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

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from a poultry processing plant in South Carolina. The United States Department of Agriculture/Food Safety and Inspection Service required the plant to request a National Institute for Occupational Safety and Health (NIOSH) evaluation in order to obtain an evisceration line speed waiver under the Salmonella Initiative Program. The plant asked NIOSH to identify the potential for increase in musculoskeletal and upper extremities trauma due to the planned evisceration line speed increase. This report describes our evaluation of the plant before and after the evisceration line speed increase.

We evaluated musculoskeletal disorders and traumatic injuries among employees at a poultry processing plant before (baseline) and after (follow-up) an increase in evisceration line speed. After our baseline evaluation, two evisceration lines were combined into one; this resulted in a similar number of birds processed by most employees daily. At baseline, 41% of participants were performing jobs above the ACGIH TLV for hand activity and force and 42% had evidence of carpal tunnel syndrome. The prevalence of hand or wrist symptoms (pain, burning, numbness, or tingling) was similar at baseline and follow-up. The Fresh Plant's rate of OSHA recordable injuries and illnesses was higher than the poultry processing industry average for 2009–2012. Recommendations are provided to improve work conditions and minimize exposures to factors that increase the risk for musculoskeletal disorders and traumatic injuries.

What We Did

- We evaluated ergonomic hazards, nerve damage in employees' hands and wrists (known as carpal tunnel syndrome), and traumatic injuries during three visits.
- We assessed repetition and force in 67 job tasks.
- We collected medical and personnel records, and logs of work-related injuries and illnesses to evaluate musculoskeletal disorders and traumatic injuries.
- At baseline in August 2012, we gave a questionnaire and tested nerve function for Fresh Plant production line employees and live hang contractors.
- In a June 2013 follow-up evaluation, we interviewed Fresh Plant production line employees and live hang contractors who had participated at baseline.
- We noted changes the plant had made after increasing the evisceration line speed.
- We assessed the effect of plant changes on musculoskeletal symptoms and traumatic injuries among employees.

What We Found

- Forty-one percent of participants at baseline worked in jobs that had levels of hand activity and force above the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit values (TLV).
- Forty-two percent of participants at baseline had evidence of carpal tunnel syndrome on the basis of our case definition.
- Thirty-nine percent of participants had hand or wrist symptoms at both baseline and follow-up evaluations.
- Fifty-seven percent of participants reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at both baseline and follow-up evaluations.

- Thirty-six percent of participants were performing job tasks that were above the ACGIH TLV at baseline and 32% were performing job tasks that were above the ACGIH TLV at follow-up.
- The Fresh Plant's rate of Occupational Safety and Health Administration (OSHA) recordable work-related injuries and illnesses was higher than the Bureau of Labor Statistics poultry processing industry average for 2009–2012.
- The most common work-related injuries by cause, for all years, were "cut/puncture/scrape," "repetitive motion," "fall/slip/trip," "cumulative," and "caught in/under/between."

What the Employer Can Do

- Implement the 2013 OSHA Guidelines for Poultry Processing and recommendations from poultry industry groups to prevent musculoskeletal disorders.
- Design job tasks so that levels of hand activity and force are below the ACGIH TLV.
- Until the redesign is completed, use a job rotation schedule so that employees rotate to jobs that are below the ACGIH TLV for hand activity and force.
- Ensure that the knife change out schedule is strictly followed.
- Provide more than one break during the work shift.
- Enhance reporting, screening, and medical assessment onsite to improve early intervention for musculoskeletal disorders and traumatic injuries.
- Remove the medicine dispenser in the cafeteria.
- Use good housekeeping procedures (e.g., repair uneven work surfaces and small holes or depressions in the floor) 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. Ensure knives are sharp by using mousetraps frequently and changing knives on a regular basis.
- 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.
- Follow up with onsite medical staff and your personal doctor if you were found to have an abnormal nerve conduction test result.

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
AL	Action limit
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
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
STS	Standard threshold shift
TLV®	Threshold limit value
USDA	United States Department of Agriculture
WMSD	Work-related musculoskeletal disorder

Introduction

The Health Hazard Evaluation Program received a request for an evaluation from a poultry processing plant in South Carolina in April 2012. The employer 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)]. The employer asked the National Institute for Occupational Safety and Health (NIOSH) to identify the potential for increase in musculoskeletal and upper extremity trauma from a planned evisceration line speed increase. This report describes our evaluation of the plant before and after the evisceration line speed 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 employer 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 Upper Limb Work-Related Musculoskeletal Disorder (WMSD) Research Consortium (http://www.cdc.gov/niosh/topics/upperlimb/), we developed an evaluation protocol to assess carpal tunnel syndrome and traumatic injuries among employees. Internal and external scientific experts reviewed the protocol.

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 an increase in evisceration line speed. This visit included an ergonomic assessment, questionnaire, and nerve conduction tests. We collected Occupational Safety and Health Administration (OSHA) Form 300 Logs of Work-Related Injuries and Illnesses (2009–2012), daily medical clinic logs (2009–2012), and 1 month (July 2012) of electronic employee records. In September 2012, we sent a letter to employer and employee representatives that summarized the visit and provided additional recommendations to reduce the risk of musculoskeletal disorders and traumatic injuries.

In February 2013, we sent a letter to all employees who participated in the nerve conduction tests to inform them of their individual 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 employer and employee representatives that summarized the nerve conduction test results without personal identifiers. In April 2013, we sent an interim report to employer and employee representatives that summarized our August 2012 visit.

In June 2013, we made a third (follow-up) visit to the Fresh Plant after the evisceration line speed had increased. The increase had begun in November 2012. The purpose of our visit was to evaluate changes the plant had made because of the evisceration line speed increase and to determine if these changes had an effect on musculoskeletal disorders and traumatic injuries among employees. In July 2013, we sent a letter to employer and employee representatives that summarized this visit and provided additional recommendations to reduce the risk of musculoskeletal disorders and traumatic injuries.

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 required cooking, marinating, and seasoning. We focused our evaluation on the Fresh Plant after confirming with the USDA/FSIS that Further Processing Plant operations would not be affected by the proposed change in the evisceration line speed.

Process Description

Baseline Evaluation

During the baseline visit, the plant processed approximately 159,000 birds per day or 800,000 birds over a 5-day workweek. The birds averaged 8.35 pounds. Approximately 1,560 full-time employees worked at the plant; 375 worked in the Fresh Plant on first-shift. 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. Each evisceration line was running at 90 birds per minute, less than the maximum speed of 140 birds per minute allowed by USDA/FSIS for a plant 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, handling, on average, 18 birds per minute. Each line also had one backup killer, one backup rehanger, one vent opener, two final trim employees, and four inspector helpers (one for each USDA/FSIS inspector). USDA/FSIS regulations state that a plant that was running up to 140 birds per minute requires four USDA/FSIS inspectors. Each inspector was presented a maximum of 35 birds per minute. The vent opener, final trim employees, and inspector helpers rotated among these three jobs every 2 hours.

Most Second Processing jobs included hand-intensive, repetitive tasks such as deboning and cut-up. Employees manually rehung birds 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. 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 between different DSI tasks. Portions of the chicken product were packaged in bags using a multi-vac machine then placed in boxes for shipment to customers.

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. Thigh trimmers used a Whizard® knife, which is 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 specific 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 timed to calculate individual production rates.

Follow-up Evaluation

During the follow-up visit, the plant processed approximately 148,000 birds per day, or 740,000 birds per 5-day workweek. The average weight of the birds increased from 8.35 pounds in August 2012 to 8.88 pounds in June 2013. The Fresh Plant's first-shift had 427 full-time employees. All Fresh Plant employees typically worked 8-hour shifts with one 45-minute break per 8-hour shift and occasional overtime.

As part of the evisceration line speed increase, the company combined the two evisceration lines into one evisceration line in October 2012. Between October 2012 and November 2012, the company gradually increased evisceration line speed. During the follow-up visit, the new evisceration line was running at 175 birds per minute. The plant continued using 10 live hangers, each still processing, on average, about 18 birds per minute. The line also had 2 backup rehangers and 2 vent openers. Only one backup killer was needed because of the conversion to one evisceration line and the addition of new equipment that required less work of the backup killer. Only two final trimmers were needed because of process changes. The plant now had five inspector helpers (one for each USDA/FSIS inspector). Thus, the total number of evisceration line workers (excluding the USDA/FSIS inspectors) was 28 at baseline and 22 at follow-up.

After the changes to the evisceration lines, the plant also made some changes in the Second Processing areas. The plant had discontinued use of the automated thigh debone machine, and all thigh deboning was done manually by employees using Whizard knives. The employer stated this change was made because automated thigh deboning was less efficient in meat recovery for the size birds they were processing. The plant had also discontinued the use of the IPM and multi-vac processes, but had installed two additional DSI portioning machines and had begun gizzard harvesting. Three Urschel portioning machines, which cut boneless breast filets into strips and popcorn chicken, were also added since our baseline visit. Cone line deboning job tasks had no substantial changes.

