U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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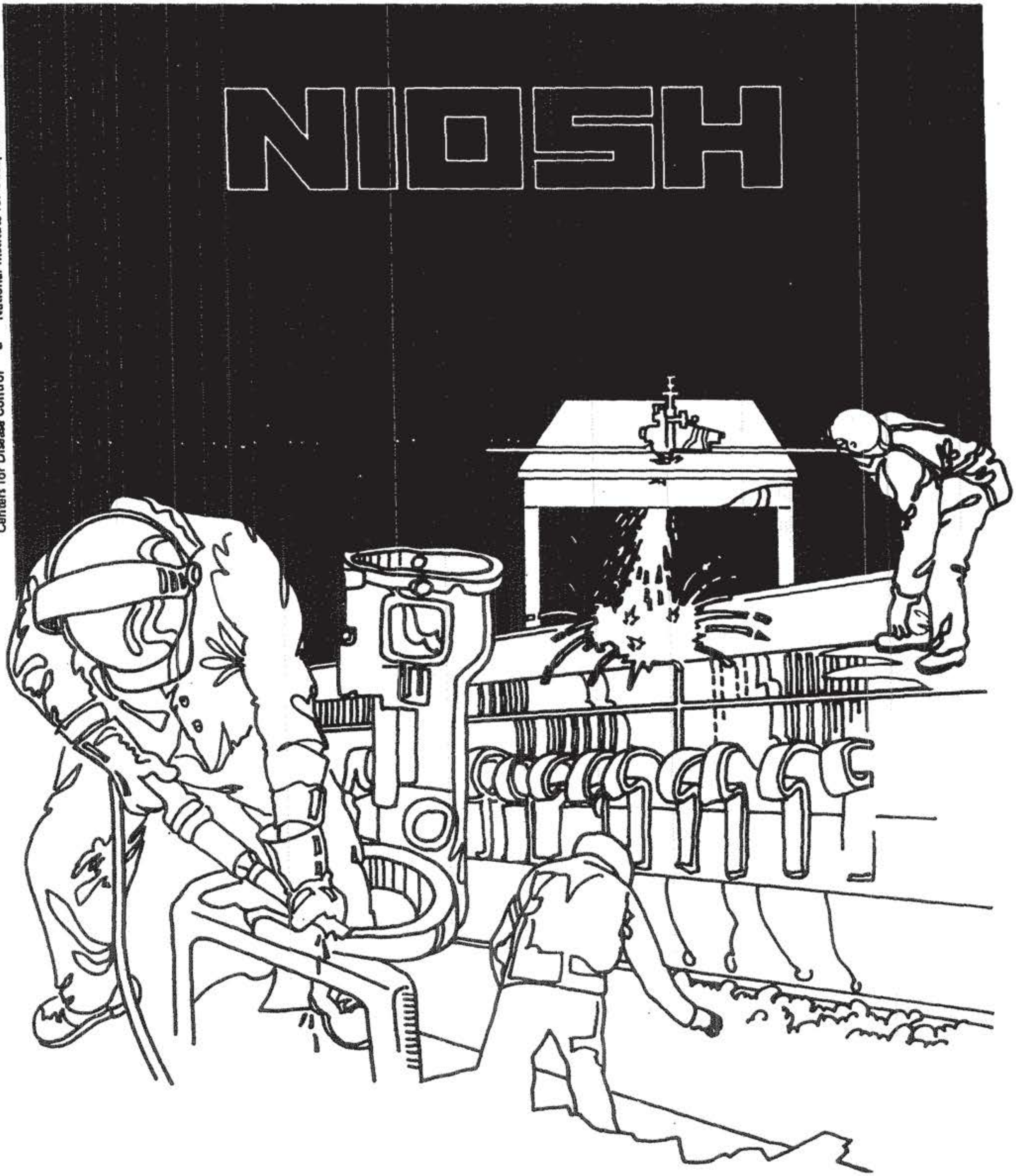

Health Hazard Evaluation Report

HETA 85-534-1855
ICI AMERICAS, INC.
INDIANA ARMY AMMUNITION PLANT
CHARLESTOWN, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 85-534-1855
DECEMBER 1987
ICI AMERICAS, INC.
INDIANA ARMY AMMUNITION PLANT
CHARLESTOWN, INDIANA

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I. SUMMARY

On September 13, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Chemical Workers Union (ICWU), Local 692, to evaluate carpal tunnel syndrome (CTS), ganglionic cysts, and tendonitis of the wrist among production workers in the igniter and propellant load lines, and in bag manufacturing at ICI Americas, Inc. ICI Americas, Inc, is the defense contractor who operates the Indiana Army Ammunition Plant (INAAP) for the U.S. Army. The company employs approximately 1800 workers in the assembly of solid propellant charges.

