Evaluation of Carpal Tunnel Syndrome and Other Musculoskeletal Disorders among Employees at a Poultry Processing Plant

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Contents

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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 plant in Maryland to evaluate risk factors for musculoskeletal disorders. The U.S. Department of Agriculture/ Food Safety and Inspection Service required the plant to request the evaluation in order for the plant to modify their poultry processing and inspection procedures.

What We Did

- We visited the plant in February 2014 to learn about plant operations and interview employees.
- We returned in April 2014 to conduct ergonomic evaluations, survey employees about their health, and do nerve conduction testing.
- We assessed hand and wrist repetition and force in 32 job tasks in the receiving, picking, evisceration, debone direct, and thigh line departments.
- We asked employees about work, medical history, hand and wrist symptoms, other musculoskeletal symptoms, work conditions, and work hours.
- We used the nerve conduction testing results and self-reported hand and wrist symptoms to determine if an employee had evidence of carpal tunnel syndrome.
- We collected logs of work-related injuries and illnesses to evaluate musculoskeletal disorders.
- In follow-up telephone calls we obtained information about changes in the plant, including increases in the evisceration line speed.

We evaluated musculoskeletal disorders among employees at a poultry processing plant. At the time of our evaluation, 59% of the jobs we evaluated were above the recommended limits of hand activity and force and 34% of participants met our case definition for carpal tunnel syndrome, which likely results from the repetitive and forceful nature of the work. Recommendations are provided to minimize the risk for musculoskeletal disorders.

What We Found

- Fifty-nine percent of the jobs we evaluated had average levels of hand activity and force above the American Conference of Governmental Industrial Hygienists' action limit.
- The receiving, picking, debone direct, and thigh line departments had jobs in different exposure groups. However, the company did not rotate employees among these jobs.
- Thirty-four percent of participants had evidence of carpal tunnel syndrome on the basis of our case definition.
- Seventy-six percent of participants had an abnormal nerve conduction test result in at least one hand.

- Sprain, strain, pain, soreness, inflammation, or repetitive motion entries were the most common Occupational Safety and Health Administration recordable injury in 2010, 2011, and 2013.

What the Employer Can Do

- Implement the 2013 Occupational Safety and Health Administration Guidelines for Poultry Processing and recommendations from poultry industry groups.
- Design job tasks so that levels of hand activity and force are below the action limit of the American Conference of Governmental Industrial Hygienists.
- Reduce cone line speeds and use additional cone lines so job tasks are below the action limit of the American Conference of Governmental Industrial Hygienists.
- Implement a rotation schedule to reduce stress to specific sets of muscles and tendons.
- Ensure that the knife change-out schedule is strictly followed.
- Provide more breaks during the work shift.
- Implement a standard process to evaluate employee symptoms. Provide appropriate treatment, work restrictions, and medical referrals.

What Employees Can Do

- Report symptoms and injuries as soon as you can to supervisors and onsite medical staff.
- Use only sharp knives for cutting. Keep knives sharp by using mousetraps frequently and changing knives on a regular basis.
- Adjust the standing platforms to the correct height to do your job.
- Follow up now with onsite medical staff and your personal doctor if you did not do so when you first received abnormal results on our nerve conduction test.
- Participate in ergonomics committees.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
AL	Action limit
CFR	Code of Federal Regulations
FSIS	Food Safety and Inspection Service
HAL	Hand activity level
HIMP	Hazard Analysis and Critical Control Point-Inspection Models Project
MSD	Musculoskeletal disorder
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
TLV®	Threshold limit value
USDA	United States Department of Agriculture

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Introduction

The Health Hazard Evaluation Program received a request for an evaluation from a poultry processing plant in Maryland in December 2013. The employer submitted the request to fulfill a U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) requirement to participate in the USDA Hazard Analysis and Critical Control Point (HACCP) Inspection Models Project (HIMP). A HIMP waiver permits plant personnel to conduct carcass sorting and trimming and to remove carcasses that they deem unlikely to pass federal inspection. USDA/FSIS states that this allows FSIS online inspectors to perform their inspection more efficiently and in less time because they visually examine only carcasses that are likely to pass inspection. HIMP also requires offline FSIS inspectors that determine if the plant is meeting relevant performance standards [USDA 2011]. The employer asked the National Institute for Occupational Safety and Health (NIOSH) to evaluate risk factors for repetitive motion disorders among workers at the plant.

We made an initial visit in February 2014, focusing on the poultry processing plant. The company's hatchery and feed mill were not part of our evaluation. We returned for an in-depth exposure and health assessment (including nerve conduction testing) in April 2014. We sent letters with our preliminary findings, recommendations, and plans to management and union representatives in March and April 2014. In June 2014, we sent letters to participating employees, managers, and union representatives regarding the nerve conduction test results. In August 2014, we held conference calls with management and union representatives to learn about changes in the plant processes (including increased evisceration line speed) implemented in July 2014 as part of the USDA HIMP. This report describes our evaluations in February and April, 2014, as well as summarizes changes to the plant discussed during those telephone conferences.

Process Description

At the time of our site visits, the plant processed approximately 177,000 birds per day or 885,000 birds over a 5-day workweek. The live birds weighed on average 8 pounds. Three hundred forty-two full-time employees worked in the receiving/picking (41), evisceration (including liver harvest 75), debone direct (168), and thigh line (58) departments on either the first or second production shift. The employees were represented by the United Food and Commercial Workers Union, Local 27. Employees typically worked 8-hour shifts with one 36-minute lunch break and an additional 12-minute break. Employees occasionally worked overtime and received an additional 12-minute break if they worked more than 8.25 hours. The live hang and debone direct jobs had performance-based incentive programs. To receive the weekly incentive, employees must work all 5 days of the week and meet a performance score established by management.

Receiving, Picking, and Evisceration

Job tasks in the receiving and picking departments included one jockey driver, one fork truck driver, and one dumper operator placing birds on an individual conveyor. The conveyor carried the birds into the building where employees worked on opposite sides of the conveyor

to supply two lines. Each line included four live hang employees, one backup killer, and one backup rehanger. Each evisceration line included the following jobs: one backup vent opener, one viscera puller, one viscera remover, one liver puller, one liver sorter, and one final trimmer. The plant operated two evisceration lines across two production shifts. During our April 2014 visit, each evisceration line was running at approximately 91 birds per minute, less than the maximum speed of 140 birds per minute allowed by USDA/FSIS for a plant of this type. Each of the three USDA/FSIS inspectors per line was assigned one presenter and one helper to assist with inspection.