The plant had new incentive programs for employees in certain jobs, including shoulder cutters, wing rounders, tender scorers, and deboning line leads. All of these were nonrotating positions. An incentive bonus was paid to employees if they met certain company criteria. The thigh debone incentive was still voluntary and did not include job rotation, but employees were no longer timed, and the incentive was based on individual production and quality and not group production.

We noted health and safety-related improvements on the follow-up visit. Housekeeping practices were improved. Specifically, we observed less water and product on the floor and fewer water hoses and electric cords in walkways. For hanging chickens, break-away plastic shackles 8 inches apart replaced metal shackles that had been 6 inches apart. We were informed that the plastic shackles eliminated "hang-ups," provided a safer work environment, and saved product because fewer wings and legs were broken.

Methods

Baseline Ergonomic and Epidemiological Assessment of Carpal Tunnel Syndrome

The objectives of the baseline visit before the evisceration line speed increase were to (1) determine the prevalence of carpal tunnel syndrome on the basis of our case definition, (2) review job tasks for ergonomic risk factors of repetition and force, and (3) identify other work-related musculoskeletal disorders.

Baseline Ergonomic Assessment

We concentrated our evaluation and job assessments on the ergonomic risk factors for hand and wrist activity. We used information from the familiarization visit to classify jobs on the basis of a combination of repetitive and forceful movements, extreme or awkward postures, and tool use. We identified those jobs that had greater hand-intensive and tool-oriented job tasks and further evaluated them. We compared our measurements of hand activity and force to the action limit (AL) and threshold limit value (TLV®) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH®) [ACGIH 2013]. This TLV was validated in a large cohort study by Bonfiglioli et al. [2013] and predicted both carpal tunnel syndrome symptoms as well as carpal tunnel syndrome confirmed by nerve conduction studies. 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 NIOSH 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 AL (exposure Group 1)
- Ratios 0.56–0.78 were at or above the AL to the TLV (exposure Group 2)
- Ratios above 0.78 were above the TLV (exposure Group 3)

Line-lead jobs and other non-hand intensive jobs did not have HAL and force ratings assessed by the two ergonomists. These jobs were categorized into the three exposure groups by the two ergonomists on the basis of observation and expert opinion during the familiarization visit. Information regarding exposure classification from previous ergonomic studies in other poultry plants [Lipscomb et al. 2008; Cartwright et al. 2012] was used in this categorization process.

Baseline Epidemiologic Assessment of Carpal Tunnel Syndrome

During our baseline site visit, we invited first-shift Fresh Plant production line employees and all first-shift contracted live hang employees to participate in our assessment. Employees gave written informed consent and their participation was voluntary. We used a case definition for carpal tunnel syndrome developed from medical literature [Katz 1990; Rosecrance and Douphrate 2010; Burt et al. 2011].

Baseline Questionnaire

We verbally administered a questionnaire to individual participants without the employer present. Four employees requested and received Spanish interpretation. The questionnaire provided information on employee demographics; work history and duties; relevant medical history; presence, frequency, and duration of neuropathic symptoms (pain, burning, numbness, or tingling in their hands or wrists); other musculoskeletal symptoms; and other factors such as training, hours worked, overtime, participation in job rotation and incentive programs, and tool use.

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 as shown in Appendix B, Figure B1. Two NIOSH medical officers independently evaluated the hand diagram for each hand; a third medical officer with expertise in ergonomics evaluated the disputed diagrams and resolved differences.

Baseline Nerve Conduction Test

Because we were not able to offer nerve conduction tests to all questionnaire participants (due to logistical issues and employee availability), we used the company roster list to select a representative sample of employees based on job title and task. 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 were assigned an identification number and were asked to wash their hands with warm water prior to testing. Their hands were warmed to 32 degrees Celsius with a radiant lamp, and median and ulnar orthodromic motor and sensory studies were performed on a XLTEK NeuroMax 1002. The wrist was held straight with the fingers extended to measure locations for electrode placement; before placing electrodes the skin area was cleansed with an alcohol swab. Also, 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. Also, severity of carpal tunnel syndrome was determined using categorization of nerve conduction results [Stevens 1997] as shown in Appendix A, Table A2.

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. Neurologists distinguished between those with polyneuropathy from those with median mononeuropathy by identifying participants' ulnar sensory latencies. Participants who had polyneuropathy without underlying median mononeuropathy confirmed on a nerve conduction study were excluded from the carpal tunnel syndrome case count. Those who had polyneuropathy with underlying median mononeuropathy confirmed on a nerve conduction study were included in the carpal tunnel syndrome case count.

Case Definition

To be considered a carpal tunnel syndrome case in our evaluation, participants had to meet 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 as shown in Appendix B, Figure B1.
- Had abnormal median nerve conduction (median mononeuropathy) in the affected hand as determined by neurologist-interpreted nerve conduction study.

Follow-up Ergonomic and Interview Assessment

The objectives of the follow-up visit after the evisceration line speed increase were to assess changes in (1) reporting of musculoskeletal symptoms and (2) ergonomic risk factors of repetition and force.

Follow-up Ergonomic Assessment

We toured all jobs in the Fresh Plant and noted changes that had been implemented since our baseline visit; we took photographs and video recordings to document our findings. New job tasks and tasks that differed on the follow-up visit were assigned to exposure groups (Groups 1–3) on the basis of our observations, expert opinion, and previous job evaluations at this plant.

Follow-up Interview

In our follow-up site visit, we held confidential medical interviews with first-shift Fresh Plant production line employees and first-shift contract live hang employees. Employee selection was on the basis of their participation in the baseline evaluation and their job title to ensure all job titles were represented by some participants.

Participants gave verbal consent to participate in confidential interviews. We did a structured interview asking employees about their demographics; work history and duties; relevant medical history; presence, frequency, and duration of neuropathic symptoms (pain, burning, numbness, or tingling in their hands or wrists); other musculoskeletal symptoms; and other factors such as training, hours worked, overtime, participation in job rotation and incentive programs, and tool use since the evisceration line speed changes.

Traumatic Injury Assessment at Baseline and Follow-up

We included specific questions about traumatic injury, safety training, and incident reporting procedures on the baseline questionnaires and follow-up interviews. We reviewed the plant's OSHA Logs, daily medical clinic logs for 2009–2013, and electronic employee database records (payroll hours worked) for 2009 as well as for the month of July 2012.

Data Analysis

We reported descriptive statistics for demographic, occupational, and non-occupational information. We calculated prevalences of carpal tunnel syndrome cases by each exposure group, and for some of the individual components (hand or wrist symptoms and nerve conduction study) from the carpal tunnel syndrome case definition. Results using data gathered at the follow-up evaluation are presented for the entire work force evaluated and, separately, for the evisceration line employees.

We used log-binomial regression with the copy method [Deddens et al. 2003] to estimate adjusted carpal tunnel syndrome prevalence and to evaluate the relationship between carpal

tunnel syndrome and the exposure groups adjusting for sex, age, body mass index, and diabetes mellitus. 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.

We calculated annual rates of traumatic injuries and compared them to national data according to the methods described by OSHA [Bureau of Labor Statistics 2013]. Medical clinic records were tabulated to examine trends.

Analysis of carpal tunnel syndrome, musculoskeletal symptoms, and their risk factors was done using SAS Institute Inc., SAS Version 9.3. Onsite medical clinic data on traumatic injuries were analyzed using R statistical software [R Development Core Team 2011].

Results

Baseline Ergonomic and Epidemiological Assessment of Carpal Tunnel Syndrome

Baseline Ergonomic Assessment

In August 2012, two ergonomists individually assessed 67 job tasks in the plant. For these assessments, the ergonomists' HAL and force ratings never differed by more than one point. Averages of the HAL and force ratings were used when the ratings differed. The 67 job tasks are listed by department and exposure group in Appendix A, Table A3. Categorization of lead jobs and other non-hand intensive tasks that did not have HAL and force ratings assessed can be found in Appendix A, Table A4.

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 2013]. 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 have access to overtime information and did not include overtime in the time-weighted exposures. We grouped participants into exposure categories using the ACGIH reference values (the AL and TLV). 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

Baseline Epidemiologic Assessment of Carpal Tunnel Syndrome

Baseline Questionnaire

In August 2012, of the 375 Fresh Plant first-shift production line employees and live hang contractors, 318 (85%) completed the administered questionnaire. Of these employees, 284 completed nerve conduction tests; one of these nerve conduction tests was not interpretable.