On November 12-13, 1985, NIOSH investigators conducted an initial site visit to become familiar with the process and to review dispensary log records. Because of deficiencies in the log, NIOSH returned to the facility on February 10-11, 1986, and distributed a questionnaire to all available production workers to determine the prevalence of upper extremity symptoms among the workforce.

The questionnaire, completed by 463 production workers, revealed that workers (particularly women) in the assemble, lace and tie (ALT) job classification had the highest prevalence of upper extremity symptoms when compared to all other job categories. ALT workers reported higher prevalences of hand and forearm symptoms, and women in this job category reported a higher prevalence of possible CTS.

Based upon the questionnaire findings, six jobs were selected for ergonomic evaluation on the presumption that jobs with the highest prevalence of upper extremity symptoms, were ergonomically the most stressful. On June 18 and 19, 1986, NIOSH investigators conducted the ergonomic evaluation. The main focus of this evaluation was to identify problem tasks and recommend modifications in the job for purposes of reducing ergonomic stress. Videotapes were taken of each job to aid in the analysis.

Analysis of the video tapes revealed that the tying of pull straps on the propellant charges was one of the most difficult jobs performed by ALT workers. This particular job involved highly repetitive, awkward and forceful manipulations of the hand and wrist, factors causally associated with cumulative trauma disorders (CTD's). Apart from hand/wrist manipulations, problems such as excessive reach distances, improper work height, and/or improper seated work posture were observed in this and the other jobs evaluated.

On the basis of our questionnaire findings and ergonomic analysis of selected production jobs, NIOSH investigators determined that production work at ICI Americas, Inc., was associated with a high prevalence of musculoskeletal disorders including carpal tunnel syndrome, ganglionic cysts, and tendonitis. Recommendations for modifying or eliminating these problems are presented in Section VI and VII of this report.

KEYWORDS: SIC 3483 (Ammunition loading and assembly plants), musculoskeletal disorders, carpal tunnel syndrome, ganglionic cysts, tendonitis, cumulative trauma disorders, ergonomics, repetitive tasks.

II. INTRODUCTION

On September 13, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at ICI Americas, Charlestown, Indiana. The request, initiated by the International Chemical Workers Union (ICWU), Local 692, asked us to address a concern that employees of the load lines, igniter lines, and the bag manufacturing area had ragarding repetitive trauma injuries to their wrists as a result of their work activities. Carpal tunnel syndrome, ganglionic cysts, and tendonitis were among the injuries reported by the workers.

A previous NIOSH health hazard evaluation(1) was conducted at this facility in 1983 when we were asked by ICWU, Local 761 to evaluate repetitive trauma injuries of the quality assurance personnel. One of the recommendations made by the NIOSH investigators at the conclusion of the survey was for an assessment to be made of the production personnel, since some of their jobs involved much more repetitive and strenuous hand/wrist movements than those of the QA personnel.

On November 12 and 13, 1985, NIOSH investigators conducted an initial site visit at the facility to familiarize ourselves with the production process. On February 10 and 11, 1986 we returned to the facility and administered a brief questionnaire to the production workers to better define the prevalence of upper extremity discomfort in the various work areas identified in the request. A second follow-up evaluation was made to ICI Americas, Inc. on June 18 and 19, 1986, at which time we collected pertinent information and obtained videotapes of several production jobs believed to be ergonomically stressful, according to the questionnaire responses.

III. BACKGROUND

ICI Americas, Inc. is the defense contractor that operates the Indiana Army Ammunition Plant (INAAP) for the U.S. Army. The company employs approximately 1800 workers in the assembly of solid propellant charges used to propel projectiles, mortars, etc. The entire facility, built by the Army in 1940, is expansive with 1387 buildings situated on 10,600 acres.

The manufacturing process consists of the assembling, packing, and shipping of propellant charges. Although INAAP has the capability of producing its own propellant, all of the propellant currently used at this facility is obtained from Radford Army Ammunition Plant, Radford, Virginia. The propellant is in the form of grains or cylindrically-shaped pellets consisting primarily of nitrocellulose, stabilizers, and additives. In addition to the propellant, igniter powder, and in some cases flash reducer, are used in the manufacture of the charges.

