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JOHN MORRELL & CO.
SIOUX FALLS, SOUTH DAKOTA

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I. SUMMARY

On March 3, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Occupational Safety and Health Administration (OSHA) for technical assistance in evaluating cumulative trauma disorders (CTDs) among employees at the John Morrell & Co. plant in Sioux Falls, South Dakota. The investigation was conducted in May 1988, with a subsequent visit on July 25-26, 1988. The investigation 1) used the OSHA 200 Logs to calculate the plant's incidence rate of upper extremity CTDs; 2) administered a questionnaire and performed a physical examination designed to elicit upper extremity CTD symptoms and signs on 200 selected plant employees; 3) gathered ergonomic exposure information on 185 jobs at the plant; 4) performed multiple logistic regression on the data to estimate associations between hand-wrist CTDs and exposure to vibrating tools, forceful jobs, and repetitive jobs; 5) calculated the number of missed and restricted work days for workers suffering from upper extremity CTDs recorded on the OSHA 200 Logs; and 6) calculated the number of missed and restricted work days for workers having surgery for upper extremity CTDs recorded on the OSHA 200 Logs.

From 5/1/87 to 4/30/88 there were 880 upper extremity CTDs recorded on the OSHA 200 Logs. This plant's upper extremity CTD incidence rate was 41.7 per 100 full-time workers per year compared to 6.7 reported for the meatpacking industry [Rate Ratio (RR)=6.24, 95% Confidence Interval (CI) 5.8, 6.7] or 0.1 per 100 full-time workers per year reported for all US industries in l987 (RR=417.1, 95% CI 390.0, 455.6).

One hundred and forty (70%) of the 200 selected workers had upper extremity CTDs during the past year determined by questionnaire. One hundred (50%) of the 200 selected workers had current upper extremities CTDs by questionnaire and physical examination.

Of the 185 jobs videotaped for ergonomic analysis, 14 jobs (8%) were determined to be low risk, 114 jobs (62%) intermediate risk, and 57 jobs (31%) were determined to be high risk for developing upper extremity CTDs.

Vibration was the strongest predictor of hand-wrist CTDs [Odds Ratio (OR)=5.3, 95% CI 2.1, 13.7], followed by force as measured by peak effort (OR=4.5, 95% CI 1.1, 18.2). Using multiple regression analysis to control for age, sex, length of employment at the plant, recreational activities, and prior medical conditions associated with carpal tunnel syndrome did not alter the crude odds ratio significantly.

For all 880 OSHA Log upper extremity CTD entries for the one-year period 5/1/87 to 4/30/88, the mean number of days off work was 0.3 (median<0.1) days with a range of 0 to 56 days. Eight hundred seventeen entries (93%) had no days off work. The mean number of days with restricted work activity was 9 (median=3.8) days, with a range of 0 to 186 days. Three hundred forty-five CTD entries (39%) had no work restrictions.

From 5/1/87 to 4/30/88, 85 surgical procedures were performed on 61 employees. The mean number of days off work was 1.1 (median=0.6) days, with a range of 0 to 9 days. Twenty-five employees had no days off after surgery. The mean number of days with restricted work activity was 24 (median=14.8) days, with a range of 0 to l86 days. Thirteen workers had no restricted work days after surgery.

Our investigation found a high incidence rate of upper extremity CTDs and carpal tunnel syndrome among workers at the John Morrell & Co. plant in Sioux Falls, South Dakota for the one-year period 5/1/87 to 4/30/88. In addition, a high prevalence of upper extremity CTDs and hand-wrist CTDs was found among current workers. Ergonomic job analysis revealed the majority of jobs require tasks that are known risk factors for developing upper extremity CTDs. Recovery time, as measured by the number of missed days and restricted days, for surgical and non-surgical upper extremity CTDs was inadequate.

On the basis of this investigation, NIOSH investigators concluded that an upper extremity CTD hazard existed at this plant. Recommendations for engineering controls, administrative controls, medical management, and installing an ergonomics program are contained in this report.

KEY WORDS:SIC 2011 (Meatpacking Plants), slaughterhouses, ergonomics, cumulative trauma disorders, carpal tunnel syndrome, trigger finger, tendonitis, tenosynovitis, vibration, force, repetition.

II. INTRODUCTION

On March 3, 1988, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Occupational Safety and Health Administration (OSHA) for technical assistance in evaluating cumulative trauma disorders (CTDs) among employees at the John Morrell & Co. plant in Sioux Falls, South Dakota. The objectives of the evaluation were to:

1. Determine the prevalence and incidence of CTDs among employees working in selected departments and jobs.

2. Determine the medical management of injured workers by the company and contract medical facilities.

3. Identify jobs with known ergonomic risk factors for developing CTDs, and make abatement recommendations to eliminate the CTD hazards.

The investigation was conducted on May 3-6, 9-13, 23-27, and July 25-26, 1988.

III. BACKGROUND

A. Plant and Process Description

John Morrell & Co., Sioux Falls, South Dakota, produces beef and pork products, predominantly for wholesale distribution. Operations began in 1909. The plant operates on three shifts: the first shift processes beef and pork, the second processes pork only [typically the heavier hogs (sows)], and the third shift sanitizes the process equipment.

The slaughtering processes for cattle and hogs are similar. The animals are killed and suspended by their hind limbs from an overhead chain conveyor. The chain conveyor line moves at a pre-determined speed while workers positioned along the lines eviscerate the animal. The head and other internal organs are immediately processed, while the carcass is cooled overnight at 34ºF. The carcasses are removed from the cooler on the next working day and re-attached to the overhead chain conveyor, allowing dissection of the meat from the carcass. The workers performing the evisceration and dissection are equipped with saws, straight knives, whizard knives (electric powered hand knife with a rotating cutting blade), hydraulic clippers, and hooks.
In addition to whole meat products, the plant also produces processed meat including sausages, weiners, liverwurst, and canned hams. Although work in these departments (Smoke Meat Pack, Sausage Cooler, Sausage Manufacture, Curing, and Canning) sometimes involves knife use, most jobs involve operating machines which produce and package the processed meat.

B. Workforce

The Sioux Falls plant employed approximately 2500 unionized employees until 5/1/87 when a union strike was called. Replacement workers were hired and approximately 10% of the previous workforce crossed the picket line. Subsequent strike settlements led to re-hiring former striking employees when positions became available. At the time of NIOSH's evaluation, approximately 2000 people were employed at the plant, including approximately 400 employees (20%) from the previous workforce (hired prior to 5/1/87).

IV. EVALUATION DESIGN AND METHODS

A. Incidence Rates

Incidence rates for upper extremity CTDs were calculated for the whole plant and specific departments using OSHA 200 logs for the one-year period 5/1/87 to 4/30/88. The total number of CTDs entered onto the OSHA 200 log was divided by the total number of employee hours worked for the whole plant (or for the specific departments being evaluated) from 5/1/87 to 4/30/88. This type of incidence rate, using employee hours worked, is used by the Bureau of Labor Statistics (BLS).[1]

All OSHA 200 Log entries were reviewed for their appropriateness to be included as an upper extremity CTD.

CTDs should be checked on the Logs under the "7f" column which are "disorders associated with repeated trauma (RTDs)."[2] Appendix A provides an explanation of the OSHA 200 logs, and lists the CTD medical conditions.[3-5]. We defined upper extremity CTDs as disorders caused, aggravated, or precipitated by repeated motion, vibration, or pressure to the neck, shoulders, elbows, wrists, or hands. All sprains, fractures, lacerations, and contusions were excluded. In addition, medical conditions involving the back, chest wall, and lower extremities were excluded. Each entry could list one or more diagnosis, and affect one or more joint areas (Tables 3,4). Thus, bilateral carpal tunnel syndrome was recorded as one entry affecting the left and right wrists and hands. We defined an "arm" entry as one affecting the shoulder, elbow, and wrist joint areas, and a "forearm" entry as one affecting the elbow, and wrist joint areas.