Table 2 shows the demographic and personal characteristics of the questionnaire participants. The average age was 39 (range: 19–73), and participants were predominantly black or African American (94%). Seventy-seven (24%) reported being a current smoker, and 85 (27%) reported using alcohol. Sixty-eight (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 nerve conduction test participants, 143 (50%) had a body mass index ≥ 30, which is considered obese [CDC 2014]. Eighteen women reported being pregnant.

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

Age (years)	Mean 39 (range:19–73)
	No. (%)
Sex	
Male	94 (30)
Female	224 (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 medical conditions ever diagnosed by a physician as reported by participants. Out of 318 questionnaire participants, 32 (10%) reported that a physician diagnosed them with carpal tunnel syndrome, and 27 (8%) reported that a physician diagnosed them with hand or wrist tendonitis.

Table 3. Medical conditions ever diagnosed by a physician as reported by questionnaire participants (n = 318)

Medical conditions	No. (%)
Carpal tunnel syndrome	32 (10)
Hand or 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 questionnaire participants such as length of employment, hours worked, hands used most at work, overtime, participation in rotation and incentive programs, and tool use. Fifty percent of participants used mostly their right hand at work, and about 43% used mostly both hands at work. The participants worked for an average of 38 hours the week prior to our visit and had been at the plant for an average of 8 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 an average of 7 hours per week.

Table 4. Workplace characteristics of questionnaire participants (n = 318)*

Characteristics	Average (range)
Years worked at any poultry plant	9 (< 1–45)
Years worked at this poultry plant	8 (< 1–30)
Hours worked last week	38 (0–56)
Characteristics	**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	52 (17)
Use knife, scissors, Whizard®, or other cutting tool in any job	185 (58)

*Numbers vary from 313 to 318 because of nonresponse to certain questions.

The two independent neurologists who interpreted the nerve conduction study findings found 204 of 283 (72%) with abnormal results indicating the presence of median mononeuropathy. Of the 204 abnormal nerve conduction studies, 79% were in both hands, 13% were right hand only, and 7% were left hand only. Of the 204 abnormal nerve conduction studies, 25% were rated as mild, 60% as moderate, and 15% as severe in at least one hand (using the most severe hand) on the basis of published criteria to determine severity [Stevens 1997].

The number of participating employees who met the case definition for carpal tunnel syndrome was 126 of 301 (42%). The denominator included all participants with sufficient questionnaire or nerve conduction test results to be classified according to the multipart case definition (Appendix B, Figure B2 provides a more complete explanation). Of 126 participants who met our case definition for carpal tunnel syndrome, 103 (82%) awakened from sleep (another clinical manifestation of carpal tunnel syndrome) because of pain, burning, numbness, or tingling in hands or wrists in the past 12 months. Table 5 shows the characteristics of median mononeuropathy severity among carpal tunnel syndrome cases. Of 126 participants who met our case definition for carpal tunnel syndrome, 101 (80%) had moderate or severe mononeuropathy confirmed on a nerve conduction study.

Table 5. Determination of median mononeuropathy severity* among carpal tunnel syndrome cases (n = 126)

Severity	No. (%)
Mild	25 (20)
Moderate	75 (60)
Severe	26 (21)

*Based on Stevens [1997]

Table 6 shows the prevalence of carpal tunnel syndrome cases by exposure group. Unadjusted prevalence increased with increasing exposure, rising from 36% in the lowest exposure group to 48% in the highest exposure group.

Table 6. Prevalence of carpal tunnel syndrome 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

Table 7 shows the results from our log-binomial regression model adjusting for sex, age, body mass index, and diabetes mellitus, which are known to be associated with carpal tunnel syndrome. The adjusted prevalence of carpal tunnel syndrome in exposure Group 3 was statistically significantly higher than that for Group 1 (PR = 1.61, 95% CI = (1.20, 2.17)).

Table 7. Carpal tunnel syndrome prevalence by exposure groups (n = 282)

Exposure groups	Adjusted prevalence*	Prevalence ratio	95% confidence interval
Group 1 (< AL†)	34%	1	—
Group 2 (AL–TLV‡)	39%	1.16§	(0.76, 1.60)
Group 3 (> TLV)	55%	1.61§	(1.20, 2.17)

*Adjusted for sex, age, body mass index, and diabetes mellitus

†AL = Action limit for the ACGIH TLV for hand activity and force

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

§Group 1 was considered the referent group.

We examined the relationship between carpal tunnel syndrome and several variables. We found that 47% of females and 28% of males met our carpal tunnel syndrome case definition; 63% of participants who reported a physician diagnosis of diabetes mellitus and 41% of participants who did not report a physician diagnosis of diabetes mellitus met our carpal tunnel syndrome case definition; 57% of obese participants and 33% of non-obese participants met our carpal tunnel syndrome case definition; 47% of participants who reported a physician diagnosis of thyroid problems and 42% of participants who did not report a physician diagnosis of thyroid problems met our carpal tunnel syndrome case definition; 34% of participants who reported regularly doing hand-intensive tasks outside of the job (working at home, doing hobbies, playing sports, or working at a second job) and 44% of participants who did not report regularly doing hand-intensive tasks outside of the job met our carpal tunnel syndrome case definition. The participants with carpal tunnel syndrome were older (mean age 42 years) than those without carpal tunnel syndrome (mean age 38 years). No one who reported kidney failure met our carpal tunnel syndrome case definition.

Two hundred thirteen participants reported pain, burning, numbness, or tingling in their hands or wrists in the past 12 months (localized or not localized to median nerve). Of those reporting these symptoms, 143 (67%) reported awakening from sleep because of these symptoms and 150 (71%) reported having these symptoms within 7 days of our visit. 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. Of 212 participants, 92 (43%) reported visiting the plant's medical clinic 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.

In addition to hand or wrist symptoms, we collected information on other musculoskeletal symptoms. The prevalences are shown in Table 8. After hand or wrist symptoms, the second highest prevalence was back symptoms at 58%. Two hundred fifty (79%) of participants reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at baseline.

Table 8. 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

Follow-up Ergonomic and Interview Assessment

Follow-up Ergonomic Assessment

A list of job tasks that were either assessed or assigned an exposure value is provided in Appendix A, Tables A3 and A4. On the basis of our observations during the follow-up visit, only one task changed exposure groups: First Processing-final trim. The final trim task was lowered from exposure Group 3 to exposure Group 2 on the basis of an employer decision to leave broken wings on the bird until they were removed on the cone line. This decision reduced the number of repetitive cuts performed by final trim employees, gave cone line employees something to hold on to while cutting wings, and improved yield of the breast meat. It is important to note that the job task that changed TLV Group categorization from our baseline visit to the follow-up visit was not related to the change in evisceration line speed.

All job tasks in the IPM and multi-vac departments were eliminated on the basis of an employer decision to stop producing those particular products at this plant. This change resulted in the loss of several exposure Group 1 job tasks. However, new exposure Group 1 job tasks were added in gizzard harvesting, Urschel portioning, and on additional DSI machines. The new jobs tasks were assigned exposure values on the basis of our observations. The cone line jobs remained mostly unchanged; however, the sharpeners (referred to as mousetraps) were moved closer to the employees on the basis of our recommendations after the baseline visit, but were still above shoulder level for most employees.

We calculated the time-weighted exposures using job task rotation information provided by each employee from the baseline questionnaire and the follow-up interviews. Table 9 shows the exposure group distribution of the 131 employees who participated in both evaluations. Of these employees, 28 (21%) moved to a lower exposure group and 13 (10%) moved to a higher exposure group at the follow-up evaluation; 90 (69%) stayed in the same exposure group.

Table 9. Distribution of questionnaire participants by exposure groups (n = 131)

Exposure groups	Baseline No. (%)	Follow-up No. (%)
Group 1 (< AL*)	61 (47)	76 (58)
Group 2 (AL–TLV†)	23 (18)	13 (10)
Group 3 (> TLV)	47 (36)	42 (32)

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

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

Of the 129 participants who responded to the question, 69 (53%) reported that their work pace had increased since the evisceration line speed changes, 7 (5%) reported that their work pace decreased, and 53 (41%) reported that their work pace stayed the same.

Follow-up Interview Assessment

Follow-up Interview — All Work Areas

Of the 318 Fresh Plant first-shift production line employees and live hang contractors who completed the administered baseline questionnaire, 214 employees were still working on the Fresh Plant first-shift at our follow-up evaluation. We invited 134 for interview; 131 agreed to participate, including 34 employees working on the evisceration line.

Seventy-five percent of the 131 interview participants were female; none were pregnant. The mean age was 44 years (range: 20–66). The majority (94%) were black or African American. A total of 28 (22%) reported regularly doing hand-intensive tasks outside of their job at follow-up.