Debone Direct

The front halves of the birds (wing and breast meat) were transported to cone lines for deboning. During our April 2014 visit, each of the five cone lines ran at 40 birds per minute. Each debone direct line included one loader, two first cutters, two second cutters, two wing cutters, one breast puller, three breast trimmers, two tender scorers, two tender clippers, and one tender puller. At the end of the debone direct lines one breast skinner worked on product from two lines.

Thigh Line

The thighs were transferred to the thigh deboning department. During our April 2014 visit, there was a thigh skinner loader, three or four thigh debone machine loaders, four thigh graders/packers, and 16 thigh trimmers who removed excess fat, skin, or bones. Three thigh trimmers used a Whizard® knife, which is an air-powered circular trimmer designed for meat cutting, and the other 13 trimmers used scissors.

Methods

Initial Visit

The objectives of our February 2014 visit were to (1) observe work processes and practices, (2) coordinate data collection plans, (3) hold confidential employee medical interviews, and (4) determine which health outcomes to evaluate. We used the company employee roster to select a convenience sample of English-speaking or Spanish-speaking employees working first- or second-shift to participate in these information-gathering interviews. We discussed work history, symptoms, and workplace health and safety concerns during the interviews. We decided to assess carpal tunnel syndrome among employees in the receiving, picking, evisceration, debone direct, and thigh line departments based on information gathered during this visit, literature reviews, and knowledge from our previous poultry evaluations.

Ergonomic and Epidemiological Assessment of Carpal Tunnel Syndrome

The objectives of our April 2014 visit were to (1) assess jobs for repetition and force, (2) determine the prevalence of carpal tunnel syndrome, and (3) identify other potential work-related musculoskeletal disorders (MSDs).

Ergonomic Assessment

We concentrated our evaluation and job assessments on the ergonomic risk factors related to hand and wrist activity. We collected videos of each previously mentioned job task in the receiving, picking, evisceration, debone direct, and thigh line departments. Videos were used to document the jobs for assessment by multiple raters [ACGIH 2014]. Because all lines were running at the same speed, we randomly chose one employee to record for each job. We recorded at least 3 minutes of video for each job task, long enough to see several complete work cycles.

After the site visit, four NIOSH ergonomists reviewed the videos and independently scored the repetition and force for each job task. We used the following approach:

- To assess repetition, we used the hand activity level (HAL) scale to separately rate repetitiveness for right and left hands during at least five complete work cycles.
- To assess force, we separately rated peak exertion of the right and left hands using the modified Borg CR-10 scale [Borg 1982].
- To address ratings that differed between the NIOSH ergonomists, we discussed our observations and came to a joint decision.

We compared our measurements of hand activity and force with the action limit (AL) and threshold limit value (TLV®) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH®) [ACGIH 2014]. The TLV uses the average hand activity level and peak hand force to determine conditions it is believed that nearly all workers can be exposed to repeatedly without adverse health effects [ACGIH 2014]. This TLV was validated in a large cohort study and predicted both carpal tunnel syndrome symptoms and carpal tunnel syndrome confirmed by nerve conduction studies [Bonfiglioli et al. 2013].

We used the HAL and force ratings to calculate a ratio using the following formula [Eastman Kodak Company 2004]:
Ratio = Force / (10 – HAL)

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

Epidemiological Assessment of Carpal Tunnel Syndrome

We used the company's employee roster to select first and second-shift production line employees to participate in our assessment. We selected all of the receiving, picking, and evisceration employees and randomly selected a sample of debone direct and thigh line employees. Employee participation was voluntary. Participating employees gave written informed consent. Employees filled out a questionnaire in their preferred language (English,

Spanish, or Creole). Interpreters, contracted by NIOSH, were available to answer employees' questions during the visit. We measured each participant's height and weight to calculate body mass index according to the following formula [CDC 2014]:
body mass index = weight in pounds × 703 / (height in inches)^2

Questionnaire

Participants completed the questionnaire without the employer or union present in an area where NIOSH controlled access to ensure privacy. The questionnaire collected information on employee demographics; work and medical history; presence, frequency, and duration of neuropathic symptoms (pain, burning, numbness, or tingling in hands or wrists); other musculoskeletal symptoms; and other factors such as hours worked and tool use. We used pictures of certain medical conditions when translation of medical terms to other languages was difficult or did not exist. We asked participants how long they had worked at this poultry plant location, including all past owners.

Participants who reported pain, burning, numbness, or tingling in their hands or wrists in the past 12 months also completed the hand symptom diagram adapted from Katz et al. [1990] shown in Appendix B, Figure B1. Participants indicated the location of their hand or wrist symptoms by marking or shading areas on the diagrams. We used these diagrams to identify symptoms associated with a classic median nerve distribution. Results from the diagram were classified into four hand categories: positive right hand only, positive left hand only, positive both hands, or negative both hands. Two NIOSH medical officers independently evaluated the hand diagrams. Both were blinded to the identity of the individual or knowledge of their job title, medical information, and questionnaire responses. They had 100% agreement with classifying the marked or shaded hands into categories.

Nerve Conduction Test

An electrodiagnostic technologist, certified by the American Association of Electrodiagnostic Technologists, performed nerve conduction tests following established guidelines [American Association of Electrodiagnostic Medicine 1992, 2002]. The technologist did not know the participant's job title, medical information, or questionnaire responses. Participants' hands were warmed to 32 degrees Celsius with a radiant lamp, and median and ulnar orthodromic motor and sensory studies were performed 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.

A board-certified neurologist blinded to the participant's job title, medical information, and questionnaire responses reviewed the nerve conduction test tracings. The neurologist interpreted results as either normal or abnormal based on established criteria as shown in Appendix A, Table A1 [Burt et al. 2011]. 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. The neurologist distinguished between those with polyneuropathy from those with median mononeuropathy by identifying participants' ulnar sensory latencies. Participants who had polyneuropathy without underlying median mononeuropathy were considered to

have a normal nerve conduction study. Those who had polyneuropathy with underlying median mononeuropathy were considered to have an abnormal nerve conduction study. Also, severity of carpal tunnel syndrome was determined using categorization of nerve conduction results [Stevens 1997] as shown in Appendix A, Table A2.

