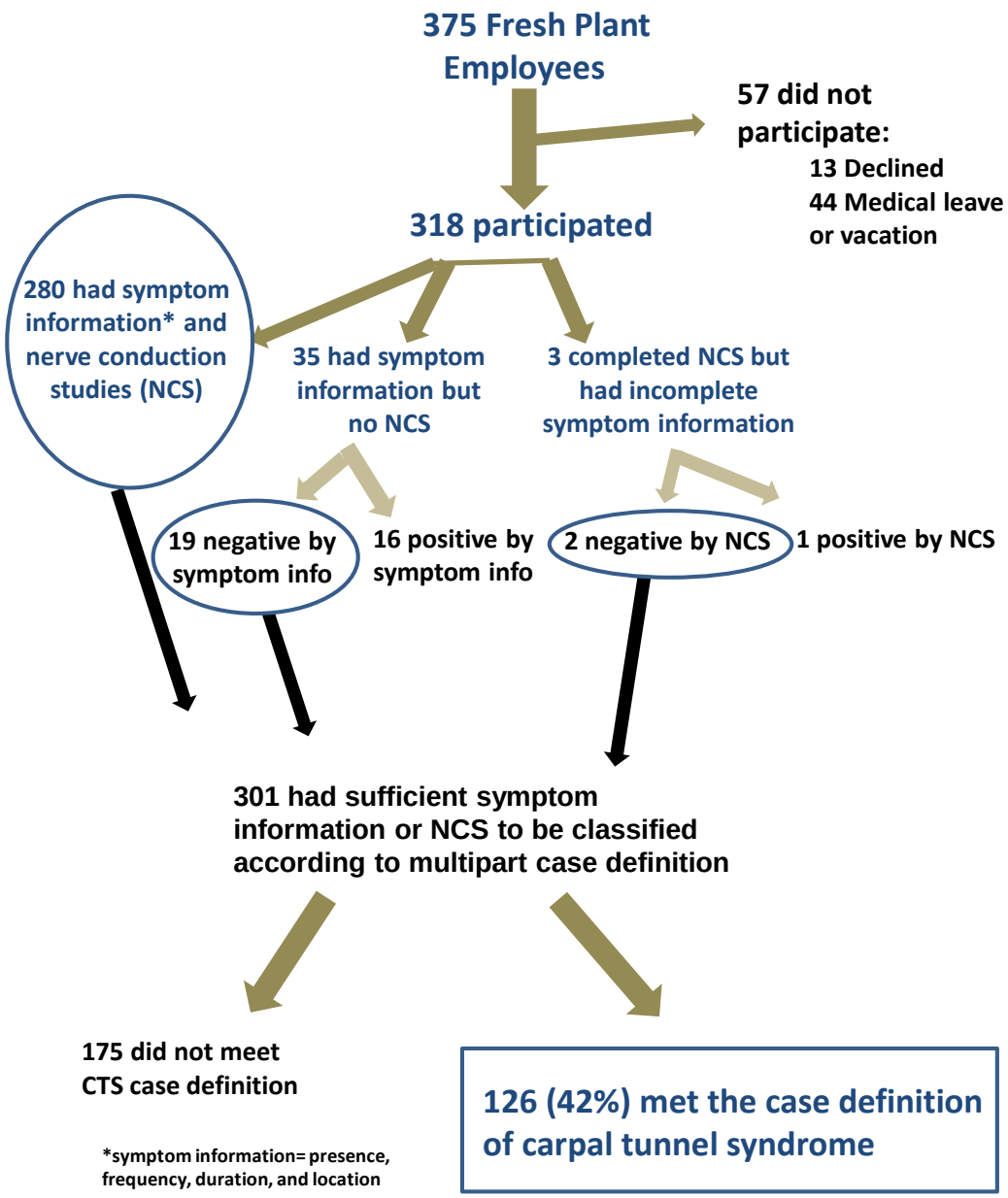

Figure B1. Defining a case of carpal tunnel syndrome among poultry employees

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