B. Period Prevalence Rates

Period prevalence rates for the 12 months prior to NIOSH's study were calculated from standardized questionnaires administered to current employees. The questionnaires elicited demographic information, work history information including months/years on the job, prior health history information including chronic diseases and prior upper extremity injuries, and information on the type and time spent on various recreational activities. The remainder of the questions addressed upper extremity pain or discomfort experienced within the previous year. If the workers had experienced recurring difficulty in one or more parts of the upper extremity, more detailed information was sought regarding the subjects's complaint including location, duration, onset, aggravating factors, and treatment.

1. Selection Criteria

All departments listed on the OSHA complaint were observed during a walk-through survey. Two departments were selected as apparently having lower exposure to repetitive and forceful hand-wrist motions than the other departments listed on the OSHA complaint. These two departments, Smoke Meat Pack and Sausage Cooler, will be referred to as the lower exposure departments (LED). All employees working the day-shift from the LED were invited to participate in NIOSH's study.

From the other departments listed on the OSHA complaint, 40 jobs in five departments were selected based on a) apparently higher exposure to repetitive and forceful hand-wrist motion based on observations during the walk-through survey, and b) jobs which employed the largest numbers of workers. These five departments (Hog Kill/Pork By-Products, Pork Cut, Pork Trim, Ham Bone, and Beef Fabrication) will be referred to as the higher exposure departments (HED). All day-shift employees working any of these 40 jobs were invited to participate in the study.

2. Case Definition

A case of upper extremity CTD was defined as one or more symptoms (pain, numbness, tingling, aching, stiffness, or burning) in one of the 5 upper extremity joint areas (neck, shoulder, elbow, wrist, or hand) which satisfied the following criteria:

1. No previous accident or sudden trauma to the joint; and
2. Symptoms began after employment at the plant; and
3. Symptoms occurred within the past year; and
4. Symptoms lasted more than one week, or occurred more than 3 times in the previous year.

Comparisons of all upper extremity and hand-wrist CTDs one-year period prevalences between the HED and LED are reported as prevalence ratios (PR) (HED/LED) with 95% 2-tailed Confidence Intervals (95% CI).

C. Point Prevalence Rates

All employees completing the questionnaire described above had a physical examination performed by physicians trained in internal and occupational medicine. These exams were limited to evaluation of the neck and upper extremities, and were designed to detect upper extremity CTDs. The examinations included inspection, palpation, range of motion (active, passive and resisted), and various maneuvers. Appendix B lists the disorders and their diagnostic criteria. An upper extremity CTD case was defined as a worker who satisfied the questionnaire case definition (criteria listed in the preceding section) and the presence of a upper extremity CTD on physical examination (criteria listed in appendix B) affecting the same specific symptomatic joint area mentioned on the questionnaire.

Comparisons of all upper extremity and hand-wrist CTDs point prevalences between the HED and LED are reported as prevalence ratios (PR) (HED/LED) with 95% CI.

D. Ergonomic Exposure Assessment

The primary goal of the ergonomic exposure assessment was to identify jobs with known ergonomic risk factors for developing CTDs, and make abatement recommendations to eliminate the CTD hazards. Ergonomic exposure assessments were determined from a videotape of workers performing their routine job tasks. All jobs held by employees participating in the medical interviews and physical examinations were evaluated. Some additional jobs were videotaped based on convenience (for example, jobs on the same production line as the targeted jobs). The videotapes were subsequently reviewed in slow motion to ascertain information on repetitiveness, force, posture, and vibration, all risk factors for developing upper extremity CTDs.[6-16]

1. Repetitiveness

Two quantitative measurements were used to assess repetitiveness: hand manipulations (cuts) per 8-hour workday, and cycle time (Appendix C). Low repetitiveness was defined as fewer than 10,000 cuts per day, medium repetitiveness as 10,000 to 20,000 cuts per day, and high repetitiveness 20,000 or more cuts per day. Using the cycle time measurement, low repetitiveness was defined as a cycle time greater than 30 seconds, and high repetitiveness as a cycle time of 30 seconds or less.

2. Force

Force was estimated using two measures: overall force and peak force. The overall force was the estimated average effort exerted during the cycle, while the peak force was the estimated maximal effort exerted at any point during the cycle (Appendix C). Using a 1 to 5 scale, 1 was defined as low force, 2 & 3 as medium force, and 4 & 5 as high force.

3. Vibration

Vibration was defined as the use of a vibrating tool such as a saw, or whizard knife.

4. Overall Job Exposure Level

An overall job exposure level was derived using the total hand manipulations (cuts) per day as the measure of repetitiveness and the average effort exerted throughout the cycle (overall force) as the measure of force. The levels were defined as follows:

Level 1 (low):	low repetitiveness and low force
Level 2: (intermediate)	low repetitiveness and medium force medium repetitiveness and low force medium repetitiveness and medium force
Level 3: (highest)	low repetitiveness and high force medium repetitiveness and high force high repetitiveness and low force high repetitiveness and medium force high repetitiveness and high force

E. Statistical Analysis

Multiple logistic regression was used to estimate associations between hand-wrist CTDs and exposures to vibrating tools, force, and repetition while controlling for potential confounding and effect modification. Hand-wrist CTDs were used because ergonomic assessment primarily evaluates hand and wrist exposure. The potential confounding and effect modification variables considered included age, sex, length of employment at the plant, recreational activities, and medical conditions with reported risk factors for carpal tunnel syndrome (diabetes, gout, hyperthyroidism, hypothyroidism, systemic lupus erythematosis, or cervical disc disease). All associations are reported as odds ratios (OR) with 95% CI.[17]

F. Medical Management

1. Missed and Restricted Days

The OSHA 200 logs were used to compute the number of days off work and the number of days on restricted duty for upper extremity CTDs. Medians are reported rather than arithmetic means because of the skewed distribution of the missed and restricted days.[18] The jobs for those employees in which no restricted duty days occurred for the diagnosis of carpal tunnel syndrome (cts) were evaluated with respect to their overall job exposure level.

2. Surgery

The company provided NIOSH with a list of 61 employees having upper extremity CTD surgery for the one year period 5/1/87 to 4/30/88. This list was extracted from the consulting surgical group's billing records using International Classification of Diseases 9th Revision (ICD-9) and Current Procedural Terminology 4th Revision (CPT-4) codes (Appendix D). Several employees had multiple surgical procedures performed during an operation; therefore, the total number of procedures exceeds the total number of employees having surgery. The names of the workers undergoing surgery were cross-referenced with the OSHA 200 logs to determine days off work, days with restricted work activity, department, and specific employee job title prior to the surgery. If an employee had more than one OSHA 200 Log entry, the date closest to the surgery was used.

G. OSHA 200 Log Recording

Recording of CTDs in the OSHA 200 Log for the one year period 5/1/87 to 4/30/88 was evaluated by matching the log against 1) the list of employees having upper extremity CTD surgery, 2) the clinic records of the contract physicians. Records of the contract physicians' clinic became computerized in November l987; therefore, the accuracy of reporting could be assessed only for the six-month period 11/1/87 through 4/30/88.

V. RESULTS

A. Incidence Rates

Between 5/1/87 and 4/30/88, 912 "Disorders associated with repeated trauma" (RTDs) entries were recorded on the OSHA 200 logs. After review of each entry, we found that 40 non-RTDs satisfied our case definition of upper extremity CTD and were re-classified as upper extremity CTDs. The OSHA 200 Log numbers of these re-classified entries have been provided to OSHA. Seventy-two RTDs were excluded because they involved the back, chest wall, lower extremities, or had duplicate entries in the OSHA 200 Logs. Thus, the total number of recorded upper extremity CTD cases between 5/1/87 and 4/30/88 was 880.

The plant, as a whole, had a upper extremity CTD incidence rate of 41.7 per 200,000 work hours (100 full-time workers per year). (Table 1) Hog Kill/Pork By, Ham Bone, Pork Cut, Beef Fab, and Pork Trim are the five departments with the highest CTD incidence rate. These five departments tended to have the highest incidence rate of carpal tunnel syndrome (cts) and trigger finger, as well. (Table 2)

Hands and wrists were the most frequently affected areas (52% and 29%, respectively), followed by elbows (10%), shoulders (7%), and neck (2%). (Table 3) Tendonitis and strains were the most common diagnoses (Table 4). One hundred seventy hand-wrists disorders were diagnosed with probable cts in 133 employees. Eighteen hand-wrist disorders were diagnosed with possible cts in 17 employees. Thus, probable/possible cts was diagnosed in 188 wrists in 150 individuals representing 17% of all recorded entries. The plant incidence rate for probable/possible cts was 7.1 per 100 full time employees per year. Stenosing tenovaginitis of the fingers (trigger finger) and the thumb (deQuervain's) was diagnosed in 118 (13%) of the log entries. The plant incidence rate for stenosing tenovaginitis was 5.6 per 100 full time employees per year.