Out of 131 participants, 15 (11%) at baseline and 22 (17%) at follow-up reported that a physician diagnosed them with carpal tunnel syndrome. Two participants who did not report a physician diagnosis of carpal tunnel syndrome at baseline but did report a physician diagnosis at follow-up had shared their abnormal nerve conduction test results with their health care provider. Thus, our baseline findings may have contributed to the increase in the prevalence of physician diagnoses. Only 9 of 118 employees reported at follow-up that they shared their NIOSH notification letter and nerve conduction test results with a healthcare provider.

Table 10 shows the workplace characteristics of interview participants. At baseline, 57 of 131 (44%) employees usually worked some overtime (average 3 hours per week) compared to follow-up, with 80 of 117 (68%) employees who usually worked some overtime (average 3 hours per week). The baseline and follow-up evaluations showed no substantial differences in length of employment, hours worked, amount of overtime, participation in rotation and incentive programs, and tool use.

Table 10. Workplace characteristics of follow-up interview participants (n = 131)

	Baseline (n = 128–131)*	Follow-up (n = 112–131)*
Characteristics	Average (range)	Average (range)
Years worked at this poultry plant†	10 (0.01–22)	11 (0.8–22)
Hours worked per week	38 (0–53)‡	40 (32–48)
Hours of overtime usually work per week	3 (0–18)	3 (0–18)
Characteristics	No. (%)	No. (%)
Have other job(s) not at poultry plant	§	5 (4)
Worked at a previous job(s) at this plant and spent more than half a shift	§	75 (58)
Usually work any overtime per week	57 (44)	80 (68)
Rotate from main job to different job tasks	50 (38)	45 (34)
Participate in an incentive program in main job	22 (17)	23 (18)
Use knife, scissors, Whizard®, or other cutting tool in any current job	74 (56)	72 (55)
Use knife, scissors, Whizard®, or other cutting tool in any previous poultry plant jobs	§	53 (47)

*Numbers vary because of nonresponse to certain questions.

†Years worked were self-reported by interviews, and discrepancies were resolved with the company roster list.

‡Hours worked the week prior to our visit

§Question was not asked on baseline visit

At baseline, 76 (58%) of the 131 follow-up interview participants reported hand or wrist symptoms in the previous year; at follow-up, 70 (53%) reported these symptoms. (Note: the baseline question asked about the previous 12 months, while the follow-up question asked about the time since evisceration line changes, approximately 7 months.) Fifty-one (39%) of these 131 participants had these symptoms at both baseline and follow-up evaluations. Of these 51, 14 (27%) reported that their symptoms were "better," 12 (24%) "worse," and 25 (49%) reported "no change at follow-up." Nineteen (15%) of the interview participants reported no symptoms at baseline but reported symptoms at follow-up, and 25 (19%) of the interview participants reported symptoms at baseline, but reported no symptoms at follow-up. Thirty-six (27%) did not report hand or wrist symptoms at either time.

In addition to hand or wrist symptoms, we collected information on other musculoskeletal symptoms. The prevalences are shown in Table 11 for the baseline and follow-up evaluations. Hand or wrist symptoms were the most frequently reported symptom at both evaluations. Ninety-seven (74%) of employees reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at baseline. Ninety-one (69%) of employees reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at follow-up. Fifty-seven percent of employees reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at both evaluations.

Table 11. Prevalence of musculoskeletal symptoms at baseline and follow-up evaluations (n = 131)

Body part	Baseline No. (%)*	Follow-up No. (%)*
Hands or wrists†	76 (58)	70 (53)
Shoulders‡	59 (45)	51 (39)
Back‡	71 (54)	50 (38)
Ankles or feet‡	51 (39)	40 (31)
Neck‡	49 (37)	35 (27)
Knees‡	33 (25)	33 (25)
Hips‡	16 (12)	14 (11)
Elbows‡	17 (13)	13 (10)

*Numbers vary because of nonresponse to certain questions.

†Pain, burning, numbness, or tingling in hands or wrists in the past 12 months for baseline evaluation and since the November 2012 evisceration line speed changes (approximately 7 months) for follow-up

‡Pain, aching, or stiffness

Follow-up Interview—Evisceration Line Workers Only

The results below describe the interview findings from the 34 evisceration line participants who participated at baseline and follow-up. Table 12 shows the exposure group distribution of these evisceration line participants. Of the 34 evisceration line employees, 12 were classified into a lower exposure group at follow-up (exposure Group 2 to exposure Group 1) mostly because the final trim task exposure was reduced.

Table 12. Distribution of questionnaire evisceration line participants by exposure groups (n = 34)

Exposure groups	Baseline No. (%)	Follow-up No. (%)
Group 1 (< AL*)	15 (44)	25 (74)
Group 2 (AL–TLV†)	11 (32)	3 (9)
Group 3 (> TLV)	8 (24)	6 (18)

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

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

Of the 34 participants, 20 (59%) reported that their work pace had increased since the evisceration line speed changes, 4 (12%) reported that their work pace decreased, and 10 (29%) reported that their work pace stayed the same.

Table 13 shows the workplace characteristics of evisceration line participants such as length of employment, hours worked, overtime, participation in rotation and incentive programs, and tool use. These characteristics were similar at baseline and follow-up.

Table 13. Workplace characteristics of evisceration line participants (n = 34)

	Baseline (n = 33–34)*	Follow-up (n = 26–34)*
Characteristics	Average (range)	Average (range)
Years worked at this poultry plant	12 (0.04–21)	13 (0.8–22)
Hours worked per week	39 (26–45)†	38 (32–40)
Hours of overtime usually work per week	1 (0–10)	0.8 (0–4.5)
Characteristics	No. (%)	No. (%)
Have other job(s) not at poultry plant	‡	1 (3)
Worked at a previous job(s) at this plant and spent more than half a shift	‡	17 (50)
Usually work any overtime per week	10 (29)	8 (31)
Rotate from main job to different job tasks	18 (53)	17 (50)
Participate in an incentive program in main job	0 (0)	0 (0)
Use knife, scissors, Whizard®, or other cutting tool in any current job	23 (68)	21 (62)
Use knife, scissors, Whizard®, or other cutting tool in any previous poultry plant jobs	‡	14 (50)

*Numbers vary because of nonresponse to certain questions.

†Hours worked the week prior to our visit

‡Question not asked on baseline visit

Of those on the evisceration line, 15 (44%) reported hand or wrist symptoms both at baseline and follow-up. Table 14 gives prevalences of musculoskeletal symptoms by body part.

Table 14. Prevalence of musculoskeletal symptoms as reported by evisceration line participants in baseline and follow-up evaluations (n = 34)

Body part	Baseline No. (%)	Follow-up No. (%)
Hands or wrists*	18 (53)	21 (62)
Shoulders†	11 (32)	16 (47)
Back†	18 (53)	13 (38)
Feet or ankles†	11 (32)	12 (35)
Neck†	11 (32)	9 (26)
Knees†	7 (21)	7 (21)
Hips†	6 (18)	4 (12)
Elbows†	8 (24)	4 (12)

*Pain, burning, numbness, or tingling in hands or wrists in the past 12 months for baseline evaluation and since the November 2012 evisceration line speed changes (approximately 7 months) for follow-up

†Pain, aching, or stiffness

Interviews with Plant and Corporate Occupational Safety and Health Personnel

The company provided required personal protective equipment (e.g., hearing protection, safety glasses, and gloves) throughout the plant. Clothing (smocks, freezer jackets/suits) was laundered by the company.

The corporate occupational safety and health personnel reported tracking all work-related injuries companywide to enable them to evaluate trends by shift, supervisor, and employee. Also, the corporate occupational safety and health personnel stated that they evaluated and monitored the employees who went to the medical clinic using a medical directive guideline and instructed those employees to return to the nurse every 3 days. For each work-related case determined by the medical staff, the supervisor escorted the employee back to the medical clinic. The nurse questioned the employee about soreness in the hands, whether they were stretching, whether they were taking anti-inflammatory medications, whether they had changes in job tasks, and whether they were making sure they were using sharp knives and scissors. The corporate occupational health personnel stated that they routinely gave nonsteroidal anti-inflammatory medication, such as ibuprofen, to employees with soreness. If the employee did not recover after a "period of time," then they would send the employee to the local off-site occupational clinic to see a physician.