In June 2014, 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 in June 2014 to employer and union representatives that summarized the nerve conduction test results without personal identifiers.

Case Definition

We used a case definition for carpal tunnel syndrome developed from medical literature [Katz et al. 1990; Rosecrance and Douphrate 2010] and previous NIOSH studies [Burt et al. 2011; NIOSH 2013; Musolin et al. 2014]. Participants had to meet all of the following criteria to be considered a carpal tunnel syndrome case in our evaluation:

- Answered "yes" on a questionnaire to pain, numbness, burning, or tingling in the hands or wrists, occurring more than three times or lasting 7 days or longer in the past 12 months.
- 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 or wrist.

Injury Data and Questionnaires

We reviewed the following information: Occupational Safety and Health Administration (OSHA) Form 300 and 300A Log of Work-Related Injuries and Illnesses (OSHA Logs) for years 2010–2013, and when available, OSHA Form 301 Injury and Illness Incident Report (2012 and 2013) and Workers Compensation First Report of Injury or Illness (2012). We reviewed paper copies of the daily medical clinic logs of employees from 2011–2013 for musculoskeletal complaints such as sprain, strain, ache, sore, cramp, spasm, muscle tension, swelling, numbness or tingling. We asked participants about injury and incident reporting on our questionnaires. We asked about severity and disposition of the work-related injury or illness to determine whether it should have been recorded on the OSHA Logs.

Data Analysis

We reported descriptive statistics for demographic, occupational, and non-occupational information. We calculated the prevalence of carpal tunnel syndrome, specific hand or wrist symptoms, and abnormal nerve conduction.

We calculated annual rates of injuries and illnesses and compared them with national data using methods described by OSHA [Bureau of Labor Statistics 2013a]. Injury and illness reports listed on daily medical clinic logs were tabulated to look for trends by musculoskeletal complaint.

We used log-binomial regression to evaluate the relationship between the exposure groups and carpal tunnel syndrome in an adjusted analysis. We also used a chi-square test to evaluate the relationship in an unadjusted analysis. We computed the prevalence ratio, comparing the carpal tunnel syndrome prevalence in exposure group 3 to that in exposure group 2. A ratio above 1 indicates a higher prevalence in group 3 and a ratio below 1 indicates a lower prevalence in group 3. We adjusted for sex, age, body mass index, and diabetes mellitus, but the results of the unadjusted and adjusted analysis were similar. Only the unadjusted results are included in this report. Analyses with p-values less than 0.05 were considered statistically significant. Data analysis was done using SAS Version 9.3 (SAS Institute Inc., Cary, NC).

Follow-up Telephone Conferences

We held conference calls with management and union representatives in August 2014 to discuss changes in plant processes after our April 2014 data collection visit. We obtained information about line speeds, staffing, and job changes (such as the addition or elimination of specific jobs).

Results

Initial Visit Interviews

In February 2014, 44 English-speaking and Spanish-speaking first- or second-shift employees from various work areas across the plant participated in private, confidential medical interviews. The average age was 46 years (range: 23–65), and 25 (57%) interviewees were male. The average length of employment in the poultry processing industry was 16 years (range: 0.6–39). Interviewees usually worked an average of 41 hours (range: 36–50) per week at the poultry plant. Eleven (25%) reported participating in an incentive program and 6 (14%) reported rotating on a schedule to different job tasks. Several reported working various job tasks within a department on an as-needed basis. Twenty-five (57%) reported their work pace to be fast.

Fifteen (34%) interviewees reported pain, burning, numbness, or tingling in their hands or wrists in the past 12 months. Fourteen (32%) interviewees reported going to the plant's medical unit because of illness or injury in the past 12 months. When asked about having any specific safety or health concerns in an open-ended question, 18 (41%) of interviewees reported having a concern. Concerns included tools (knives/scissors) being dull and heavy, not getting proper treatment from the medical unit, slippery floors, and lack of workspace.

Ergonomic and Epidemiological Assessment of Carpal Tunnel Syndrome

Ergonomic Assessment

We collected videos for 32 job tasks in the receiving, picking, evisceration, debone direct, and thigh line departments. The job tasks are listed by department and exposure group in Table 1. Overall, the majority of job tasks (59%) were in exposure group 3, i.e., above the

ACGIH AL. All job tasks in the evisceration department were in exposure group 3. The other departments had jobs tasks in all three exposure groups, which would allow for rotation to jobs with lower levels of exposure.

Table 1. Job tasks by area and department categorized by exposure group

Department	Exposure group 1	Exposure group 2	Exposure group 3
Receiving and Picking	Jockey driver Dumper operator	Backup killer Backup rehang	Forktruck driver Live hang
Evisceration			Backup vent opener Viscera pull Presenter Inspector helper Liver pull Liver sort Viscera removal Final trim Salvage Salvage-vacuum
Debone direct	Tender clip Breast skinner loader	Loader Wings Breast trim Breast pull	First cut Second cut Tender score
Thigh line	Debone machine loader Grader	Packer	Skinner loader Weigher Trim-Whizard Trim-scissors

We were not able to calculate a time-weighted average exposure for each employee because employees performed a variety of job tasks within a department daily and their job tasks varied throughout the work week. So that we could look at the relationship between exposure group and prevalence of carpal tunnel syndrome, we grouped participants into exposure groups on the basis of the department in which they reported working (Table 2). The departments were given an exposure score using a weighted average that included the number of employees performing a job and the exposure group for that job. The receiving, picking, evisceration, and thigh departments were all categorized into exposure group 3. Debone-direct was categorized into exposure group 2.

Table 2. Distribution of participants by exposure groups on the basis of department classification (n = 191)

Exposure groups	No. (%)
Group 2 (AL–TLV)	66 (35)
Group 3 (> TLV)	125 (65)

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

TLV = ACGIH threshold limit value for hand activity and force

We observed workplace conditions, work processes, and work practices during the video collections. Employees had to reach above shoulder height to use sharpeners (i.e., mousetraps). Adjustable platforms were not available at most workstations. Employees on the debone direct line did not have the platforms set at the proper position for their height and type of work. Also, employees did not always adjust the platforms at the start of their shift.