The major production areas at INNAP include the propellant and igniter load lines (LL), and bag manufacturing. A description of is presented below:

Propellant load lines - Propellant is processed in LL5A&B and LL6A&B by approximately 250 (Dept. 360) workers. Load lines are located in separate geometrically-spaced buildings, each with two load lines (A&B) where similar or different propellant charges are processed. The work is fairly labor intensive; automation is difficult to incorporate into the process because of the explosion hazard posed by sparks. Because of this, all of the sewing machines located in the load and igniter lines are belt-driven, by motors located outside of the buildings.

Bulk pelletized propellant is delivered to the plant in various sized containers and stored in underground bunkers. These containers are transferred to the propellant load line buildings via forklift. The propellant is emptied into elevated holding bins and gravity-fed into measuring hoppers. These dispense a specified amount of propellant which is weighed and then dumped into cylindrical cloth bags. The filled bags are individually sealed via a machine sewing operation. The bags vary in size and weight depending on the application. Small bags (up to about 2 lbs.) are used for multiple (4 to 5) increment charges while larger bags (about 20 lbs.) are used for single increment charges. As indicated earlier, igniter powder is also used in the assembly process. Therefore, even the single increment charge has more than one bagged component. Bagging and assembly of both types of charges is basically the same although the larger bag involves more muscular force to manipulate. Assembly of the charges is accomplished by placing the propellant and igniter bags on top of each other while inside a cylindrical metal fixture. One or more straps, positioned lengthwise around the bags and tied in a knot at the top, are used to secure the bags together. The completely assembled multiple increment charge, now consisting of several bags and weighing up to about 12 lbs., is placed directly into metal shipping containers while the larger completely assembled single increment charge, consisting of two bags weighing approximately 22 lbs., is wrapped in corrugated cardboard prior to being stuffed into the metal shipping container. These containers are either stored on-site or shipped elsewhere.

Igniter lines - Igniter powder is processed in load lines LL3A&B, LL8A and in Igniter 2 building. The powder is handled by approximately 80 (Dept. 365) workers and bagged in much the same manner as the propellant. The loaded and sealed igniter bags, typically weighing no more than a couple of pounds, are used in the assembly of the propellant charges. Because of their weight, minimal force is needed in the handling of these bags.

Bag manufacturing - All of the bags used in the load and igniter lines are manufactured in Building 1001 by approximately 200 (Dept. 340) workers. Equipment and operations are similar to that found in the garment industry. Fabric is received in large rolls, cut to the desired length and width in slitter machines, then machine sewn together to form a hollow cylinder of various sizes depending on the type of charge. In one of the larger charges (155MM M119A2), an insert containing granularized flash reducer is sewn inside the bag prior to being filled with propellant.

IV. EVALUATION DESIGN AND METHODS

The health hazard evaluation request indicated complaints of upper extremity disorders, including carpal tunnel syndrome (CTS), ganglionic cysts, and tendonitis. We were informed that the affected individuals worked in bag manufacturing, and on the load and igniter lines.

Our initial visit, November 12-13, 1985, involved a walk-through where we observed operations. Additionally, we reviewed the previous two years' OSHA 200 logs and dispensary logs, in an attempt to determine the distribution of cumulative trauma disorders (CTD's) by department.

Because of the limitations inherent in the logs, a decision was made to subsequently distribute a two-page self-administered questionnaire (Attachment A) to all production workers. The intent was to identify jobs with a high relative prevalence of upper extremity symptoms suggestive of carpal tunnel symdrome, so that ergonomic evaluation could be directed toward those jobs.

During the week of February 10, 1986, this questionnaire was distributed on-site to groups of 20-60 individuals, and collected immediately upon completion. NIOSH employees were available to assist in proper completion of the questionnaires, as needed. The questionnaires were distributed to all available employees from bag manufacturing and from any load or igniter line in use. The questionnaire elicited basic demographic information, a brief work history, and the occurrence of symptoms which may be indications of cumulative trauma disorders of the upper extremities. A brief medical history concerning previous diagnosis of those medical conditions was also included.