Traumatic Injury Assessment at Baseline and Follow-up

Baseline Questionnaire and Follow-up Interview

We asked participants questions about being injured at work in the previous 12 months. Not all participants answered every question, so the denominators vary slightly. When asked at baseline, of the 318 participants, 22 (7%) reported work injuries. When reviewing the OSHA Logs and onsite medical clinic data from this period, we found 5 incident reports of work-related injuries. On the follow-up visit, 6 of 131 participants reported they had work-related injuries since the evisceration line speed changes were implemented, although there was only 1 entry on the OSHA Logs or on-site medical clinic data during this period. Five (24%) participants at baseline and two (33%) at follow-up reported their injury kept them away from work more than a day. Six (29%) participants at baseline and three (50%) at follow-up reported their injury led to a work restriction or transfer to another job. Ten (48%) participants reported their injury needed medical treatment beyond first aid, one did not provide information on the injury at baseline, and three (50%) reported this at follow-up. Two participants reported they required hospitalization or more than an emergency room visit, and one reported loss of consciousness at baseline, but none reported any of these outcomes at follow-up. Twenty-one (95%) participants said they reported their injury to the employer at baseline, and all six (100%) said this at follow-up.

Our baseline questionnaire included items about injury reporting and safety training. All but one participant indicated they knew how to report an injury at work. When asked about all potential sources of learning about how to report 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, coworker, or other personnel). Three hundred seven participants (97%) 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 their lead person or other supervisor had trained them.

Logs of Injuries and Illnesses

Table 15 shows that the total OSHA recordable industry-wide poultry processing (North American Industry Classification System code 311615] injury and illness rates for 2009 and 2012 were 5.5 and 4.9 cases per 100 full-time equivalent (FTE), respectively [Bureau of Labor Statistics 2009, 2010, 2011, 2012]. The Fresh Plant incidence rates were calculated by the method described by OSHA [Bureau of Labor Statistics 2013]. The Fresh Plant OSHA recordable injury rates were higher than the industry-wide rates in all years. The 2009 employee data records indicated 1,455,303 hours worked or 7.28 per 100 FTEs. For rates in 2010–2013, we used 106,849 hours worked or 6.41 per 100 FTEs. This was the number of hours from July 2012, the only data available to us.

Table 15. Injury and illness rates from OSHA's Form 300 Logs of Work-Related Injuries and Illnesses

Year	Fresh Plant injuries and illnesses	Fresh Plant hours per 100 FTE*	Fresh Plant rate per 100 FTE*	Industry-wide recordable rate per 100 FTE†	Rate ratio Fresh Plant rate/Industry rate
2009	67	7.28	9.20	5.5	1.67
2010	52	6.41	8.11	5.9	1.37
2011	40	6.41	6.24	5.8	1.07
2012	36	6.41	5.61	4.9	1.14
2013	36‡	6.41	5.61	4.9§	1.14

*2009 data obtained from employee records; other years' data extrapolated from the employee records data for July 2012

†North American Industry Classification System code 311615. Bureau of Labor Statistics 2009, 2010, 2011, 2012

‡16 injuries and illnesses reported by June 10, 2013. (161 days or 44% of the year). Projected = 16 * (365/161) = 36

§2013 Bureau of Labor Statistics industry-wide (poultry processing) data not available; used 2012 data.

Table 16 shows that in 2009, sprain, strain, soreness, and inflammation were the most common OSHA recordable injury. In 2010, "hand pain" and "contusion/abrasion" were the most common recordable injury. In 2011, "hand pain" was the most common recordable injury, and in 2012 "hand pain" and "Hearing Loss Standard Threshold Shift (STS)" were the most common injuries. In the first 6 months of 2013, "hand pain" and "Hearing Loss Standard Threshold Shift" were the most common injuries reported on the OSHA Logs.

Table 16. OSHA's Form 300 Logs of Work-Related Injuries and Illnesses entries by type for years 2009–2013

Type	2009	2010	2011	2012	2013*
Sprain, strain, soreness, inflammation	29	9	0	2	1
Hand pain	12	12	9	7	4
Head injury	0	0	1	0	0
Laceration	11	8	8	5	0
Contusion/abrasion	9	12	5	4	2
Fracture	0	3	7	1	0
Amputation	0	0	1	1	1
Avulsion	0	0	0	1	0
Burn	2	1	0	1	1
Foreign body	1	1	2	0	0
Hearing loss (STS)	1	2	6	7	4
Slips, falls	0	3	1	3	3
Repetitive–trigger thumb	1	0	0	2	0
Carpal tunnel syndrome	1	0	0	1	0
Chemical splash to eyes	0	1	0	1	0
Total entries	67	52	40	36	16

*Up to June 10, 2013

Medical Clinic Records

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 June 10, 2013. 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 thumb, hand, and ear(s) (most likely from hearing loss) were the most frequently injured body parts. The next most frequently reported were finger(s), thumb, and hand (Appendix A, Table A5). "Strains," "cut/puncture/scrape," "fall/slip/trip" and "struck by" or "caught in/under/between" were the most frequently reported Type of injury for 2009–2012 (Appendix A, Table A6). The most frequent Cause of injury was "cut/puncture/scrape," "repetitive motion," or "fall/slip/trip" for 2009–2012 (Appendix A, Table A7). 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 A8). 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 A9). In 2012 "near miss" was the third 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 69% in 2013 (Appendix A, Table A10).

Training

Follow-up Training

When asked questions at the follow-up evaluation about information or training provided by the employer since August 2012 (date of baseline visit), 50 of 128 (39%) reported they knew how to report musculoskeletal symptoms, 54 of 131 (41%) reported receiving information or training on nerve conduction testing, 42 of 130 (32%) reported receiving information on ergonomics, 22 of 129 (17%) reported receiving information or training on carpal tunnel syndrome, and 34 of 129 (26%) reported receiving information or training on the NIOSH evaluation.

Discussion

Poultry processing involves a combination of highly repetitive and forceful movements that places employees at an increased risk for upper extremity WMSDs [Lipscomb et al. 2008; Cartwright et al. 2012]. Because much of the work on a poultry processing line involves the hand and wrist, workers may be particularly at risk for carpal tunnel syndrome. Chiang et al. [1993] found a significant relationship between increasing exposure to repetition and force among poultry workers and increasing prevalence of carpal tunnel syndrome more than 20 years ago. For this evaluation, as a measure of exposure, we used the ACGIH TLV for hand activity and force. This TLV has been validated and shown to predict a dose-response relationship for the incidence of carpal tunnel syndrome [Bonfiglioli et al. 2013]. Of the 131 employees who participated in both the baseline and follow-up evaluations, 47 (36%) were performing job tasks that were above the ACGIH TLV for hand activity and force at our baseline visit and 42 (32%) were performing job tasks that were above the ACGIH TLV for hand activity and force at our follow-up visit. It is important to note that those job tasks that changed ACGIH TLV exposure category levels between our baseline and follow-up visits were unrelated to the increase in evisceration line speed. More importantly, before the evisceration line speed increase, approximately 41% of the 318 participants at this plant were performing job tasks that were above the ACGIH TLV for hand activity and force.

We found that 42% of participants in our baseline evaluation met our carpal tunnel syndrome case definition. 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. Cartwright et al. [2012] reported on results of a study 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 because 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%, similar to the 42% prevalence in our evaluation. Because early detection and aggressive treatment are keys 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. Other studies have defined carpal tunnel syndrome by different criteria, using symptoms in combination with physical examination, median nerve conduction study alone, symptoms alone, or a combination of these criteria. This variation in case definition may contribute to differences in the reported prevalence of carpal tunnel syndrome ranging from 7.8% to 73.9% [Kim et al. 2004; Cartwright et al. 2012].

Because of the work required in processing chickens, some workers use both 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 the 126 individuals that met our carpal tunnel syndrome case definition for either hand.

Although a strong relationship exists between specific work factors and carpal tunnel syndrome [National Research Council 2001], non-occupational factors must also 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 also has been associated with carpal tunnel syndrome risk. In our analysis, we adjusted for sex, age, body mass index, and diabetes mellitus. After controlling for the effects of these variables, the work factors (force and repetition) remained statistically significantly associated with our carpal tunnel syndrome case definition.

We did not look at all the components of our carpal tunnel syndrome case definition at our follow-up visit; however, at baseline and follow-up evaluations (including the subset of evisceration line participants only) we found similar prevalences of hand or wrist symptoms, as well as other musculoskeletal symptoms. We did not conduct nerve conduction studies at follow-up primarily because of the high prevalence of abnormal nerve conduction test results at baseline (72%). Also, the relatively short time between baseline and follow-up evaluations lessened the likelihood of finding new cases or seeing meaningful changes in severity.

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 (1) some cases in the lower exposure groups (below the ACGIH AL, 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 (2) 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 that have 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 AL is exceeded, other ergonomic controls should be employed.

We found that the risk of carpal tunnel syndrome increased with increasing exposure to the occupational risk factors for musculoskeletal disorders. These results suggest the need for ergonomic interventions and improvement of work processes and medical evaluation. Despite repeated studies in this industry in the past 20 years that found high prevalence of carpal tunnel syndrome, poultry processing jobs continue to be hazardous. OSHA has had guidance for preventing musculoskeletal disorders in the poultry industry since early 2000 and recently updated that guidance [OSHA 2013]. Early recognition of, reporting of, and intervention in 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 2013].