We reviewed the Associate Safety and Health Orientation Handbook. The handbook had an ergonomics section; however, it did not have a section describing the proper setup of adjustable platforms. During conversations between employees and interpreters, employees reported that aprons were too long and boots were too tall and heavy for some employees. Employees were also concerned about the availability of sharp knives and scissors. They reported that knives were changed out at the lunch break only. The sharpening schedule was confirmed by the plant safety manager. The company reported purchasing a new sharpening system within the past year for knives and scissors.

Epidemiologic Assessment of Carpal Tunnel Syndrome

Participants

In April 2014, 96% (191/199) of employees invited to participate completed the questionnaire and nerve conduction tests. Table 3 shows the demographics and personal characteristics of the participants. The average age was 40 years (range: 20–70), and participants predominantly were Spanish-speaking (43%) and Hispanic (46%). Thirty-five (18%) reported drinking alcohol. The average body mass index was 29.6 (range: 20–56), which is considered overweight (CDC considers body mass index ≥ 30 obese) [CDC 2014]. Three women reported being pregnant.

Table 3. Characteristics of participants (n = 191)

Age (years)	Mean 40 (range: 20–70)
Body mass index	Mean 29.6 (range: 20–56)
	No. (%)
Sex	
Male	95 (50)
Female	96 (50)
Currently pregnant*	3 (3)
Ethnicity/Race	
Black	58 (30)
Creole	38 (20)
Hispanic	88 (46)
White	4 (2)
Other	3 (2)
Language†	
Spanish‡	82 (43)
English	76 (40)
Creole§	33 (17)
Medical Conditions¶	
Diabetes mellitus	16 (8)
Thyroid problems	10 (5)
Kidney failure	3 (2)

*Out of 94 responding females; 3 did not know

†Questionnaire language as selected by participants

‡6 participants who reported being Hispanic preferred to take the questionnaire in English.

§5 participants who reported being Creole preferred to take the questionnaire in English.

¶Reported medical conditions ever diagnosed by a physician

Forty-five percent of participants used mostly their right hand at work, 11% mostly their left, and 44% mostly both. Eighty percent of participants reported using a knife, scissors, or a Whizard. The participants usually worked for an average of 40 hours (range: 28–48.5) a week and had been at this plant for an average of 6 years (range: 0.06–42). The 94 participants who had worked at other poultry plants worked an average of 4 years (range: 0.02–28) at those plants.

Nerve Conduction Tests

Seventy-six percent (145/191) of participants had abnormal nerve conduction study results indicating the presence of median mononeuropathy as shown in Figure 1. Most of these abnormal results were rated as moderate 64% (93/145). Seventy-nine percent of the 145 were bilateral, 14% were right hand only, and 6% were left hand only.

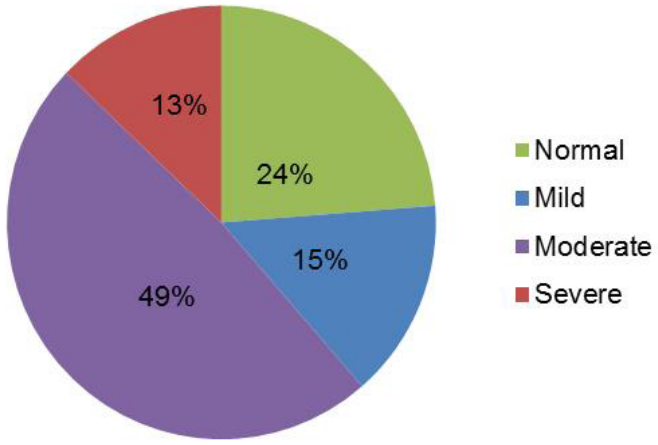


Figure 1. Distribution of participants' nerve conduction studies.

Carpal Tunnel Syndrome

Thirty-four percent (64/191) of participants met the case definition for carpal tunnel syndrome. As shown in Figure 2, of those 64 participants 59 (92%) had moderate or severe median mononeuropathy grading in at least one hand (using the most severe hand). We found bilateral carpal tunnel syndrome in 27 (42%) of these 64 participants.

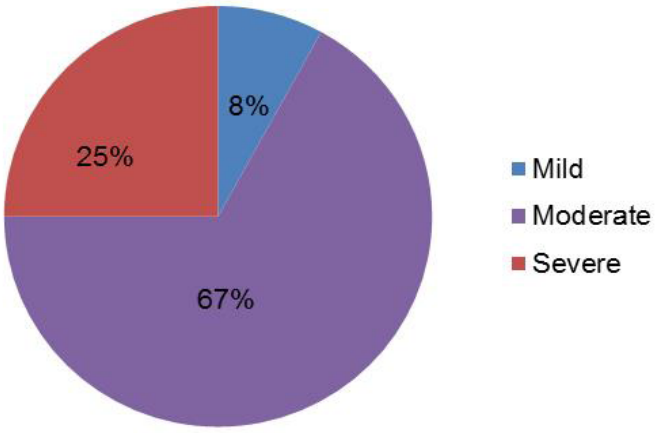


Figure 2. Distribution of carpal tunnel syndrome cases (n = 64) by median mononeuropathy severity.

MSD Conditions and Symptoms

Out of 191 participants, 11 (6%) reported that a physician diagnosed them with carpal tunnel syndrome, 8 (4%) hand or wrist tendonitis, 7 (4%) trigger finger, and 6 (3%) a ganglion cyst. In addition, 110 (58%) 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 110 participants reporting symptoms, 64 (58%) reported awakening from sleep (another clinical manifestation of carpal tunnel syndrome) because of these symptoms in the past 12 months and 63 (58%) reported having these symptoms within 7 days of our visit. Of the 64 participants who met our carpal tunnel syndrome case definition, 44 (69%) reported being awakened from sleep because of these symptoms in the past 12 months, 22 (34%) reported visiting the plant's medical clinic because of hand or wrist symptoms in the past 12 months and 15 (23%) reported seeing a doctor or nurse, outside of work for these symptoms in the past 12 months.

The prevalence of other musculoskeletal symptoms is shown in Table 4. The most common symptoms were hand or wrist, and the second most common were shoulder symptoms. One hundred twenty-three (64%) of participants reported at least one of these musculoskeletal symptoms other than hand or wrist symptoms.