As a measure of carpal tunnel syndrome (CTS), we considered anyone a possible case if they reported "repeated feeling of numbness, tingling, or pins and needles sensation in one or both hands" during the previous month, and if they reported that pain in the hands, or other upper extremity pain, wakened them from their sleep. We also examined the prevalences of the upper extremity symptoms and possible CTS status within the various departments, areas, and jobs. The data were analyzed using the Statistical Analysis System (SAS).

On June 19 and 20, 1986, we conducted an ergonomic evaluation of six jobs, selected on the basis of the questionnaire we administered to employees in February. Because the questionnaire was designed to elicit information concerning job classifications and not specific jobs, we selected (six) representative jobs from those job classifications which were identified as having high symptom prevalence rates. A listing of these six jobs is presented by department and location in Table 1, along with other pertinent information.

It should be noted that we intended to evaluate some of the jobs in LL5B, since the questionnaire data revealed that workers on this load line had a higher prevalence of upper extremity musculoskeletal symptoms as compared to workers in other areas of the plant. Unfortunately, this load line was not operational at the time of our June site visit.

Our evaluation consisted of a work methods assessment for purposes of documenting work postures and types of motions which could contribute to the types of symptoms reported by the workers. Videotapes were taken to assist in this portion of the evaluation. In addition, we obtained a copy of the company job and safety analysis description (OSHA forms) for each of the jobs that were videotaped, in order to become familiar with the specific tasks and personal protective equipment required to perform a particular job, and the safety hazards incurred when recommended procedures are not followed.

V. EVALUATION CRITERIA

There is evidence in the literature that cumulative trauma disorders (CTD's) are associated with repetitive and forceful movements of joints and muscles[2-6]. Examples include carpal tunnel syndrome, tendonitis, tenosynovitis, ganglionic cysts, epicondylitis, myositis, and bursitis. These disorders affect the nerves, tendons, and tendon sheathes of the upper extremity. The reported causal factors of these ailments, particularly those found in the workplace, are the posture of the hand/wrist during exertion, the force of exertion, and the frequency of the movement.

The postures most often associated with upper extremity CTD's are wrist extension and flexion, ulnar and radial deviation of the wrist, open-hand pinching, twisting movements of the wrist and elbow, and shoulder abduction. With respect to muscular force, one study found that workers performing jobs with force levels of 4 kilograms (8.8 lbs) or more were four times more likely to develop a hand/wrist CTD as those workers whose jobs required muscular exertions of 1 kilogram or less[6]. There are studies which indicate a level of risk associated with certain frequencies of movements and length of job cycles[7-13]. In studies reporting an incidence of CTD's the number of hand movements ranged from 5,000 to 50,000 per day(7-13). Job tasks with cycle times lasting 30 seconds or less were found to have an incidence of upper extremity CTD's three times greater than those jobs where the cycle time was greater than 30 seconds(6).

CTD's are considered in many cases to be work-related because awkward postures and highly repetitive movements are required in many manufacturing and assembly jobs. Occupations for which a high incidence of CTD's is known to exist include electronics components assembly(14), meat processing and packing(15), fish filleting(16), and buffing and filing(12). CTD's have also been seen among workers in non-manufacturing jobs, such as office workers using typewriters and/or VDT's(17-20), cash register operators(21,22), and accounting machine operators(23). What is common to all of these jobs is high speed repetitive motions, particularly in combination with postures which produce high biomechanical forces. The incidence of CTD's among these and other jobs has not yet been established, but incidences as high as 44 cases per 200,000 work-hours are known to exist(24).

Although occupational factors can play a significant role in the development of CTD's , there are many non-occupational components. For example, activities such as woodworking, tennis, weight lifting, knitting, and sewing may impose the same type of physical demands on the musculotendinous system as does job-related manual work.

Because of the complexity of repetitive motion patterns and the fact that few quantitative criteria exist to define the presence or extent of ergonomic hazards, it has been difficult to define the critical point at which posture, frequency, and force pose a CTD risk. Consequently, the current strategy for reducing the risk of CTD's for a certain task is to minimize job factors which are biomechanically stressful, i.e., akward postures, high forces and repetition rates. This is most effectively achieved through the redesign of work stations, tools, or work methods that are identified through job analysis as risk factors for CTD's.