The National Chicken Council and the Poultry & Egg Institute have long-standing workplace recommendations regarding ergonomics and injury prevention [National Chicken Council 2008; 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's 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 to supervise the program. The American Meat Institute recommends that each work shift have access to healthcare providers to facilitate treatment, medical surveillance, and the recording of information [American Meat Institute 2009]. 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 recommended exercises and medication to help with the discomfort associated with the adjustment to the job. Although this letter recommended that employees see their healthcare provider before taking any medication, during our baseline visit we observed a medicine dispenser in the cafeteria that sold pain relievers. At our follow-up visit, the medicine dispenser was still present. 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 publicized the importance of early medical intervention in preventing the onset of serious musculoskeletal disorders. Early detection and aggressive treatment of musculoskeletal disorders were described as keys 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 most participants knew how to report an injury at work and to whom to report the injury. The discrepancy we found between self-reported injury and OSHA Log entries may have been due to (1) failure to report the injuries by the employees to their supervisors or the medical clinic or (2) the fact that the injuries may not have been severe enough to be an OSHA recordable 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 and illness rates in all of the 5 years studied [Bureau of Labor Statistics 2009, 2010, 2011, 2012]. However, there was a decreasing injury rate and frequency over these years for the Fresh Plant. 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.

We found that 42% of participants met the carpal tunnel syndrome case definition, but this prevalence was not indicated in the medical clinic data. Between 2009 and 2012, the number of reported injuries decreased, and the most frequently reported injured body part changed (Appendix A, Table A5). Few “wrist” or “wrist(s) and hand(s)” injuries were reported. Although 14 incidences of pain are listed in Appendix A, Table A8, for 2012, further examination of these medical clinic records shows seven cases with the body part listed as “hand” or “wrist” and only one was “repetitive motion” by cause. These discrepancies could be due to a change in reporting procedures or 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 that were OSHA recordable increased over most years (Appendix A, Table A10).

During our initial visit, 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. At the follow-up visit, we noted improvements in housekeeping practices and a reduced frequency of "fall/slip/trip" injuries based on 6 months of data, but these were still the leading "Type" and "Cause" of injury in 2013.

We observed dust exposures in the Further Processing Plant (Breading Area) during our initial tour of the plant. While we did not evaluate these exposures, we had previously informed plant managers about our observations.

Strengths and Limitations

Our carpal tunnel syndrome case definition used well-accepted criteria, including objective nerve conduction measurements assessed by two independent board-certified neurologists. To assess hand activity and force we used the ACGIH TLV for HAL, a standardized and validated assessment tool.

This health hazard evaluation was performed as two cross-sectional surveys that measured health outcomes and exposures at points in time. Cross-sectional studies provide data useful for supporting inferences of cause and effect. One advantage of our evaluation was that we were able to assess the same poultry workers at two points in time and learn about their exposures and reported health symptoms. Selection bias was minimal because of the 85% participation rate in August 2012. Inherent in this type of study is the potential for "survivor bias" (i.e., including employees who may have remained in their jobs, and not capturing those who may have left work because of injury or other reasons). Such survivor bias may result in an underestimation of the prevalence of injuries, including carpal tunnel syndrome. Some exposure misclassification may have occurred because our exposure assessment was based on the current job(s) and did not account for overtime work or shift work. Of 150 who usually worked some overtime, the average was 7 hours per week. Also, some evidence shows that employees on later work shifts experience more injuries and, therefore, our evaluation of only the first-shift may have underestimated the prevalence [Strong and Zimmerman 2005].

Although we requested employee database records from the company for 2010–2012, they were not provided. Thus, 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 other years. Having the actual number of hours worked for each year may have changed 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 2011. This change would potentially result in 25% higher rates and correspondingly higher rate ratios prior to November 2011 (4% higher in 2011). However, the higher rates could not be documented without the actual payroll 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. Although the evisceration line speed increased, the number of chickens handled by most workers and the total production remained the same at the time of our follow-up visit.

Conclusions

At our baseline evaluation 42% of participants had evidence of carpal tunnel syndrome on the basis of our case definition and 41% of participants worked in jobs above the ACGIH TLV for hand activity and force. Increased levels of hand activity and force were associated with increased carpal tunnel syndrome prevalence among participants. Of the 131 employees who participated in both our baseline and follow-up evaluations, at follow-up 32% were performing job tasks that were above the ACGIH TLV for hand activity and force after the evisceration line speed increase. The most common reported musculoskeletal symptom involved the hand or wrist with 39% of participants reporting these symptoms at both baseline and follow-up evaluations. Also, 57% of these participants reported at least one musculoskeletal symptom (not including hand or wrist symptoms) at both baseline and follow-up evaluations. The Fresh Plant's rate of injuries and illnesses reported on the OSHA Logs was higher than the poultry processing industry average for 2009–2012 [Bureau of Labor Statistics 2009, 2010, 2011, 2012]. These results suggest the need for ergonomic interventions and improvement of work processes.

For the employees who participated in both of our evaluations, we found that workplace characteristics including length of employment, hours worked, overtime, participation in rotation and incentive programs, and tool use at baseline and follow-up remained similar. Combining two evisceration lines into one did not change the number of birds processed by most workers at this facility. The prevalence of hand or wrist symptoms (pain, burning, numbness, or tingling) was similar for both evaluations.

The challenge to the industry is to redesign poultry processing work so that a meaningful reduction in risk factors for musculoskeletal disorders and traumatic injuries takes place. While some mechanization in certain processes has been helpful, more changes are needed. Changes to one task may have unintended adverse effects on other tasks. When tasks are changed, an assessment of potential risk factors for all tasks should be done. Existing industry guidelines for prevention, early recognition and intervention, and medical management must be put into place and vigorously and routinely reinforced. Continued research to improve existing guidelines that lead to better outcomes for poultry employees is also needed.

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 this 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. Several of these recommendations were made in our interim report and discussed during our follow-up evaluation.

Elimination and Substitution

Eliminating or substituting hazardous processes or materials reduces hazards and protects employees more effectively than other approaches. Prevention through design, considering elimination or substitution when designing or developing a project, reduces the need for additional controls in the future.

1. Design job tasks so that they are below the ACGIH TLV to minimize the risk for developing carpal tunnel syndrome, which could include using the sixth cone line and reducing the speed of all cone lines to reduce repetition.
2. Automate or semiautomate 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. Although this job task had been discontinued at the time of our follow-up evaluation, this recommendation may be useful if the company re-introduces the task.
4. Redesign the drumstick packer workstation to eliminate twisting and reaching for the label with the right hand. Although this job task had been discontinued at the time of our follow-up evaluation, this recommendation may be useful if the company re-introduces the task.
5. 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.
6. 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.
7. Place sharpeners (referred to as mousetraps on cone lines) in locations that do not require reaching above the shoulder to use them.
8. Redesign the paw line to eliminate reaching over shoulder height to grade paws.

9. Install a tilter or dumper for loading product in Urschel portioning machines. Employees were seen removing product from tubs near shoulder height. Alternatively, provide shorter bins or bins with drop-down sides and shovels.
10. Move the employee in Urschel portioning across the conveyor to eliminate the need for the employee to twist his body while sorting product.
11. Redesign the start/stop switch at the Urschel portioning machine loading workstation. The employees were not using the switch because it required an extended reach.
12. Provide slip-resistant antifatigue mats at each standing workstation.
13. Remove the solid surface placed over the open grated adjustable platform on the thigh debone line, as this may be a potential slip, trip, and fall hazard.
14. Hang the water hoses off the floor to prevent slip, trip, and fall hazards.
15. 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: Prevention of Musculoskeletal Injuries in Poultry Processing [OSHA 2013] and the recommendations of the National Chicken Council and the Egg & Poultry Institute [National Chicken Council 2008; 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 AL 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 symptoms early to the onsite medical clinic so medical personnel can evaluate these symptoms promptly. The medical personnel can then alert management of specific work areas of concern or a worker's fitness for duty, while maintaining confidential patient medical information.
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. Encourage employees to follow up with onsite medical staff and their personal doctor if they were found to have an abnormal nerve conduction test result.