Table 4. Prevalence of musculoskeletal symptoms
(n = 190–191)

Body part	No. (%)
Hands or wrists*	110 (58)
Shoulders†	73 (38)
Back†	69 (36)
Neck†	37 (19)
Ankles or feet†	34 (18)
Hips†	33 (17)
Knees†	32 (17)
Elbows†	14 (7)

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

†Aching or stiffness in the past 3 months

Table 5 shows the prevalence of carpal tunnel syndrome by several personal characteristics and conditions. Carpal tunnel syndrome prevalence was similar for those above and below age 40. In addition, carpal tunnel syndrome prevalence was similar for those who reported and those who did not report ever having a physician diagnosis of diabetes mellitus. Only one of the three participants who reported kidney failure met our carpal tunnel syndrome case definition. We did not find statistically significant relationships between carpal tunnel syndrome and gender ($P = 0.07$) and carpal tunnel syndrome and ethnicity/race (Black, Creole, Hispanic) ($P = 0.08$). We did find a statistically significant association between carpal tunnel syndrome and obesity ($P = < 0.01$).

Table 5. Prevalence of carpal tunnel syndrome, by personal characteristics and conditions

Variable	N	Carpal tunnel syndrome cases No. (%)
Sex		
Female	96	38 (40)
Male	95	26 (27)
Age		
≤ 40	109	35 (32)
> 40	82	29 (35)
Body Mass Index ≥ 30		
Yes	75	34 (45)
No	116	30 (26)
Diabetes*		
Yes	16	5 (31)
No	175	59 (34)
Ethnicity/race†		
Black	58	25 (43)
Hispanic	88	28 (32)
Creole	38	8 (21)

*Participants who reported ever having a physician diagnosis of diabetes mellitus

†Self-reported ethnicity/race on the questionnaire

The distribution of carpal tunnel syndrome cases among work departments showed that the debone direct department had the highest prevalence of carpal tunnel syndrome cases and the thigh line department had the lowest prevalence, but the differences between work departments were not statistically significant.

Table 6 shows the distribution of carpal tunnel syndrome cases by exposure group. Carpal tunnel syndrome prevalence did not differ significantly between the two exposure groups (prevalence ratio = 0.82, $P = 0.35$).

Table 6. Prevalence of carpal tunnel syndrome, by exposure group (n = 191)

Exposure group	N	Carpal tunnel syndrome cases No. (%)
Group 2 (AL–TLV)	66	25 (38)
Group 3 (> TLV)	125	39 (31)

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

TLV = ACGIH threshold limit value for hand activity and force

Injury Data and Questionnaires

Questionnaires

Thirty (16%) participants reported work-related injuries or illnesses in 2013 on the questionnaire. Sixty-six percent (20/30) reported at least one work-related injury or illness that met OSHA 300 reporting criteria as discussed below, but only one was reported on the 2013 OSHA Logs. On the questionnaire, 95% (18/19) responded that they reported their injury to their supervisor, manager, the plant nurse, or other company representative.

Logs of Injuries and Illnesses

Entries on the plant's OSHA Logs for 2010–2013 are described in Table 7. Sprain, strain, pain, soreness, inflammation, and repetitive motion entries were the most common, followed by slips/trips/falls, and laceration/puncture. Hands, fingers, or wrists were the most commonly reported for sprain, strain, soreness, inflammation, or repetitive motion. The most common cause of injury was repetitive motion, lifting, pulling, or twisting.

Table 7. OSHA Form 300 Logs of Work-Related Injuries and Illnesses entries by type for years 2010–2013

Type	2010	2011	2012	2013	Total 2010–2013
Sprain, strain, pain, soreness, inflammation, repetitive motion	7	12	5	9	33
Slips/trips/falls	5	10	8	3	26
Laceration/puncture	6	7	8	3	24
Not otherwise classified	1	10	3	0	14
Chemical/other splash to eyes	2	1	1	0	4
Carpal tunnel syndrome	1	0	1	2	4
Other*	2	5	5	1	13
Total entries	24	45	31	18	118

*Burn, tendonitis, fracture, foreign object, insect/other bite, head injury, contusion

We used the injury and illness data recorded on the plant's OSHA Logs to calculate and compare incidence rates using the method described by OSHA [Bureau of Labor Statistics 2013a]. Nonfatal occupational injury and illness incidence rates for the plant were below the U.S. poultry processing industry (North American Industry Classification System code 311615) rates for 2012 and 2013, but above industry rates for 2010 and 2011 (Table 8). From 2011 to 2013, the plant showed a decrease in the total injury and illness rates, which coincided with the decrease in U.S. rates for this industry. The DART (Days Away/Restricted or Job Transfer Rate) at the plant was at or higher than the U.S. industry rate for 2010, 2011, and 2012 but lower or the same for 2013 (Table 9).

Table 8. Comparison of nonfatal occupational injury and illness incidence rates for years 2010–2013; Maryland poultry plant and U.S. poultry processing industry

Year	Plant injuries and illnesses	Plant rate per 100 FTE*	U.S. industry† recordable rate per 100 FTE	Rate ratio Plant rate/ U.S. industry rate
2010	24	6.0	5.9	1.0
2011	45	6.0	5.8	1.0
2012	31	3.6	4.9	0.7
2013	18	2.1	4.5	0.5

*FTE = Full-time equivalent

†North American Industry Classification System code 311615. Bureau of Labor Statistics 2010, 2011, 2012, 2013b

Table 9. Comparison of nonfatal occupational injury and illness incidence rates for years 2010–2013; Maryland poultry plant and U.S. poultry processing industry*

Year Case Type	2010 Plant	2010 U.S.	2011 Plant	2011 U.S.	2012 Plant	2012 U.S.	2013 Plant	2013 U.S.
Days away†	2.0	0.9	2.5	0.9	2.4	0.7	1.8	0.7
Job transfer‡	3.2	3.2	1.3	3.0	1.3	2.6	0.2	2.3
DART§	5.2	4.1	3.9	3.9	3.6	3.3	2.1	3.0

*North American Industry Classification System code 311615. Bureau of Labor Statistics 2010, 2011, 2012, 2013b

†Cases involving days away from work.

‡Cases involving job transfer or restricted work activity only.

§Total cases involving days away from work (including days of restricted work activity and/ or job transfer).