B. Prevalence Rates

One hundred and forty-nine day-shift workers were employed in the 40 jobs selected from the HED. Five (3%) of these 149 workers refused participation, and 12 selected employees were not made available to NIOSH researcher because, it was explained, their absence would disrupt the production line. Ninety-three day-shift workers were employed in the two LED. Twenty-five (27%) of these 93 employees refused participation. Fourteen of these 25 refusals did not care to participate because they stated they lacked upper extremity problems while the remaining 11 did not clearly state why they refused participation.

Our study group thus consisted of 200 employees: 68 from LED, and 132 from HED. One hundred and forty of the 200 workers had upper extremity CTDs determined by questionnaire for an overall one-year period prevalence of 70%. Employees in the HED had an upper extremity CTD one-year period prevalence of 80%, while the LED employees had an upper extremity CTD period prevalence of 50% (PR=1.61, 95% CI = 1.25, 2.07). (Table 5) The one-year period prevalence of hand-wrist CTDs for the HED was 74% compared to 41% in the LED (PR=1.80, 95% CI 1.33, 2.44).

One hundred of the 200 workers had current upper extremities CTDs by questionnaire and physical examination, for an overall point prevalence of 50%. Employees in the HED had an upper extremity CTD point prevalence of 62%, while the LED employees had a upper extremity CTD point prevalence of 27% (PR=2.35, 95% CI = 1.55, 3.56). (Table 5) The point prevalence of hand-wrist CTDs for the HED was 57% compared to 21% in the LED (PR=2.76, 95% CI 1.69, 4.50).

C. Ergonomic Assessment

All jobs held by employees participating in the medical interview and examinations, plus some additional jobs, were videotaped for a total of 185 jobs representing 14 departments. These 14 departments have a total of 421 jobs. (Table 6)

1. Repetitiveness

Seventy-eight (42%) of the 185 jobs made fewer than 10,000 cuts per day, 83 (45%) made between 10,000 and 20,000 cuts per day, and 24 (13%) made 20,000 or more cuts per day. One-hundred-forty-six (79%) of the 185 had a cycle time of 30 seconds or less, while 39 (21%) had a cycle time more than 30 seconds. Sixteen jobs (9%) were low repetitive jobs as defined by a cycle time more than 30 seconds and fewer than 10,000 cuts per day.

2. Force

Twenty-one (11%) of the 185 jobs had low overall force, 122 (66%) had medium overall force, and 42 (23%) had high overall force. Using peak effort as the measure of force, 12 (7%) of the 185 jobs had low peak force, 101 (55%) had medium peak force, and 72 (39%) had high peak force.

3. Vibrating Tools

A total of 21 (11%) of the 185 jobs utilized a vibrating tool (13 whizard knives and 8 saws).

4. Overall Job Exposure Levels

Fourteen (8%) of the 185 jobs were Level 1 (lower) risk, representing 72 workers; 114 jobs (62%) were Level 2 (intermediate) risk, representing 436 workers; and 57 jobs (31%) were classified as Level 3 (highest) risk, representing 293 workers.

One hundred sixty-two (81%) of the 200 workers participating in the interview and physical examination process had an ergonomic exposure assessment of their job. The 38 remaining workers did not have an ergonomic exposure assessment for one of four reasons: 1) job rotation within their departments (Smoke Meat Pack and Sausage Cooler), 2) injury began on a previous job which was not videotaped, 3) the job title listed by the employee could not be found on the supervisors or foreman's list, or 4) the job was not videotaped due to oversight. Level 3 risk job categories had an upper extremity CTD point prevalence of 55%, Level 2 risk job categories had an upper extremity CTD point prevalence of 57%, and Level 1 risk job categories had a point prevalence of 36%. (Table 7) Point prevalences of hand-wrist CTDs showed a similar pattern (51%, 53%, and 21% for level 3, 2, 1, respectively). (Table 7) These differences were not statistically significant: Chi-square test for linear trend is 1.53, p=0.22 for all upper extremity CTDs; and 3.34, p=0.07 for hand-wrist CTDs.

D. Regression Analysis

From the 162 workers with ergonomic exposure assessment, 9 workers had CTD symptoms and signs only on the non-dominant hand for which detailed exposure information was not ascertained. These nine were excluded from the multiple logistic regression analysis. Seventy-one (46.4%) of these 153 workers had current hand-wrist CTDs based on interview and physical examinations. Use of vibrating tools was the strongest predictor of hand-wrist CTDs (OR= 5.3, 95% CI 2.1, 13.7), followed by force as measured by peak effort [level one compared to level five (Appendix C); OR= 4.5, 95% CI 1.1, 18.2]. Using multiple regression analysis to control for age, sex, length of employment at the plant, recreational activities, and prior medical conditions associated with carpal tunnel syndrome did not result in the crude odds ratio being significantly altered. However, a significant interaction was detected in low and medium peak force jobs between gender and the use of vibrating tools. Women had a higher rate of hand-wrist CTDs when using vibrating tools (OR= 39, 95% CI 6.3, 242), than men (OR=2.6, 95% CI 0.7, 9.9) under conditions of low and moderate peak force. Men and women were using different types of vibrating tools. Women predominantly used whizard knives, while men predominantly used saws.

Neither the ergonomic risk levels, nor repetitiveness, as defined by cycle time or total cuts per day, was a significant predictor of hand-wrist CTDs.

E. Medical Management

1. Missed and Restricted Days

For all 880 OSHA Log upper extremity CTD entries, the mean number of days off work was 0.3 days, with a range of 0 to 56 days (median<0.1 days). Eight hundred seventeen entries (93%) had no days off work. The mean number of days with restricted work activity was 9.0 days, with a range of 0 to 186 days (median=4 days). Three hundred forty-five CTD entries (39%) had no work restrictions. Examining carpal tunnel syndrome (cts), 138 (92%) of the 150 entries for cts had no days off work, and 34 (23%) had no restricted work activity. Ergonomic risk assessment was available on 21 of these 34 jobs with no restricted work activity. One had a Level 1 (lower) rating, 13 had a Level 2 (intermediate) rating, and 7 were rated as Level 3 (highest) risk jobs.

2. Surgery

Eighty-five surgical procedures were performed on 61 employees. Fifty-four tendon sheath releases were performed for trigger finger, 20 carpal tunnel releases were performed for median nerve compression, 2 carpal tunnel releases were performed for ulnar nerve compression at the wrist, 3 elbow tendon sheath releases were performed for ulnar nerve compression at the elbow, and 6 synovectomies were performed on the palms or fingers.

Four employees having surgery were not listed on the OSHA 200 Log. For the 57 employees with OSHA 200 Log documented missed and restricted work activity, the mean number of days off work was 1.1 with a range of 0 to 9 days (median=0.6 days). Twenty-five employees had no days off after surgery. The mean number of days with restricted work activity was 24 with a range of 0 to l86 days (median=15 days). Thirteen workers had no restricted work days after surgery. (Table 8) The mean (or median) number of days off or number of days with restricted work activity did not vary substantially by the type of surgical procedure. (Table 8)

F. OSHA 200 Log Recording

Four of the 61 (7%) employees having upper extremity CTD surgery between 5/1/87 and 4/30/88 were not listed on the OSHA 200 Logs. Six of the 183 (3%) employees treated in the contract physician's clinic from 11/1/87 to 5/1/88 were not recorded in the OSHA 200 Logs.