The carpal tunnel is a canal bordered on the bottom and sides by bone, and on the palmar side of the wrist by a fibrous sheath called the flexor retinaculum. The canal leads from the forearm to the hand, with the median nerve and several tendons passing through it. Carpal tunnel syndrome (CTS) is a disorder caused by injury to the median nerve. The syndrome begins with tingling or numbness in the hand and fingers, and can progress to an impaired function due to loss of feeling and/or grip strength. CTS is associated with other common conditions such as pregnancy, menopause, obesity, diabetes, use of oral contraceptives, gynecological surgery, rheumatoid arthritis, acromegaly, and gout[25]. Since a number of these conditions are unique to women, their risk of developing CTS may be elevated. This may explain in part why CTS occurs from 3 to 10 times more often in women than men.

VI. FINDINGS

A. Questionnaire Survey

As reported in NIOSH's letter of March 5, 1986, of the 549 people in the targetted departments, 463 (84%) completed and returned their questionnaire. The response rates were: Bag Manufacturing (area 1001) - 161/200 (81%); Igniter 2 - 14/17 (82%); LL3A - 14/14 (100%); LL3B - 21/23 (91%); LL5A - 59/67 (88%); LL5B - 66/72 (92%); LL6A - 53/68 (78%); LL6B 56/61 (92%); LL8A - 15/23 (65%); and department 390 - 4/4 (100%).

The study-wide symptom prevalences and comparisons of symptomatics versus non-symptomatics for such factors as gender, age, time at the same job, and time at ICI are included in Table 2. The significant findings from that table are reported here. Overall, 139 of 463 (30.0%) reported hand symptoms (question 1, Appendix A). Comparing those who reported hand symptoms with those who did not, their average time at the plant was significantly less (92.8 months versus 116.5 months, $p = 0.02$) and females had a statistically significant ($p = 0.0005$) elevated relative risk (RR) of 2.21 (95% Confidence Interval: 1.41 - 3.48, $p=0.0005$) of reporting that symptom (their risk of having hand symptoms was more that twice as greater as males' risk).

One hundred sixteen of 462 people (25.1 percent) reported forearm symptoms (question 2, Appendix A). Those who reported forearm symptoms had less average time at the plant (89.8 months vs 115.6 months, $p=0.01$).

Eighty-eight of 463 people (19.0 percent) reported elbow symptoms (question 3, Appendix A) Those who reported elbow symptoms had less average time at the plant (88.0 months vs 114.4 months, $p=0.03$).

One hundred sixty-eight people (36.3 percent) reported shoulder symptoms (question 4, Appendix A). Those who reported shoulder symptoms were significantly younger (43.6 years old vs 45.9 years, $p=0.03$), had worked less time at ICI (85.8 months vs 122.9 months, $p=0.0001$), and were more likely to be female (RR = 1.56, 95 % Confidence Interval: 1.10 - 2.22, $p=0.01$).

Eighty-six people (18.6 percent) had possible CTS, based only on the questionnaire. They had worked significantly less at ICI (87.6

months vs 114.4 months, p=0.03). Women were at increased risk relative to men (RR = 3.31, 95 percent CI: 1.63-6.70, p=0.0009).

The prevalences of each symptom and of possible CTS were looked at in each department, area, and job. In only a few instances did the prevalence differ significantly from the plant-wide prevalence. Those differences which are significant are reported here, and are summarized in Table II.

Department 360

Workers in department 360 had significantly higher prevalences of forearm symptoms (74/247 (30.0 percent), RR=1.53, 95% C.I.: 1.11 - 2.12) and elbow symptoms (60/247 (24.3 percent), RR=1.87, 95% C.I.: 1.26 - 2.79) than did workers in the rest of the plant. Because hand complaints, shoulder complaints, and possible CTS were all significantly more likely to be reported by women when we looked at the whole population, we stratified by gender when looking at the prevalences of those symptoms by department, area, or job. Comparing women who work in department 360 to all other women who were studied, the department 360 women reported a significantly higher number (65/166 (39.2 percent), RR=1.34, 95% C.I.: 1.01 - 1.78) of hand symptoms. They were also more likely to be considered to have possible CTS (44/166 (26.5 percent), RR=1.51, 95% C.I.: 1.02 - 2.23). The 81 men who worked in department 360 were not significantly more likely to report any of the symptoms compared to the other men in our study.

Department 370

Department 370 included fifteen people who were studied, all of whom were women. Compared to other women in the study, these women reported significantly fewer hand symptoms (1/15 (6.7 percent), RR=0.19, 95% C.I.: 0.05 - 0.80). None of the women had possible CTS, which was significantly different from the rest of the women.