8. Institute a medical surveillance program for musculoskeletal disorders to monitor employee health and determine the effectiveness of exposure prevention and medical management strategies. Several good sources for information on medical monitoring and surveillance are available, among them the American Meat Institute and OSHA websites. In addition, we recommend a comprehensive program for medical nurse visits that captures information about symptoms, clinical signs, laboratory tests, and follow-up to differentiate between diagnoses and determine effectiveness of treatment.
9. Remove the medicine dispenser in the cafeteria and educate employees about the reasons for doing so.
10. Develop procedures for employees to provide information and feedback on work equipment and procedure modifications.
11. 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].
12. 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.
13. Ensure that knives are sharpened regularly so employees do not have to exert undue force to make cuts; this should reduce cuts/lacerations and reduce the risk of musculoskeletal disorders.
14. Although we did not evaluate noise exposures, STSs were reported on the OSHA Logs. If an audiogram indicates a STS, refer the employee for a medical evaluation.
15. Improve maintenance to reduce the slip, trip, and fall hazards that we observed, such as uneven work surfaces that protruded in the floor and small holes or depressions in the floor.
16. Discuss with employees the changes already made to the plant and any future changes that are planned. Communicate these plans face-to-face and in writing.

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	> 3.7 ms
	or	
	Mid palm to wrist sensory latency	> 2.2 ms
	or	
	Motor latency	> 4.4 ms
B Normal distal ulnar nerve latency and amplitude (both indicators present)	Wrist to little finger sensory amplitude	≥ 10 μV
	and	
	Wrist to little finger sensory latency	≤ 3.7 ms
C Distal median nerve latency > distal ulnar latency	Median wrist to index finger *minus* ulnar wrist to little finger latency	difference > 1.0 ms
	or	
	Median mid palm to wrist *minus* ulnar mid palm to wrist latency	difference > 0.5 ms

ms = milliseconds

μV = microvolts

Table A2. The severity of carpal tunnel syndrome using nerve conduction results [Stevens 1997]

Severity	Nerve conduction results
Mild	• Is defined by relative or absolute prolongation of either the sensory or palmar median nerve. Additionally, at times the amplitude of the potential is seen to be slightly diminished.
Moderate	• Both sensory and motor latencies are relatively or absolutely prolonged.
Severe	• Is characterized by both motor and sensory latencies being prolonged with either an absent sensory or palmar potential or low amplitude or absent motor potential.

Table A3. Job tasks by area and department categorized by exposure group

Area	Department	Exposure group 1	Exposure group 2	Exposure group 3
First processing	Evisceration	Backup killer Backup rehanger Vent opener Reprocess vacuum USDA trimmer/helper	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†

*Final trim was changed from Category 3 to Category 2 because of work changes noted during the follow-up site visit.

†These jobs were eliminated between the time of the baseline and follow-up visits.

Table A4. Job tasks assigned to exposure groups at baseline and follow-up 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 Dead on arrival/ escape*	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 Scale*	N/A	N/A
	Cut-up	Whole leg lead Flex line floor Parts/product wash Wing operation floor Lead*	N/A	Whole leg stack
	Multi-vac	N/A	Scale† Box maker†	N/A
	Gizzard harvesting	Grader* Bagger*	N/A	N/A
	DSI	Quality control/SPC Floor Lead	N/A	N/A
	IPM	Move nuggets to tub† Lead†	N/A	N/A
	Urschel portioning	Loader* Feeder* Grader* Final grader* Lead* Floor*	N/A	N/A

*New jobs assigned during follow-up site visit.

†These jobs were eliminated between the time of the baseline and follow-up visits.

Table A5. Onsite medical clinic visits – “Body Part” affected by year

Body part	2009	2010	2011	2012	2013*
Hand	29	18	18	7	2
Finger(s)	27	12	10	6	1
Ear(s)	4	6	5	7	5
Multiple body parts	12	2	6	1	3
Lower back area	11	6	1	3	0
Thumb	5	4	4	7	1
Wrist	9	4	2	2	0
Shoulder	8	5	1	3	0
No physical injury	1	9	1	5	0
Lower arm	8	3	4	0	0
Foot	3	4	6	3	1
Knee	5	3	4	0	1
Upper arm	6	3	2	0	0
Multiple upper extremities	5	4	2	1	0
Eye(s)	3	4	2	2	1
Ankle	2	3	4	1	0
Wrist(s) and hand(s)	3	1	2	0	1
Upper back area	4	1	1	0	0
Multiple lower extremities	3	1	2	0	0
Multiple head injury	0	3	3	0	0
Lower leg	3	1	2	1	0
Other (four or fewer in any one year)	25	7	8	4	0
Total	176	104	90	53	16

*Up to June 10, 2013

Table A6. Onsite medical clinic visits – “Type” of injury by year

Type	2009	2010	2011	2012	2013*
Strain/injury by	46	29	18	7	1
Cut/puncture/scrape injured	44	13	14	10	1
Miscellaneous cause	23	15	9	13	4
Fall/slip/trip injury	17	16	20	5	4
Struck/injured by	19	9	9	9	2
Caught in/under/between	7	11	12	4	3
Striking against/stepping on	13	6	5	3	0
Burn/scald, hot/cold contact	4	2	2	1	1
Motor vehicle	0	3	0	1	0
Rubbed or abraded by	1	0	1	0	0
Non-work related	1	0	0	0	0
Cut, puncture, scrape	1	0	0	0	0
Total	176	104	90	53	16

*Up to June 10, 2013

Table A7. Onsite medical clinic visits – "Cause" of injury by year

Cause	2009	2010	2011	2012	2013*
Cut/puncture/scrape, NOC†	39	10	12	9	0
Repetitive motion	21	18	12	4	1
Fall/slip/trip, NOC	12	10	13	4	4
Cumulative, NOC	10	8	5	8	4
Caught in/under/between, NOC	6	10	11	4	3
Struck or injured, NOC	10	6	4	3	0
Striking against/stepping on,	9	4	5	3	0
Other - miscellaneous, NOC	9	6	3	5	0
Strain/injury by, NOC	6	6	3	1	0
Lifting	10	2	2	0	0
Pushing or pulling	7	2	0	0	0
Object being lifted or handled	4	2	2	0	1
Hand tool, utensil; not powered	5	1	2	0	1
Slip, or trip, did not fall	0	1	3	0	0
On same level	3	0	1	0	0
Fellow worker, patient, or other	2	1	1	0	0
Steam or hot fluids	1	1	1	0	0
Stationary object	2	1	0	0	0
On stairs	1	0	2	0	0
Object being lifted and handle	0	2	0	1	0
Moving parts of machine	3	0	0	0	0
Hand tool or machine in use	0	0	1	2	0
From liquid or grease spills	0	3	0	0	0
From different level (elevation)	0	2	1	0	0
Foreign matter (body) in eye(s)	2	1	0	0	0
Falling or flying object	1	1	1	3	0
Collision with fixed object	0	2	0	1	0
Chemicals	1	1	0	1	0
Absorption, ingestion, or inhalation	2	0	1	0	0
Using tool or machinery	1	0	0	1	0
Machine or machinery	1	0	1	0	0
Holding or carrying	2	0	0	0	0
Wielding or throwing	0	1	0	0	0
Twisting	0	0	1	1	0
Motor vehicle	0	0	0	1	1
Rubbed or abraded by, NOC	0	0	1	0	0
Object handled	0	1	0	0	0
Non-occupational disease	1	0	0	0	0
Moving part of machine	1	0	0	0	0
Knives/scissors	1	0	0	0	0
Into openings	1	0	0	0	0
Hot objects or substances	1	0	0	0	0
Contact with, NOC	0	0	1	0	1
From ladder or scaffolding	0	0	0	1	0
Collision or sideswipe with an object	0	1	0	0	0
Cold objects or substances	1	0	0	0	0
Total	176	104	90	53	16

*Up to June 10, 2013
†NOC = not otherwise classified

Table A8. Onsite medical clinic visits – “Nature” of injury by year

Nature	2009	2010	2011	2012	2013*
Contusions/bruise	32	21	20	5	4
Sprain/strain	34	16	12	3	1
Laceration/cut	33	12	12	7	0
Pain	12	8	6	14	1
Other	20	7	2	0	1
Hearing loss	4	6	5	7	1
Musculoskeletal disorders	1	12	6	3	0
Multiple physical injuries	10	2	6	3	1
None	1	7	2	5	3
Puncture	9	3	1	1	1
Inflammation/swelling	9	0	4	0	0
Fracture	0	4	7	1	0
Scratch/abrasion	2	3	0	0	1
Irritation	2	1	1	1	0
Burn	2	1	1	0	1
Avulsion	2	0	0	2	0
Foreign body	0	1	2	0	0
Minor first aid care	2	0	0	0	0
Amputation	0	0	1	1	1
Respiratory condition	0	0	1	0	0
Electric shock	0	0	1	0	0
Cut/laceration	1	0	0	0	0
Total	176	104	90	53	16