VI. DISCUSSION

A. Incidence Rates

The plant had an upper extremity CTD incidence rate of 41.7 per 100 full-time workers per year compared to 6.7 reported for the meatpacking industry [Rate Ratio (RR)=6.24, 95% CI 5.8, 6.7] or 0.1 reported for all US industries in l987 (RR=417.1, 95% CI 390.0, 455.6).[19] Several biases can influence the CTD incidence rates between meatpacking plants. These include differing: 1) access to the first aid department for symptomatic employees (reporting bias), 2) criteria for CTD diagnosis (misclassification bias), and 3) criteria for a work-related injury and/or illness being "recordable" onto the OSHA 200 Logs (recording bias). These biases could account for some of the observed differences of the CTD incidence rate at Morrell compared to other meatpacking plants. However, the results of our medical interview and questionnaire suggest Morrell workers did not have adequate access to the first aid facility (only 92 of the 140 (59%) workers fulfilling our questionnaire upper extremity CTD case definition were seen in the first aid department). In addition, 39 of these 92 (42%) workers evaluated in the first aid department were not recorded on the OSHA 200 log. Given the above biases and that our investigation excluded back, chest wall, and lower extremity CTDs, this plant's 41.7 episodes per 100 full time employees per year is an underestimate of all CTDs in this plant. This investigation did not address the extent of these biases among other meatpacking plants, nor the magnitude of its effect on the meatpacking industry's CTD incidence rate.

John Morrell & Co. contracts medical care of their Sioux Falls employees to the Central Plains Clinic. Physicians in this clinic examine, diagnose, and treat Morrell workers, and when an injury or illness is deemed "recordable" (a decision made by the nursing staff at the plant's first aid department) the physician's diagnosis is transcribed onto the OSHA 200 Logs. The diagnostic criteria for CTDs could vary between clinic physicians; therefore, disease misclassification may be present on the OSHA 200 Log data. This misclassification may be very common among the reference meatpacking plants because CTDs may be recorded as injuries, not as "RTDs".

The plant's "probable" cts incidence rate was 6.3 per 100 full time employees per year. A recent study found a population-based cts age-adjusted incidence rate per l00 person-years of 0.149 for females, 0.052 for men, and 0.105 for both genders combined.[20] Using the age-and sex-adjusted cts incidence rate as the standard, this plant's rate ratio for developing cts would be 60.0 (95% CI 50.3, 71.1). The plant's cts incidence rate could not be adjusted for age and gender because the OSHA 200 Logs do not contain age or sex information and we did not obtain it from other sources. Advancing age and female gender are two risk factors for developing cts, but this plant's workforce is composed mainly of of young men.[20] Adjusting the plant's cts incidence rate for age and sex would most likely increase the rate ratio. The methods to identify cts cases in this working population (OSHA 200 Logs) were very different from the methods used to identify cts cases in the population based study (medical records) used as the referent. It is not possible to predict the direction in which the rate ratio would be affected by this bias, but with an estimated rate ratio of 6O.0, the association of employment at this plant and cts is not from bias in identifying cts cases on the OSHA 200 log.

The plant's stenosing tenovaginitis incidence rate was 5.6 per 100 full time employees per year. Published estimates on the incidence of stenosing tenovaginitis in the general or working populations are lacking, but studies evaluating upper extremity CTDs using similar questionnaires and physical examinations find the prevalence of stenosing tenovaginitis generally to be less than 1/2 of the cts rate.[3] This plant's stenosing tenovaginitis rate was 89% of the probable cts rate.

Although several surgical and contract physician visits were not recorded on the OSHA 200 Logs (7%), the logs could be used to identify departments where workers were at high risk for developing upper extremity CTDs. (Table 1) Calculating upper extremity CTD incidence rates for specific jobs was not undertaken for two reasons. First, the employees frequently used vernacular job terms not recognized by the foremen, supervisors, or nursing personnel, therefore the job title listed on the OSHA 200 Log was inaccurate. Second, the number of employee hours worked for specific jobs was not available.

B. Prevalence Rates

The departments with the highest incidence rates for upper extremity CTDs (Hog Kill/Pork By, Ham Bone, Pork Cut, Beef Fab, and Pork Trim) also had the highest prevalence of upper extremity CTDs determined from the questionnaires and physical examinations. (Table 5) Ergonomic exposure assessments were available on 131 of the 267 (49%) jobs within these departments: 4 were Level 1 (3%), 76 were Level 2 (57%), and 53 were Level 3 risk (40%). The OSHA 200 Logs also indicate other high risk jobs exist within these departments and other high risk departments exist, but were not studied due to resource and time constraints. (Tables 1 and 2)

The lower exposure departments (LED), Smoke Meat Pack and Sausage Cooler, have point prevalences for upper extremity CTDs of 30% and 21%, respectively. Selection bias may have contributed to these two departments' high point prevalences. Twenty-five of the 93 selected employees in the LED refused participation (27%). Fourteen of these 25 stated that they did not care to participate because they lacked upper extremity problems. The lower participation rate most likely resulted in over-estimates of the period prevalences of upper extremity CTDs within these two departments. If all employees refusing study participation lacked upper extremity CTDs, the point prevalences for Smoke Meat Pack would be 25%, and 13% for Sausage Cooler. A point prevalence of 25% or 13%, however, is still high compared to true low risk working environments, which are estimated to have upper extremity CTD point prevalences of less than 1%.[10] The high prevalence of CTDs in these two LEDs is confirmed by the OSHA 200 Log data. The Smoke Meat Pack department had an upper extremity CTD incidence rate of 47.9 per 100 full time employees per year, while the Sausage Cooler department had an upper extremity incidence rate 15.4. Both these rates are above the average for the meatpacking industry (6.7 per 100 full time employees per year in l987).[19]

During the period 5/1/87 to 4/30/88 employee turnover was reported to be between 200 and 400%. This high rate of employee turnover suggests that survivor bias may be a substantial problem in our investigation. "Survivors" are usually healthier (that is, lacking illness or injury that would interfere with work) than those who have left employment. This "healthy worker" or "survivor effect" has been described in studies of the meatpacking and other industries, and is an inherent bias of this study's cross-sectional design.[21] Neither of these selection biases, however, invalidate the basic conclusion of this study: all departments studied with questionnaires and physical examinations had substantially elevated rates of upper extremity CTDs.

The elevated incidence and prevalence rates for upper extremity CTDs found in this plant are not due to misclassification of disease status, selection bias, or confounding factors. Misclassification is unlikely to have biased the prevalence rates because they identified cases using standardized techniques used in other epidemiological studies.[10] The general agreement between the independently derived incidence and prevalence rates in terms of which departments are the highest risk for developing upper extremity CTDs, and the magnitude of that risk, suggests that misclassification can not explain the high rates observed in this investigation. Selection bias, if present, would likely raise rather than lower the prevalence rate (discussed above as the "healthy worker" or "survivor effect"). The multiple logistic regression analysis controlled for confounding variables and found no evidence that non-occupational factors were responsible for the high rate of upper extremity CTDs within this plant.

C. Ergonomic and Multiple Logistic Regression Analysis

The objectives of this investigation (described in the introduction) did not include determining the epidemiological relationship between specific ergonomic risk factors and upper extremity CTDs. Nevertheless, a strong association between use of vibrating tools and hand-wrist CTDs was identified in women. Since the predominant vibrating tool used by women in this plant was the whizard knife, further studies on the role of whizard knives causing hand-wrist CTDs are warranted.

Despite being reported risk factors for upper extremity CTDs, repetitiveness and awkward postures were not significant predictors of hand-wrist CTDs in our investigation. As reported earlier, only 16 (9%) of the 180 videotaped jobs were clearly non-repetitive (cycle time more than 30 seconds and total cuts less than 10,000 per day). When the high and medium overall force jobs are removed from these 16 non-repetitive jobs, only 2 non-repetitive, non-forceful jobs (4 workers) remain. Thus, there was insufficient data from non-repetitive, non-forceful jobs to allow independent examination of the role of repetitiveness causing hand-wrist CTDs. Our measure of posture was a simple classification into extreme and non-extreme joint angles. No attempt was made to determine the length of time spent in extreme posture or control for the physical and technique differences between workers. As a result no detailed examination of extreme postures was undertaken in our statistical analysis. Because our investigation was not designed to test the hypotheses that repetitiveness, force, extreme posture, or vibration are causal factors in the development of upper extremity CTDs, our results do not invalidate these hypotheses. The support for these hypotheses are based on biomechanical, anatomical, and other types of laboratory, clinical and epidemiological investigation.[6-16].