Area LL5B

Comparing the symptom prevalences in each area of the plant, LL5B had significantly higher prevalences of many symptoms. The women of LL5B had significantly higher prevalences of hand symptoms (20/32 (62.5 percent), RR=2.02, 95% C.I.: 1.38 - 2.96) and possible CTS (13/32 (40.6 percent), RR=2.06, 95% C.I.: 1.23 - 3.44) compared with all other women. The men in LL5B had prevalences of 7/33 ((21.2 percent), RR=1.79, 95% C.I.: 0.69 - 4.65) for hand symptoms and 3/33 ((9.1 percent), RR=1.79, 95% C.I.: 0.39 - 8.29) for possible CTS. These were higher, but not significantly higher, than the prevalences for other men in the study. Taken as a whole, the LL5B workers had significantly higher prevalences of forearm symptoms (25/65 (38.5 percent), RR=1.68, 95% C.I.: 1.15 - 2.45) and elbow symptoms (22/65 (33.8 percent), RR=2.04, 95% C.I.: 1.33 - 3.12) than did other workers.

Bag Manufacturing

Bag manufacturing (area 1001) differed significantly from other areas in the following ways: women had a lower prevalence of hand symptoms (41/153 (26.8 percent), RR=0.70, 95% C.I.: 0.51 - 0.94) and of possible CTS (23/153 (15.0 percent), RR=0.57, 95% C.I.: 0.38 - 0.88). Taken as a whole, the workers in bag manufacturing had a lower prevalence of elbow symptoms (22/161 (13.7 percent), RR=0.63, 95% C.I.: 0.41 - 0.96).

LL6A

The only other area which had any significant difference was women in LL6A, who had a lower prevalence of shoulder symptoms (9/38 (23.7 percent), RR=0.58, 95% C.I.: 0.35 - 0.98) than all other women in the study.

Assemble, Lace and Tie - Light

The only job for which the symptom prevalences differed significantly from all others was assemble, lace and tie - light (ALT-L). Women in that job category had significantly higher prevalences of hand symptoms (13/16 (81.3 percent), RR=2.58, 95% C.I.: 1.64 - 4.04) and possible CTS (9/16 (56.3 percent), RR=2.81, 95% C.I.: 1.56 - 5.07). Men also had a higher prevalence of hand symptoms (4/10 (40 percent), RR=3.28, 95% C.I.: 1.19 - 9.03). Taken as a whole, the workers doing that job had a higher prevalence of forearm symptoms (13/26 (50 percent), RR=2.12, 95% C.I.: 1.30 - 3.45).

Of the 26 ALT-L workers who were studied, 14 worked on LL5B, 3 on LL6A, and 9 on LL6B. All 26 are in department 360. We then attempted to see if the higher symptom prevalences in department 360 and area LL5B were due to the ALT-L workers.

Department 360, excluding ALT-L workers

Excluding the 26 ALT-L workers from the analysis, we found that workers in department 360 still had significantly higher prevalences of forearm symptoms (61/221 (27.6 percent), RR=1.41, 95% C.I.: 1.00 - 1.99) and elbow symptoms (55/221 (24.9 percent), RR=1.92, 95% C.I.: 1.28 - 2.87). Though the prevalences of hand symptoms (52/150 (34.7 percent), RR=1.18, 95% C.I.: 0.87 - 1.61) and of possible CTS (35/150 (23.3 percent), RR = 1.33, 95% C.I.:

0.88 - 2.01) among women of Department 360 were still slightly higher than all other women's, the differences were no longer statistically significant.

Area LL5B, excluding ALT-L workers

Again excluding all 26 ALT-L workers, the remaining LL5B workers still differed significantly from all other workers in the study for a number of symptom prevalences. For forearm and elbow symptom prevalences, the differences were slightly more significant than before: forearm - 20/51 (39.2 percent), RR = 1.82, 95% C.I.: 1.19 - 2.77; elbow - 19/51 (37.3 percent), RR = 2.25, 95% C.I.: 1.43 - 3.52. For the remaining women in LL5B, prevalences of hand symptoms (12/24 (50 percent), RR=1.66, 95% C.I.: 1.01 - 2.70) and of possible CTS (9/24 (37.5 percent), RR=2.00, 95% C.I.: 1.08 - 3.70) were still significantly higher.