Medical Clinic Logs

The onsite medical clinic was staffed during each shift by an Emergency Medical Technician (first responder) or a Certified Nursing Assistant who maintained clinic visit logs. The logs did not capture basic information needed to assess patterns in injuries or illnesses and information was not recorded using standardized medical terminology. Sixty percent (602/997) of musculoskeletal visits were reported as hand, finger, or wrist complaints.

The term "protocol" frequently was recorded on the medical logs to describe the actions taken. According to the company, protocol is medical treatment for employees with burns or employees new to the job with symptoms such as soreness, pain, aching in the hand, wrist, arm, shoulder, or any other part of the body. Protocol consists of heat or cold treatment one or two times per shift, plus exercises for the hand, shoulder, neck, head, and legs. Although it is expected to last 2–3 weeks, the logs documented instances of protocol lasting longer. The company explained that if there were no signs of improvement, some employees were referred for medical evaluation and treatment or were allowed to change jobs, with supervisory approval. From our employee interviews we had learned that some employees were concerned they were not getting proper treatment from the medical clinic. However, we could not determine if medical treatment was appropriate based on this record review because of the limited and inconsistent information on the daily logs including poor documentation of medical information.

Changes to the Plant Discussed in Post-Evaluation Conference Calls

On April 21, 2014, with USDA/FSIS approval the plant increased evisceration line speed from 91 birds per minute to 110 birds per minute, with its existing evisceration equipment; after that time the plant processed approximately 180,000 birds per day or 900,000 birds over a 5-day workweek. The live birds weighed on average 7.76 pounds. Because the number of live hang employees was unchanged, the change led to the number of birds processed per person increasing from 23 to 27.5 birds per minute. The plant continued to run five debone direct lines at 40 birds per minute. The thigh line department was unchanged.

On July 17, 2014, the plant implemented the HIMP inspection process using plant evisceration sorters and USDA/FSIS online and offline inspectors, with new evisceration equipment. The following job tasks in the evisceration department were eliminated due to the new automated equipment: backup vent opener, viscera puller, liver puller, liver sorter, viscera removal, evisceration presenter, and inspector helper. These jobs were previously performed by approximately 22 employees. One picking sorter was added to each line to inspect for cadavers, hock infections (synovitis), and tumor processes. USDA/FSIS defines cadavers as "carcasses of poultry showing evidence of having died from causes other than slaughter" [9 CFR 381.85]. Four evisceration sorters were added to each evisceration line. The sorters are plant employees who inspect carcasses for infectious process and conditions such as overscald that may result in carcass condemnation. In a previous NIOSH evaluation, a similar USDA trimmer/helper job was categorized as exposure group 1 [NIOSH 2013].

Discussion

Poultry processing involves a combination of highly repetitive and forceful movements that place employees at increased risk for upper extremity work-related MSDs [Lipscomb et al. 2008; Cartwright et al. 2012]. Poultry workers may be particularly at risk for carpal tunnel syndrome because much of the work on a poultry processing line involves the hand and wrist. 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. We used the ACGIH TLV for hand activity and force as a measure of exposure in our evaluation. Fifty-nine percent of jobs we evaluated were above the ACGIH AL, including all jobs in evisceration. Cold temperatures, common in poultry processing facilities, combined with repetition and force, increase the risk of developing MSDs [OSHA 2013]. ACGIH recommends using professional judgment to reduce the exposures below the action limits for employees working in low temperature environments. We did not do a posture analysis of the jobs, but several employees did not have adjustable platforms at their workstations. In cases where adjustable platforms were available, employees did not always adjust them at the beginning of their shift. The company's Associate Safety and Health Orientation Handbook did not mention the proper adjustment of platforms or provide appropriate working height recommendations.

Use of well-established interventions based on sound ergonomic principles is important in reducing the risk of work-related MSDs. An exposure assessment by job (such as that done in our evaluation) allows for application of those principles to be prioritized toward jobs representing higher risk (i.e., those found to be above the ACGIH AL). The increased production rate implemented after our evaluation would be expected to worsen the exposures in those jobs where the number of workers remains the same (e.g., the live hang area). Although the debone direct lines did not change, the company reported plans to increase the amount of product running on these lines; however, they also planned to increase the number of lines, which would allow them to keep each line at the current line speed. If this is the case, we would expect the exposure risk to stay approximately the same as we documented, with the majority of jobs above the ACGIH AL. It is important to realize that changes to one task may have unintended adverse effects on other tasks. When tasks are changed, a re-assessment of potential risk factors for all related tasks may need to be conducted.

Employees had only two regularly scheduled rest breaks, unless they worked over 8 hours and 15 minutes. Tucker et al. [2003] found that limiting continuous work to less than 2 hours reduced risk of injury. Under the current break schedule, employees are working continuously for more than 2 hours. Adding more scheduled breaks would allow more rest as well as more opportunities to change out knives. Dull knives and lack of time for knife change out was a concern mentioned by some employees. Sharp knives lower the force (and possibly repetitions) required to complete a task [OSHA 2013]. Studies show a positive association between highly repetitive work alone or in combination with other factors (i.e., force) and carpal tunnel syndrome [NIOSH 1997].

There were no regular job rotation patterns at the plant, although rotation would be possible in the departments we evaluated that had a mixture of exposure groups. Rotation among job

tasks of similar exposure has not been found to reduce the risk of developing MSDs [Jonsson 1988]. However, rotating from higher-exposure tasks to lower-exposure tasks can result in less fatigue and improved performance [Raina and Dickerson 2009]. Ideally, 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]. Job rotation decisions should include evaluating jobs using the ACGIH TLV and AL. The TLV documentation states that it can be extended to multi-task jobs by using time-weighted exposures [ACGIH 2014]. When the AL is exceeded, additional ergonomic controls should be employed.

We found that 34% of participants met our carpal tunnel syndrome case definition. 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, in addition to differing risks by industry, may contribute to differences in the reported prevalence of carpal tunnel syndrome among workers ranging from 7.8% to 73.9% [Kim et al. 2004; Cartwright et al. 2012].