The prevalence of hand-wrist CTDs were lower in level 1 (lower) overall job exposure compared to levels 2 & 3 (intermediate and higher), but this difference was not statistically significant. As with the case of repetitiveness, there was insufficient data from non-repetitive, non-forceful jobs to demonstrate a significant difference of hand-wrist CTDs between these three levels. Nonetheless, the prevalence of disease within each job exposure level was higher than in another study which used similar study design and upper extremity CTD definitions.[10] In addition, the stronger relationship between hand-wrist CTDs and risk level compared to upper extremity CTDs and risk level is not surprising because the risk levels are based predominantly on hand-wrist exposures rather than elbow, shoulder, and neck exposures.

D. Medical Management

After sustaining a CTD injury, an inflamed tendon, ligament, or nerve needs rest. The OSHA 200 Logs maintained at this plant recorded 817 workers (93%) had no time off work after sustaining an upper extremity CTD, while the mean number of days off work was 0.3 days. The mean number of days off work for any upper extremity CTD in Sweden's meatpacking industry in 1983 was 53 days.[22] It must be noted that these two data sources (the OSHA 200 Logs and Sweden's occupational disease system) probably differ in their CTD case definitions. The OSHA 200 Log may report less severe disease (fewer days off work).
One-hundred-thiry-eight (92%) of the 150 diagnosed cts cases apparently had no days off work (92%). A hand surgeon commenting in general on the non-surgical management of cts among meatpacking employees said, "Most patients had a trial of non-operative treatment for several months to years before surgical release. Splinting and anti-inflammatory agents helped little unless a leave of absence from work was also taken."[12]

From the OSHA 200 Log data, we concluded that 345 employees (39%) had no rehabilitating work days after sustaining an upper extremity CTD. From the questionnaire and physical examination data, we concluded that 49 employees (49%) with an upper extremity CTD were not assigned rehabilitating work days. In addition the type of job chosen for light or restricted duty was inadequately monitored to evaluate its effectiveness at relieving the

employee's symptoms. A job re-assignment must be chosen with knowledge of whether the new task will require use of the injured tendons, or pressure on the injured nerves. Inappropriate job re-assignment can continue to injure the inflamed tendon or nerve, which can lead to permanent symptoms, surgery, or both.[22] The questionnaire and physical examination data showed that 19 of the 49 employees (39%) with assigned "rehabilitating jobs" stated the pain did not improve while on the new job. Thus, to prevent permanent symptoms or disability, CTD symptoms need aggressive intervention involving time off work, an appropriate rehabilitating job, and frequent medical follow-up to monitor the disorder's course.

From 5/1/87 to 4/30/88, 61 employees at John Morrell & Co. underwent surgery for upper extremity CTDs. Based on the OSHA 200 Log data, we concluded that workers were not given adequate post-operative days off work, nor given an appropriate type or length of restricted work activity. For single carpal tunnel release of the median nerve (CTR-M), this plant apparently gave a mean of 0.5 days off work, and a mean of 21 restricted work days. Published reports show the mean number of days off following CTR-M in a meatpacking plant was 53.6, with a range of 7 to 285 days.[12] The exact number of days off before resuming job activities requiring repetitive hand movements should vary with the individual employee; on the average, however, 90 days of rest (off work) after CTR-M surgery should be prescribed to employees returning to very repetitive jobs, such as those found in the meatpacking industry.[23,24] Returning to the workplace prematurely, can not only cause pain at the operative site, but a recurrent tenosynovitis can develop where the tendons pass through the carpal tunnel. When this rest period is reduced, there may be recurrence of symptoms.[5,23] Some surgeons recommend supporting the hand in a neutral position for two weeks, allowing the soft tissues around the median nerve to heal. If premature motion is initiated, a neuritis can develop.[25]

Like cts, the days off work after trigger finger surgery depends on the individual case, but on the average, 4-6 weeks off work is appropriate for employees returning to very repetitive jobs such as those found in the meatpacking industry.[15,23] In this plant, 41% of the workers having trigger finger surgery apparently had no days off work.

The mean (and median) missed and restricted work days for surgical and non-surgical cases were generated from the OSHA 200 Logs. We have assumed the logs accurately reflect physician's return to work orders. Confirming the accuracy of the OSHA 200 Logs in recording the number of actual missed and restricted work days would require further investigation.

Due to product's seasonal demand, during the week preceding the Thanksgiving holiday and the three weeks preceding the Christmas holiday, most departments worked over 50 hours per week. Not only do these lengthy hours increase the job's risk factors for causing CTDs (more total cuts per day), but they shorten the recovery period from work stresses. Further research is needed to test the hypothesis that overtime hours increase the risk of acquiring upper extremity CTDs.

VII. CONCLUSION

Our investigation found a high incidence rate of upper extremity CTDs and carpal tunnel syndrome among workers at the John Morrell & Co. plant in Sioux Falls, South Dakota for the one-year period 5/1/87 to 4/30/88. In addition, a high prevalence of upper extremity CTDs and hand-wrist CTDs was found among current workers. Ergonomic job analysis revealed the majority of jobs require tasks that are known risk factors for developing upper extremity CTDs. Recovery time, as measured by the number of missed days and restricted days, for surgical and non-surgical upper extremity CTDs was inadequate. At the time of this investigation, the investigators concluded that the company needed to expand the ergonomics program as described in the following section.

VIII. RECOMMENDATIONS

Prevention of occupational upper extremity CTDs can be categorized into 3 areas: engineering, administrative, and medical.

A. Engineering

Specific ergonomic recommendations for 100 workstations have been provided to OSHA, John Morrell & Co. management, and the local union. (Appendix E) General recommendations designed to reduce the job demands of high repetition, high force, and extreme postures have been generated from these specific workstation recommendations.

1. Reduction of extreme postures can be achieved by re-orienting the knife or tool handle, providing adjustable fixtures and rotating cutting tables so that the position of the meat can be easily manipulated; and providing work stations and delivery bins that accommodate the heights and reach limitations of workers of various sizes.

2. Reduction of excessive force typically involves automating aspects of the process, but can also be achieved through use of mechanical devices which aid in removing bones or separating meat from bones. Use of power tools, maintaining sharp cutting edges on knives, and installation of adjustable fixtures which allow cuts and movements to be made in mechanically advantageous postures (close to the body) are also effective methods in reducing applied force.

3. Reduction of highly repetitive movements or cuts can be accomplished by slowing down the main line or providing diverging conveyors off the main line so that certain activities can be performed at slower rates. Automation, increasing the number of employees performing a task, or restructuring jobs so that each worker's task is varied and in balance with other jobs on the line, are other ways of reducing repetitiveness.

4. Although the meat was to be cooled just above the freezing stage (34ºF), many workers complained of cutting frozen meat, particularly when the meat was kept in the cooler more than one working day. Frozen meat increases the forces required to perform various cuts. Meat should be prevented from freezing or thawed prior to processing.

B. Administrative

Training, job rotation, rest pauses, and meat temperature are all general administrative factors to be considered.

1. Training new employees should involve demonstrations and time to practice proper cutting techniques, proper knife care, and proper knife steeling. This training should include those operating the knife sharpening equipment. In addition, employees and immediate supervisors should receive education on CTD prevention, with emphasis on early symptom recognition. New employees should be given the opportunity to condition their muscle-tendon groups prior to working at full capacity. This could be accomplished through slower paced lines, varying each worker's task (mentioned previously), or job rotation (discussed below).

2. The principle of job rotation is to alleviate physical fatigue and stress of a particular set of muscles-tendon-nerve groups by rotating employees among one or two other jobs that use different muscle-tendon-nerve groups. Caution must be used in deciding which jobs are used; although different jobs may appear to have different stressors they may actually pose the same physical demands.

3. Rest pauses are needed to relieve fatigued muscle-tendon groups. The length of time needed depends on the task's overall effort and total cycle time.

4. Reduction of exposure to vibration and force may be achieved by instituting a monitoring program for whizard knives which includes vibration level measurement of the knives to verify that they are in proper working order and within original specifications.