*Up to June 10, 2013

Table A9. Onsite medical clinic visits – "Injury Degree Status" by year

Degree status	2009	2010	2011	2012	2013
Medical only	56	59	39	27	6
First aid occupational health staff	85	30	43	13	4
Lost time	13	5	4	3	2
Near miss	1	5	0	8	4
First aid nonmedical responder	11	1	2	0	0
Temporary restriction	4	4	2	2	0
Not indicated	5	0	0	0	0
Preventative restriction	1	0	0	0	0
Total	176	104	90	53	16

*Up to June 10, 2013

Table A10. Onsite medical clinic visits injury OSHA recordable status by year

OSHA recordable	2009 N = 176 number (%)	2010 N = 104 number (%)	2011 N = 90 number (%)	2012 N = 53 number (%)	2013* N = 16 number (%)
No	109 (62)	53 (51)	50 (56)	21 (40)	5 (31)
Yes	67 (38)	51 (49)	40 (44)	32 (60)	11 (69)

*Up to June 10, 2013

Appendix B: Figures

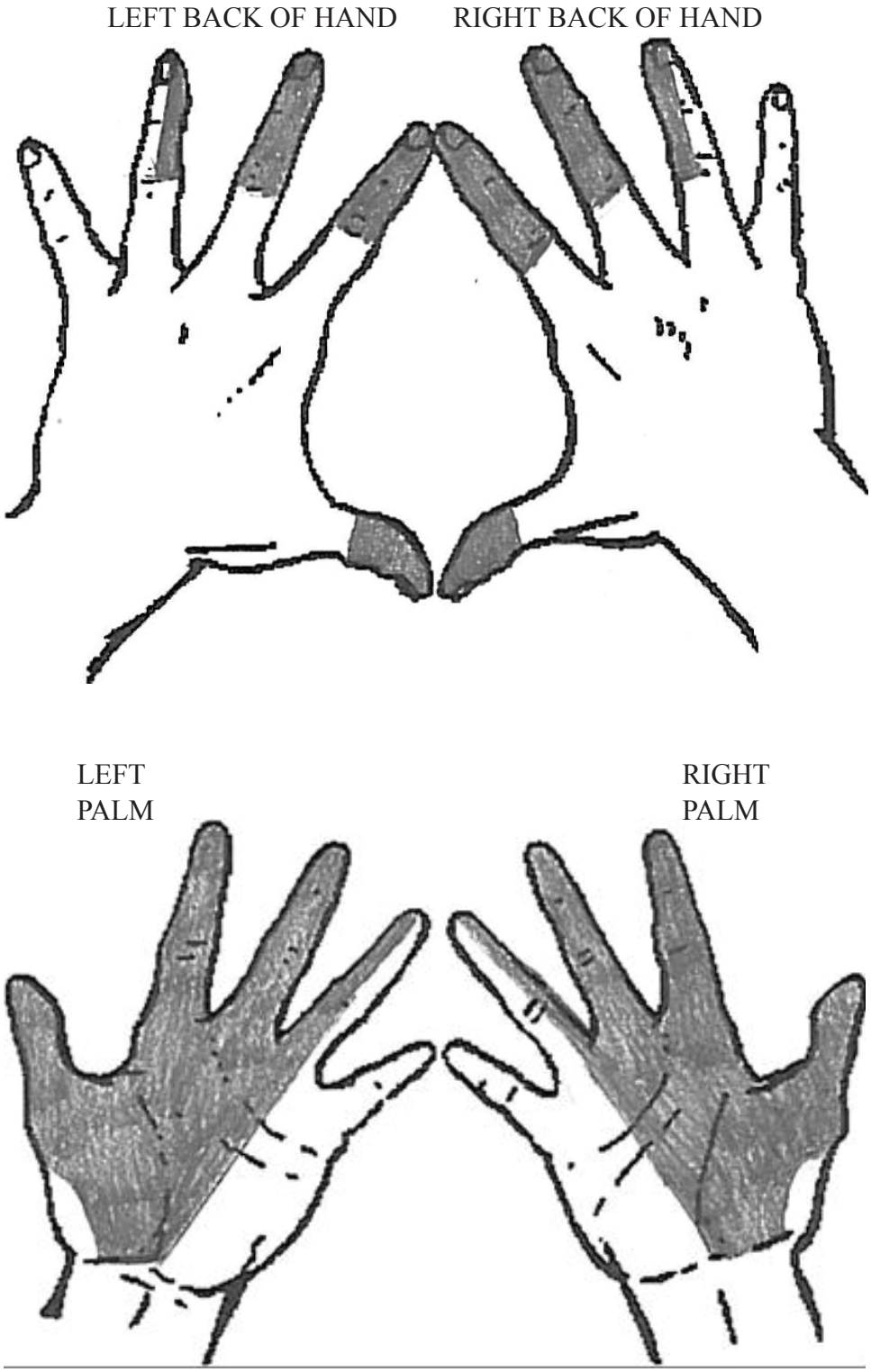

Figure B1. Hand symptom diagram showing median nerve distribution.

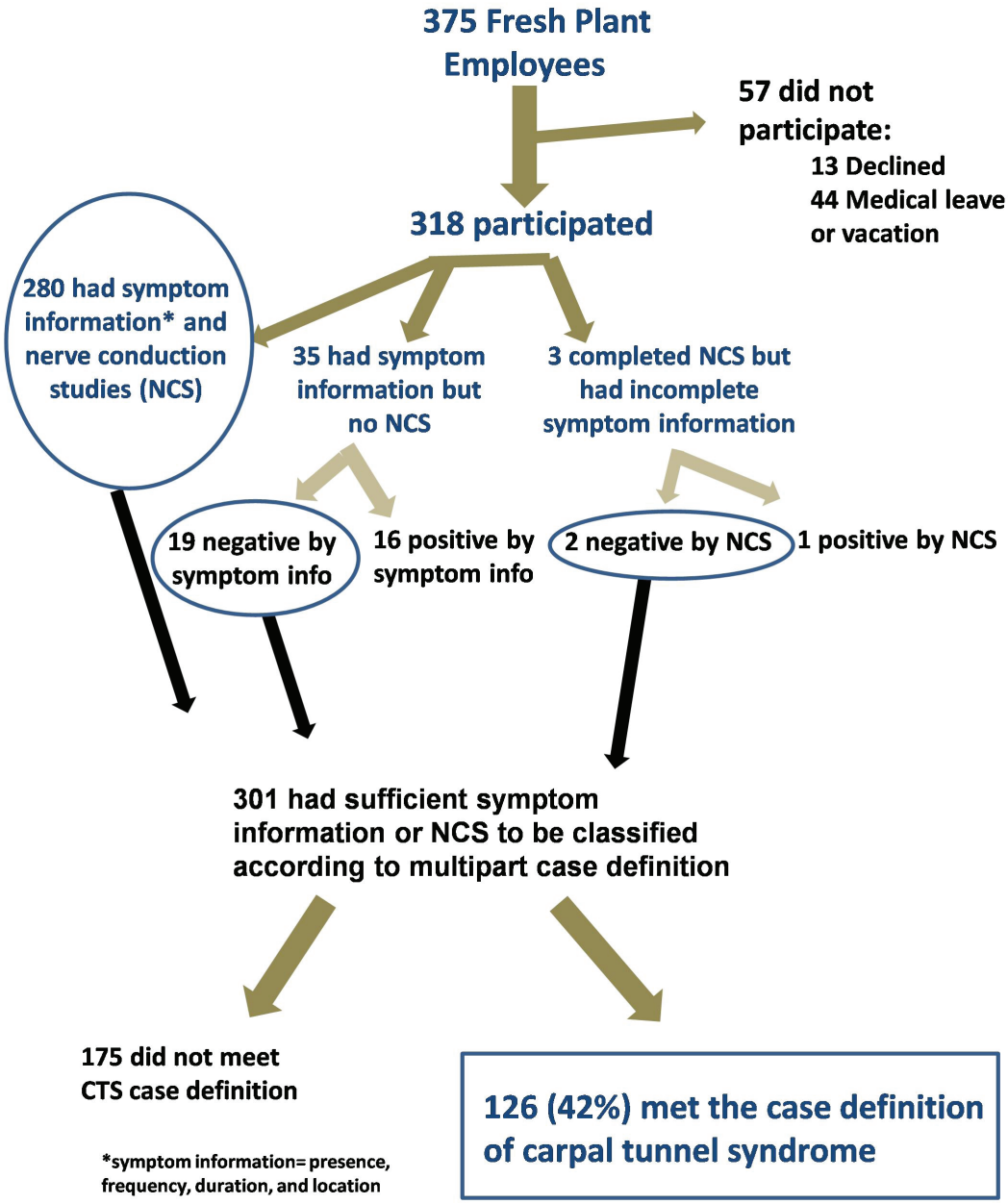

Figure B2. Defining a case of carpal tunnel syndrome among poultry employees.

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Availability of Report

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