Although a strong relationship exists between specific work factors and carpal tunnel syndrome [National Research Council and Institute of Medicine 2001], non-occupational factors must also be considered. Medical conditions such as obesity, diabetes mellitus, and thyroid disease have been positively associated with carpal tunnel syndrome [Werner et al. 1994; Becker et al. 2002; Karpitskaya et al. 2002]. In addition, age (greater than 40 years old) has been positively associated with carpal tunnel syndrome [Werner et al. 1994; Becker et al. 2002]. Although we saw some evidence that carpal tunnel syndrome was related to non-work factors (i.e., female gender and obesity), employees in this plant are exposed to work-related factors that put them at risk for carpal tunnel syndrome and other MSDs. Because none of the departments we evaluated were in exposure group 1, however, we could not quantify the work-related risk of carpal tunnel syndrome.

While 76% of participants had an abnormal nerve conduction study in at least one hand, only 34% met the carpal tunnel syndrome case definition. The difference may reflect a subclinical entity associated with carpal tunnel syndrome, the ability of nerve conduction tests to identify disease early in the process, or underreporting of symptoms.

We saw a discrepancy between injuries and illnesses reported on our questionnaire and those reported on the OSHA Logs, even though the majority of employees reported that they mentioned their injury or illness to a supervisor, manager, the plant nurse, or other company representative. In addition, we noted discrepancies between the number of daily medical log musculoskeletal complaints and the OSHA Logs. Because these daily medical logs were based on employee complaint rather than final diagnosis, non-specific complaints could have been related to MSDs and thus the number of visits and complaints for MSDs may be underestimated. Both findings are consistent with previous reports of problems with the reporting of occupational illnesses and injuries [GAO 2009].

The company used paper-based medical logs in which the information was incomplete and recorded in a non-standard manner. Additionally, the company did not analyze information on the logs for trends over time or by job task or department. The use of electronic medical logs

can facilitate trend analysis of injuries and illnesses, standardization of criteria to determine referral for medical follow-up, and easy navigation through employees' medical log history. Surveillance of injuries and illnesses is important to identify existing or potential problems and this includes reviewing first-aid logs, nurse's logs, OSHA Logs, workers' compensation claims, insurance company reports, and employee reports of problems [OSHA 2013].

Our results suggest the need for ergonomic interventions and improvement of work processes and medical evaluation. Poultry processing jobs continue to be hazardous despite repeated studies documenting the high prevalence of carpal tunnel syndrome. OSHA has had guidance for preventing MSDs in the poultry industry since early 2000 and recently updated that guidance [OSHA 2013]. Early recognition of, reporting of, and intervention in MSDs 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]. We observed a medicine dispenser near the medical clinic that sold pain relievers, making it easy for employees to self-medicate and delay diagnosis and treatment of MSDs, which can lead to worse medical outcomes and irreversible damage.

The Poultry Safety and Health Committee Task Force has publicized the importance of early medical intervention in preventing serious MSDs since 1986 [Poultry Safety and Health Committee Task Force 1986]. Medical intervention must be combined with job improvement to reduce the risk of work-related carpal tunnel syndrome. Carpal tunnel syndrome is unlikely to go away in a year without implementing such measures [Silverstein et al. 2010].

The National Chicken Council and the Poultry & Egg Institute have long-standing workplace recommendations regarding ergonomics and injury prevention, including 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 [National Chicken Council 2008; Poultry & Egg Institute 2013]. We agree with the North American Meat Institute's 2013 recommendations for an effective medical management program, which call for a physician or an occupational health nurse with training in preventing MSDs to supervise the program [North American Meat Institute 2013]. The recommendations call for each work shift to have access to healthcare providers to facilitate treatment, medical surveillance, and the recording of information. Specifically, the medical management program should address the following:

- Injury and illness recordkeeping
- Early recognition and reporting of symptoms
- Systematic evaluation and referral
- Conservative treatment
- Conservative return to work
- Systematic monitoring of injury trends
- Adequate staffing and facilities

Strengths and Limitations

A strength of our evaluation is that we included a carpal tunnel syndrome case definition on the basis of well-accepted criteria, including objective nerve conduction measurements assessed by a board-certified neurologist. Additional strengths include the high participation rate and our use of the ACGIH TLV for HAL, a standardized and validated assessment tool, to assess hand activity and force. Additionally, four ergonomists independently scored HAL for job tasks. ACGIH states that multiple observers increase the precision of the ratings [ACGIH 2014].

Limitations include the cross-sectional nature of this evaluation, which measured health outcomes and exposures at a single point in time. Cross-sectional studies provide data useful for supporting inferences of cause and effect. However, no causal inference can be made from this study. 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 underestimating the prevalence of injuries, including carpal tunnel syndrome.

Conclusions

Thirty-four percent of participants met our case definition for carpal tunnel syndrome and 59% of the jobs evaluated were above the ACGIH AL for hand activity and force. Over half of participants reported musculoskeletal symptoms of the hand or wrist. Sprain, strain, pain, soreness, inflammation, or repetitive motion entries were the most common OSHA recordable injuries. Following our evaluation, several evisceration jobs were automated; however, the MSD risks remain for many workers, and in some jobs (e.g., live hang line) those risks are likely increased because of production rate increases after our evaluation was completed. This report provides recommendations for ergonomic interventions and improvement of work processes intended to help decrease MSD risk among workers at this plant.

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.

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. Automate or semiautomate front-half deboning.

Engineering Controls

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

1. Provide adjustable standing platforms at all workstations. Some employees did not have platforms and were reaching near shoulder height to perform their job.
2. Place sharpeners (i.e., mousetraps) in locations that do not require reaching above the shoulder to use them.

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. Design job tasks so that they are below the AL of the ACGIH TLV to minimize the risk for developing carpal tunnel syndrome. Reducing cone line speeds and using additional cone lines would reduce repetition for each person on the line. The overall goal is to reduce the HAL rating, which can be accomplished by altering the cycle times at individual workstations on these lines.
2. 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].
3. Employ a rotation schedule that rotates employees between jobs that use different muscle groups and rotates them from high to low risk jobs. One option is to rotate employees on a regular basis between an exposure group 2 or 3 job to an exposure group 1 job.
4. Sharpen knives and change them out regularly so employees do not have to exert undue force to make cuts; this should reduce cuts/lacerations and reduce the risk of MSDs. Sharp knives could be provided near the line so employees can change out when they feel a sharper knife is needed.