C. Medical

1. Educate employees on the early signs of upper extremity CTDs.

2. Encourage early physician evaluation of CTD symptoms.

3. Once a CTD is diagnosed, allow appropriate time off work for all muscle-tendon-nerve groups to heal. The number of days off work should depend on each worker's individual response.

4. Upon returning to work after a CTD injury provide slower paced, lower force tasks to allow re-conditioning of the injured muscle-tendon-nerve groups.

5. With the implementation of the preceding engineering, administrative, and medical recommendations the need for surgical treatment of occupational upper extremity CTDs should be drastically reduced. However, until these recommendations are implemented the need for surgical management of severe, progressive cases will remain. After an upper extremity CTD surgery, appropriate time off work is needed to allow all injured muscle-tendon-nerve groups, and for the operative site to heal. The exact number of days off work will depend on individual variation. The following averages have been proposed.[23,24]

   After Carpal Tunnel Release Surgery and returning to a:

-non-repetitive, non-forceful job* - 3 weeks off (minimum 10 days)
-L-M repetitive, L-M forceful job** - 6 weeks off (minimum 21 days)
-highly repetitive, highly forceful job# - 12 weeks off (minimum 42 days)

   After surgery for trigger finger and returning to:

-non-repetitive, non-forceful job* - 2 weeks off (minimum 7 days)
-L-M repetitive, L-M forceful job** - 4 weeks off (minimum 14 days)
-highly repetitive, highly forceful job# - 6 weeks off (minimum 21 days)

   It must be emphasized these are averages, and some workers may require more or less time depending on their individual response. Also, these recovery times are the opinion of the authors of the published articles and do not represent NIOSH policy. They emphasize, that recovery time is generally a matter of weeks, not merely a few days.

6. Medical re-evaluation for return to work capabilities.

7. Institute a surveillance program to monitor CTD trends in this plant. This will provide information about the effectiveness of the various instituted programs in decreasing CTDs.

* - Non-repetitive, non-forceful job = jobs with a cycle time of 5 minutes or more, and never requires lifting lifting objects over l pound. No use of hand tools. No hand pinching or gripping.

** - L-M = Low to moderate repetitive, low to moderate forceful job = jobs with a cycle time between 30 seconds and 5 minutes, and only lifting objects less than 2 pounds during most job cycles. Occasional use of hand tools. Use of key strokes acceptable.

- Highly repetitive, highly forceful job = jobs with cycle time less than 30 seconds, and lifting more than 2 pounds during most job cycles. Use of any vibrating tool (whizard knife). The holding or use of a hand tool such as a knife, meat hook, saw, drill, or whizard knife for more than half of the job cycle (even if the job cycle is longer than 30 seconds) places the job in a highly repetitive, highly forceful category.

8. Finally, an ergonomics program needs to be developed and implemented with input from consultants, management, non-union employees, and union which consists of the following:

   a) Commitment and support of the program from management, union, and non-union workers;

   b) Committee to oversee ergonomics program composed of:
      1. Management
      2. Union
      3. Non-union workers
      4. Supervisors
      5. Medical (nurses, and physicians);

   c) Training the committee on ergonomic and medical principles of CTDs;

   d) Systematic evaluation of all jobs with regard to existing and new work practices, jobs, tools and equipment to identify stressors (repetition, force, vibration, and postures);

   e) Evaluation of the program's effectiveness including employee acceptance of work changes, number of job transfers related to CTDs, and trends in the CTD incidence rate.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. John Morrell & Co.
2. U.S. Department of OSHA, Bismarck area office
3. NIOSH, Region VIII
4. OSHA, Region VIII

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

OSHA INFORMATION ONLY

UPPER EXTREMITY NON-RTDs RECLASSIFIED AS CTDs

JOHN MORRELL & CO, SIOUX FALLS
HETA 88-180

1987

1) 87-542
2) 87-588
3) 87-717
4) 87-866
5) 87-916
6) 87-945
7) 87-951
8) 87-1075
9) 87-1118
10) 87-1162
11) 87-1450
12) 87-1466
13) 87-1521
14) 87-1543
15) 87-1544
16) 87-1631
17) 87-1632
18) 87-1846
19) 87-1884
20) 87-1895
21) 87-2100
22) 87-2104
23) 87-2184
24) 87-2273
25) 87-2311
26) 87-2361

1988

27) 88-119
28) 88-191
29) 88-280
30) 88-324
31) 88-370
32) 88-433
33) 88-434
34) 88-467
35) 88-469
36) 88-487
37) 88-577
38) 88-607
39) 88-616
40) 88-629

TABLE 1
INCIDENCE RATES OF UPPER EXTREMITY CTDs REPORTED
ON OSHA 200 LOGS (5/l/87 TO 4/30/88) BY DEPARTMENT

JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

Department	OSHA Log Cases	Incidence Rate*
+ Hog kill/Pork By	l85	77.6
+ Ham Bone	79	75.3
+ Pork Cut/Conversion	2l8	66.6
+ Beef Fab	l33	61.7
+ Pork Trim	58	59.9
+ Smoked Meat Pack	21	47.9
+ Sliced Bacon	32	42.5
+ Canned Meat	l3	42.5
+ Hides	0l	42.5
+ Beef Kill	24	42.4
+ Green Grade	l6	37.8
+ Beef Cooler	6	28.9
+ Smoked Meat Wash	l2	25.7
+ Beef Offal	8	24.8
+ Sausage Manufacture	l2	19.0
+ Fresh Meat	7	18.0
+ Sausage Cooler	l2	15.4
+ Curing	9	17.2
Garage	1	14.0
Night Clean-up	10	11.9
Animal Feed	1	8.5
Loading and Shipping	8	8.0
Maintenance	6	4.2
Lard Refinary	l	4.0
Routabout	1	3.6
Plant Freezer	0	0.0
Yard Office	0	0.0
Over the Road	0	0.0
Stockyards	0	0.0
Engine and Boiler	0	0.0
Mechanical	0	0.0
+ Cafeteria	0	0.0
Storeroom	0	0.0
Laundry	0	0.0
Other**	6	-
Total (Whole Plant)	880	41.7

* Incidence Rate= # of Upper Extremity CTDs per 100 full time employees per year.
\+ Departments listed on the OSHA complaint.
** Other = Departments with salaried employee; no employee hours were available to calculate incidence rate.

TABLE 2
INCIDENCE RATES OF CARPAL TUNNEL SYNDROME AND TRIGGER FINGER
REPORTED ON THE OSHA 200 LOGS (5/1/87 TO 4/30/88) BY DEPARTMENT

JOHN MORRELL & CO., SIOUX FALLS

HETA 88-180

Department	Probable&Possible Carpal Tunnel Syn. cases	I.R.*	Trigger Finger cases	I.R.*
+ Hog kill/Pork By	36	15.1	13	13.0
+ Ham Bone	14	13.3	9	8.6
+ Pork Cut/Conversion	34	10.4	43	13.1
+ Beef Fab	23	10.7	8	3.7
+ Pork Trim	10	10.3	5	5.2
+ Smoked Meat Pack	6	13.7	0	0.0
+ Sliced Bacon	3	4.0	1	1.3
+ Canned Meat	2	5.1	0	0.0
+ Hides	0	0.0	0	0.0
+ Beef Kill	4	7.1	3	5.3
+ Green Grade	2	4.7	2	4.7
+ Beef Cooler	1	42.5	1	42.5
+ Smoked Meat Wash	2	4.3	0	0.0
+ Beef Offal	3	9.3	0	0.0
+ Sausage Manufacture	l	1.6	0	0.0
+ Fresh Meat	1	2.6	0	0.0
+ Sausage Cooler	2	2.5	0	0.0
+ Curing	2	3.8	0	0.0
Garage	0	0.0	0	0.0
Night Clean-up	1	1.2	0	0.0
Animal Feed	0	0.0	0	0.0
Loading and Shipping	0	0.0	0	0.0
Maintenance	0	0.0	0	0.0
Lard Refinary	1	4.0	0	0.0
Routabout	0	0.0	0	0.0
Plant Freezer	0	0.0	0	0.0
Yard Office	0	0.0	0	0.0
Over the Road	0	0.0	0	0.0
Stockyards	0	0.0	0	0.0
Engine and Boiler	0	0.0	0	0.0
Mechanical	0	0.0	0	0.0
+ Cafeteria	0	0.0	0	0.0
Storeroom	0	0.0	0	0.0
Laundry	0	0.0	0	0.0
Other**	2	--	1	--
Total (Whole Plant)	150	7.2	92	4.4

* Incidence Rate (IR)= # of CTS or TF cases per 100 full time employees per year.
\+ Departments listed on the OSHA complaint.
** Other = Departments with salaried employee; no employee hours were available to calculate incidence rates.