5. Provide more breaks to limit continuous work to less than 2 hours. Adding more scheduled breaks would allow more rest as well as more opportunities to change out knives.
6. Encourage employees to report musculoskeletal symptoms early to the onsite medical clinic so medical personnel can evaluate their symptoms and ensure prompt and appropriate medical management as needed. Medical personnel should alert management of specific work areas of concern after reviewing patterns of illness and injury by department and job task.
7. Provide bulletin board and safety meeting reminders and break room handouts in primary language spoken by employees to emphasize the importance of early reporting of possible work-related symptoms.
8. Encourage employees to follow up with onsite medical staff and their personal doctor if they were found by NIOSH to have an abnormal nerve conduction test result.
9. Institute a medical surveillance program for MSDs 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 North American Meat Institute and OSHA websites. Ensure that the findings from the medical surveillance program, including clinic visits, are recorded in a standard manner with regards to symptoms, clinical signs, laboratory tests, diagnoses, and effectiveness of treatment. Medical protocols should be reviewed and signed off be a physician familiar with the current scientific information about hazards in the industry.
10. Improve recordkeeping by logging complete, descriptive, and accurate injury and illness information. Use injury and illness cases recorded on OSHA Logs and other incident reporting systems to look for trends in type of injury or illness over time and by job title or work area to target interventions. This may be especially helpful for MSDs because they constituted the majority of OSHA Log entries. Information on using OSHA Logs to improve safety and health programs can be found at https://www.osha.gov/recordkeeping/handbook/.
11. Remove the medicine dispenser near the medical clinic and educate employees about the reasons for doing so.
12. Improve maintenance to reduce slip/trip/fall hazards. Use the health and safety committee to investigate reasons behind slips, trips, and falls.
13. Discuss with employees and the union the changes already made to the plant and any changes that are planned. Communicate these plans face-to-face and in writing.
14. Implement an active ergonomics committee including management, employee, and union representatives. Effective committees use employee input and experience to help determine work practice and engineering controls. Guidelines and suggestions for developing effective health and safety committees can be found at https://pantherfile.uwm.edu/groups/sa/usa/public/Safety/safcomm.pdf and http://www.nj.gov/health/peosh/documents/jlmhsc.pdf.

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Provide employees with a variety of different-sized personal protective equipment (aprons, boots, etc.) to reduce slip/trip/fall hazards resulting from items that do not fit properly.

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	Latency or Amplitude
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

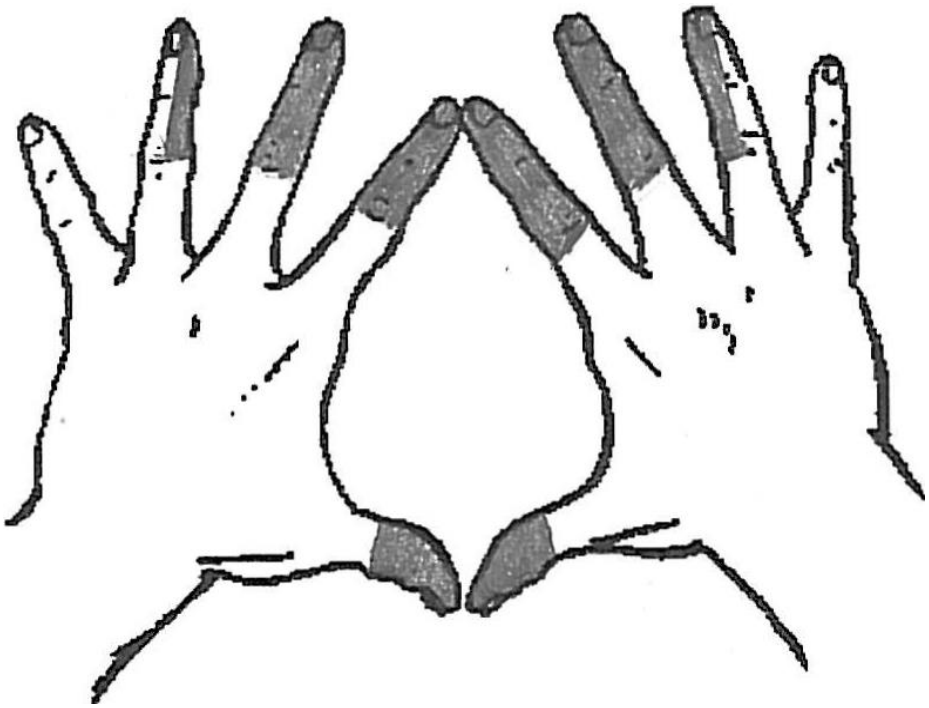
*From: Burt S, Crombie K, Jin Y, Wurzelbacher S, Ramsey J, Deddens J [2011]. Workplace and individual risk factors for carpal tunnel syndrome. J Occup Environ Med *68*(12):928–933.

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	• Is defined by both sensory and motor latencies being 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.

Appendix B: Figures

Left back of hand Right back of hand



Left palm Right palm

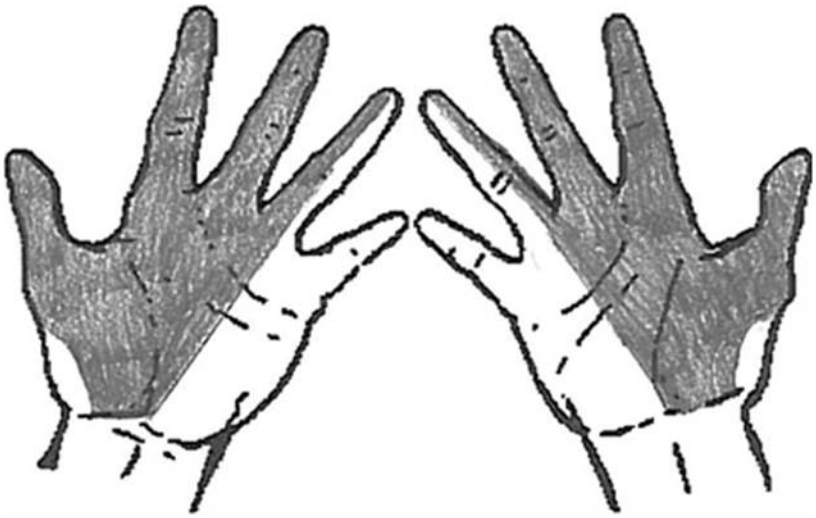


Figure B1. Hand symptom diagram showing median nerve distribution. Figure by NIOSH.

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The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 (29 U.S.C. § 669(a)(6)). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CFR Part 85).

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Availability of Report

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