TABLE 3

INJURED JOINT AREA AS REPORTED ON THE OSHA 200 LOGS

JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

	#	(%)
Hands	774	(52.1%)
Wrists	426	(28.7%)
Elbows	147	(9.9%)
Shoulders	112	(7.5%)
Neck	28	(1.9%)
Total	1487*	100.1%**

* The total number exceeds the 880 entries since more than one joint area could be involved in a single log entry.

** Due to rounding error

TABLE 4

MEDICAL CONDITIONS DEFINED AS
UPPER EXTREMITY CTDs REPORTED ON THE OSHA 200 LOGS

JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

	#	(%)
Tendonitis	369	34.2%
Strain	265	24.6%
Probable carpal tunnel syndrome	133	12.3%
Possible carpal tunnel syndrome	17	1.6%
Stenosing tenovaginitis (trigger finger)	92	8.5%
Stenosing tenovaginitis (deQuervain's)	26	2.4%
Tennis Elbow, Epicondylitis	47	4.4%
Tenosynovitis	38	3.5%
Myalgia, Myositis	19	1.8%
Neuralgia, Neuritis	16	1.5%
Synovitis	15	1.4%
Bursitis	13	1.2%
Ganglion Cyst	12	1.1%
Miscellaneous*	14	1.3%
	1079**	100.2%***

* Miscellaneous diagnoses include costochondritis, irritation, rotator cuff, torticollis, fingernail avulsion, arthritis, overuse syndrome

** Number is greater than 880 (the number of entries) because more than one diagnosis could be listed for each entry

*** Due to rounding errors

TABLE 5
OVERALL and HAND-WRIST CTD CASES BY DEPARTMENTS
JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

	Number of Workers	Questionnaire (Q) # (%)	Q and PE* # (%)
HIGH EXPOSURE DEPARTMENTS			
Hog Kill/By Products	(12)		
Overall cases		10 (83%)	8 (67%)
Hand-Wrist cases		8 (67%)	7 (58%)
Pork Cut/Conversion	(20)		
Overall cases		16 (80%)	l0 (50%)
Hand-Wrist cases		15 (75%)	9 (45%)
Pork Trim	(18)		
Overall cases		l6 (89%)	l4 (78%)
Hand-Wrist cases		15 (83%)	13 (72%)
Ham Bone	(41)		
Overall cases		36 (88%)	34 (83%)
Hand-Wrist cases		36 (88%)	33 (81%)
Beef Fabrication	(41)		
Overall cases		28 (68%)	l6 (39%)
Hand-Wrist cases		24 (59%)	13 (32%)
Subtotal:	(132)		
Overall cases		106 (80%)	82 (62%)
Hand-Wrist cases		98 (74%)	75 (57%)
LOWER EXPOSURE DEPARTMENTS			
Smoke Meat Pack	(40)		
Overall Cases		2l (53%)	l2 (30%)
Hand-Wrist Cases		20 (50%)	9 (23%)
Sausage Cooler	(28)		
Overall Cases		13 (46%)	6 (2l%)
Hand-Wrist Cases		8 (29%)	5 (18%)
Subtotal:	(68)		
Overall Cases		34 (50%)	18 (27%)
Hand-Wrist Cases		28 (41%)	14 (21%)
ALL DEPARTMENTS TOTAL:	(200)		
Overall cases		140 (70%)	100 (50%)
Hand-Wrist cases		126 (63%)	89 (45%)

* PE = Physical Examination

TABLE 6

NUMBER OF JOBS VIDEOTAPED IN EACH DEPARTMENT

JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

DEPARTMENT	# JOBS VIDEOTAPED	# JOBS TOTAL	% Videotaped
Beef Fab	43	90	(48%)
Hog Kill & Pork By	35	65	(54%)
Port Cut	31	78	(40%)
Sausage Cooler	l3	24	(54%)
Beef Kill and By	l3	49	(27%)
Pork Trim	ll	l5	(73%)
Ham Bone	ll	l9	(58%)
Smoke Meat Pack	l0	l8	(55%)
Sliced Bacon	6	l8	(33%)
Curing	4	*	
Smoke Meat Wash	3	22	(l4%)
Green Grade	2	8	(25%)
Canning	2	*	
Beef Cooler	l	l5	(7%)
TOTAL	l85	42l	(44%)

* = Number of jobs in these departments not ascertained.

TABLE 7

PREVALENCE OF UPPER EXTREMITY CTDs BY ERGONOMIC RISK ASSESSMENT

JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

	NUMBER OF PARTICIPANTS	ALL CTDs BY Q & PE* # (%)	H-W CTDs** BY Q & PE* # (%)
HIGHEST RISK	74	41 (55%)	38 (51%)
INTERMEDIATE RISK	74	42 (57%)	39 (53%)
LOW RISK	14	5 (36%)	3 (21%)
TOTAL	162	88 (54%)	80 (49%)

* Q & PE = Questionnaire and Physical Examination
** H-W CTDs = Hand-wrist cumulative trauma disorders
Chi-squared test for linear trend for upper extremity CTDs with one degree of freedom, $X^2=1.53$, $p=0.22$.
Chi-squared test for linear trend for hand-wrist CTDs with one degree of freedom, $X^2=3.34$, $p=0.07$.

TABLE 8
MISSED & RESTRICTED DAYS BY SURGICAL PROCEDURE
JOHN MORRELL & CO., SIOUX FALLS
HETA 88-180

Procedure	# of Cases	Missed Days [Mean]	Missed Days Median	No Missed Days (Range)	No Missed Days # (%)	Restricted Days [Mean]	Restricted Days Median	No Restricted Days (Range)	No Restricted Days # (%)
Trigger Finger Release (Single)	24	[1.4]	0.6	(0-9)	9 (38%)	[24]	15	(0-90)	5 (21%)
Trigger Finger Release (Multiple)	10	[0.7]	<0.1	(0-3)	6 (60%)	[14]	5	(0-60)	3 (30%)
Carpal Tunnel Release-Median Nerve (Single)	10	[0.5]	<0.1	(0-2)	6 (60%)	[17]	10	(0-49)	3 (30%)
Carpal Tunnel Release-Median Nerve (Multiple)	2	[2.0]	2.0	(2)	0 (-)	[49]	49	(43-55)	0 (-)
Carpal Tunnel Release-Ulnar Nerve	1	[1.0]	1.0	(-)	0 (-)	[5]	5	(-)	(-)
Elbow Ulnar Nerve Release	1	[4.0]	4.0	(-)	0 (-)	[30]	30	(-)	(-)
Trigger Finger Release & Carpal Tunnel Release-Median Nerve	2	[1.0]	1.0	(1)	0 (-)	[21]	21	(0-41)	1 (50%)
Trigger Finger Release & Carpal Tunnel Release-Median Nerve & Synovectomy	3	[0.0]	<0.1	(-)	3 (100%)	[9]	9	(5-186)	0 (-)
Trigger Finger Release & Synovectomy	3	[1.0]	1.0	(0-2)	1 (33%)	[8]	8	(0-27)	1 (33%)
Carpal Tunnel Release-Ulnar Nerve & Elbow Ulnar Nerve Release	1	[2.0]	2.0	(-)	0 (-)	[56]	56	(-)	0 (-)
Totals	57	[1.1]	0.6	(0-9)	25 (44%)	[24]	15	(0-186)	13 (23%)
Not Listed on OSHA 200 Logs	4 (2 single Trigger Finger Release, 1 single Carpal Tunnel Release and 1 Elbow Ulnar Nerve Release)								
Employees Having Upper Extremity CTD Surgery	61								

APPENDIX A

MEDICAL CONDITIONS RECORDED AS A UPPER EXTREMITY CTD ON THE OSHA 200 LOGS

Tendonitis
Strain
Probable Carpal tunnel syndrome (cts)*
Possible Carpal tunnel syndrome (cts)**
Trigger Finger, Stenosing tenosynovitis of the fingers
deQuervain's, Stenosing tenosynovitis of the thumb
Tennis Elbow, Epicondylitis
Tenosynovitis
Myalgia, Myositis
Neuralgia, Neuritis, Ulnar Nerve
Synovitis
Bursitis
Ganglion Cyst
Rotator Cuff
Costochondritis
Irritation, pain
Torticollis
Fingernail avulsion
Arthritis
Overuse Syndrome

* Probable cts = (probable cts, early cts)
** Possible cts = (? cts, rule out cts, vs. cts)

OSHA 200 Logs provide a record of "OSHA - recordable occupational injuries", which include all work-related deaths and illness, and work-related injuries involving one or more of the following: loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment other than first aid.[1] OSHA log entries of CTDs are typically listed under the "7f" column, which includes "disorders associated with repeated trauma."

APPENDIX B

DIAGNOSTIC CRITERIA FOR SPECIFIC DISORDERS

Symptomatic employees were asked to quantitate their pain of a scale of 0 to 8. Zero represents no pain, while 8 represents the worst pain that individual has ever experienced.

NECK

A. Tension Neck Syndrome
   1. Palpable muscle tightness, hardening, or2. Pain greater than or equal to (GE) 3 on passive or resisted neck flexion or rotation.

B. Cervical Root Syndrome
   1. Pain (GE 3) radiating from the neck to one or both arms with numbness in the hand.

SHOULDER

A. Bicipital Tenosynovitis
   1. Positive Yergason's test*

B. Rotator Cuff Tendonitis
   1. Pain (GE 3) in deltoid muscle on resisted 90° abduction.

ELBOW

A. Lateral Epicondylitis (Tennis Elbow)
   1. Pain (GE 3) at lateral epicondyle on resisted wrist extension, or
   2. Pain (GE 3) at the lateral epicondyle on palpation.

B. Medical Epicondylitis (Golfer's Elbow)
   1. Pain (GE 3) at medial epicondyle on resisted wrist flexion, or
   2. Pain (GE 3) at the medial epicondyle on palpation.

* Yeragson's test = pain in the bicipital groove on resisted supination with flexed elbow.

HAND AND WRIST

A. Ulnar Nerve Compression
   1. No cervical root disorder, and
   2. Positive Tinel's sign at Guyon's canal.*

B. deQuervain's Disease
   1. Positive Finkelstein's test.**

C. Carpal Tunnel Syndrome (cts)
   1. Positive Phalen's test.***

D. Definite Trigger Finger
   1. Palpable nodule at base of digit, or
   2. Locking in flexion or extension of digits.

E. Tendonitis, Tenosynovitis
   1. Pain (GE 3) on resisted flexion or extension of the wrist, or fingers

F. Osteoarthritis of the Wrist
   1. Passive range of motion (ROM) wrist pain (GE 3), and
   2. #1 GE E above.

G. Non-Specific PIP Joint
   1. Pain (GE 3) in the PIP joint on palpation, or
   2. Swelling of the PIP joint, or
   3. ROM limitation of PIP joint.

* Gentle tapping over the ulnar nerve at the wrist resulting in pain, tingling, or numbness in the ulnar nerve distribution.

** Ulnar deviation of the hand with the thumb flexed against the palm and the finger flexed over the thumb. Severe pain results at the radial styloid due to stretching of the abductor pollicus longus and extensor pollicis brevis.

*** Unforced, complete flexion of the wrist for 60 seconds resulting in pain, numbness, or tingling in the median nerve distribution.

APPENDIX C

DETAILED EXPLANATION OF THE ERGONOMIC RISK ASSESSMENT METHOD

Ergonomic analysis, using a videotape recording of designated jobs, allows quantitative measurements of job risk factors associated with developing CTDs. Analysis focused on the upper extremities and was designed to provide an efficient measure of exposure. The factors under ergonomic analysis are repetitiveness, force, posture, and vibration.

1. REPETITIVENESS

Cycle Time measures the frequency of repetitive movements. A cycle begins with a cut or movement and ends with the same cut or movement on the next piece of meat. If a piece of meat passes without being touched, it is not counted as a new cycle. An average cycle time was calculated from the mean of 4 to 20 cycles. Waiting time, knife "steeling" time (for reconditioning the edge), and time for tasks performed every few cycles, were averaged over the number of cycles examined and included in the average cycle time.

Cuts (Movements) Per Cycle - For jobs using knives, saws or other cutting tools, the average number of cuts per cycle was determined. Criteria for a cut include:

1. removing and re-inserting the knife into the meat, or
2. re-gripping the knife, or
3. cutting, then stopping for any noticeable length of time, and cutting again, or
4. abrupt change in motion, even without withdrawing the knife from the meat, (exception - short back and forth motion resulting in a straight line cut, which was counted as a single cut.

Knife "steeling", and other "non-cutting" movements of the dominant hand were not included in the number of cuts per cycle.

Cuts (Movements) Per Hour - calculation based on cuts (movements) per cycle multiplied by the number of cycles per hour.

2. FORCE

Two qualitative parameters were used to assess force: overall effort level and peak effort level. Overall effort level was assessed by visual inspection of the videotape using a scale of l to 5 (l = easiest, 5 = most difficult). Factors involved in assigning an overall effort level include the number of forceful cuts and movements in a cycle, the amount of waiting involved in each cycle, extreme postures, size and type of tool, type of cut, size and weight of meat handled.

Peak effort level is a subjective measure of the maximum force exerted in a cycle, again using a l to 5 scale.

3. POSTURE

Extreme postures occurring at least once every two cycles were recorded for the dominant hand. Extreme postures were defined as:

wrist: flexion ($\geq$75°), extension ($\geq$50°), radial deviation ($\geq$l0°), ulnar deviation ($\geq$20°);

shoulder: flexion ($\geq$90°), extension ($\geq$20°), and abduction (>90°). If there were extreme shoulder postures, then pronation and supination of the forearm was also noted.

4. VIBRATION

Defined as the use of a vibrating tool, such as a saw or whizard knife.

5. HANDEDNESS

A. Definition of the Dominant Hand

The dominant hand holds the cutting tool. If no tool is used, or both hands hold a tool, the dominant hand performs the more difficult job, determined by repetitiveness and estimated force exerted irrespective of whether the worker is right or left handed. If a knife is held in one hand and a hook in the other, the hand with the knife is designated the dominant hand.

Tools were recorded for both the dominant and non-dominant hand. If a saw use is recorded for both hands, then both hands are holding the same saw.

B. Evaluation of use of the Non-dominant Hand

An abbreviated analysis was performed on the non-dominant hand. Tools, if any, were noted. For hooks, the percent of time that the hook is held was noted. In addition, the number of forceful movements (including cuts) of the non-dominant hand was noted.

APPENDIX D

ICD-9* and CPT-4** CODES FOR EXTRACTING UPPER EXTREMITY CTDs

A. ICD-9 Codes

1. 7270: Synovitis and Tenosynovitis
2. 3540: Carpal Tunnel Syndrome (cts)
3. 3542: Lesions of the Ulnar Nerve

B. CPT-4 Codes

1. 26055: Tendon sheath release for trigger finger
2. 26145: Synovectomy or radial tendon synovectomy of the flexor palm, or fingers
3. 64718: Neurolysis and/or transposition of the ulnar nerve at the elbow
4. 64719: Neurolysis and/or transposition of the ulnar nerve at the wrist
5. 64721: Neurolysis and/or transposition of the median nerve at the carpal tunnel.

* ICD-9 = International Classification of Diseases - 9th Revision
** CPT-4 = Current Procedural Terminology - 4th Revision

APPENDIX E
SPECIFIC ERGONOMIC JOB RECOMMENDATIONS AND CTD MEDICAL DOCUMENTATION

Copies available upon request.