Summary of Questionnaire Results:

Based upon the questionnaire results, women throughout the areas surveyed reported significantly higher prevalences than did men of hand symptoms, shoulder symptoms, and possible carpal tunnel syndrome (CTS). Those people who reported hand symptoms, forearm symptoms, elbow symptoms, shoulder symptoms, and who had possible CTS had, on average, worked significantly less time at ICI than had those without the symptoms. This phenomenon is not unusual, and is often thought of as a kind of survivor effect, whereby those workers who become ill or experience ongoing discomfort leave their job, while those who remain have less adverse health effects.

Compared to all other workers studied, people in Department 360 had a higher prevalence of forearm and elbow symptoms. Women in that department (compared to women in other departments) had higher prevalences of hand symptoms and of possible CTS. Workers in Area LL5B had significantly higher prevalences of forearm symptoms and elbow symptoms, and women had higher prevalences (compared to women in other areas studied) of hand symptoms and of possible CTS. Finally, the single job category for which workers were at significantly higher risk was assemble, lace and tie - light (ALT-L). Those workers reported higher prevalences of hand and forearm symptoms, and women in that job had a higher prevalence of possible CTS.

B. Work Methods Assessment: Description and Impressions of Jobs

Six jobs, selected on the basis of the results of the questionnaire data and representing four different job classifications were evaluated by NIOSH. A list of these jobs is presented in Table 1. Videotapes taken of each job were reviewed with the goal of identifying task elements which are associated with development of CTD's. For each of the jobs evaluated we will present our findings and impressions, along with recommendations to make the job less ergonomically stressful.

1. Dept. 360; LL5A; Assemble, Lace and Tie Job Classification; Manual Tie Charge Operation

The worker stands on an elevated platform and performs the final tie-down on assembled 155MM M4A2 five-increment propellant charges. The charges are supported upright in tie cups (hollow, cylindrical metal fixtures) which move on a conveyor in front of the worker. As the charge becomes positioned in front of the worker he/she pulls up on two pairs of cloth tie straps (sewn on the base increment) and manually ties them together in knots at the top of the charge. This is done to secure the five increments in a vertical stack. The cycle time for the tie down operation averages about 6 seconds. It should be noted that the worker in this job rotates about every 10 minutes with five other jobs on this load line to minimize boredome. The other jobs are also repetitive in nature.

There are several aspects of this job we feel may pose unusual ergonomic demands on the upper extremity musculoskeletal system. These include improper work height, excessive force and hand/wrist manual manipulations, and excessive reaching.

The work height (i.e., top of the charge) is not at the same position relative to the body for every worker because worker height is variable. Although platforms are used to elevate the worker, those workers of short stature, particularly the women, need to elevate their elbows and shoulders in order to tie the knots, because the top of the charge is at a relatively higher position for them as compared to taller workers. With the elbows and shoulders abducted, workers are more likely to develop muscle strain when tying the knots. Ideally, the top of the charge should be about 2 to 4 inches below elbow height [26]. Because the height of the workers vary, we believe that the best way for each of them to be at the proper height would be to provide the workers with individual or adjustable foot stools.

Apart from work height, knot tying was considered a problem task because it required highly repetitive, awkward, and forceful manipulations of the hand and wrist. The speed of the conveyor also appeared to be too fast since some of the workers could not complete this task when the tie cup was directly in front of them. As a result, they ended up tying the knot with both hands breast-high on the right side of their body, a situation which necessitated workers to assume awkward wrist positions and to utilize more force than actually needed.

Probably one of the best ways to minimize the force requirements and hand/wrist manipulations inherent in this job would be to replace the tie straps with a different type of fastening system, such as Velcro. In the event that the tie straps have to be used, substituting the existing tie strap fabric with a lower friction fabric should be explored. Although this will not reduce the number of hand/wrist manipulations it would reduce the force requirements and thus the risk of workers developing musculoskeletal problems. Consideration should also be given to reducing the conveyor speed so that workers can complete the tie down task while the tie cup is positioned directly in front of them.

2. Dept. 360; LL6A; Assemble, Lace and Tie Job Classification; Tie Pullstrap Operation

The workers performing this job stand next to a conveyor which supplies them with 155MM M119A2 single-increment propellant charges. The worker removes the 22 lb. charge from the conveyor and places it into a stationary tie cup. This metal fixture holds the charge upright during the tie down operation. Fabric pull straps, previously placed in the base of the cup with its ends overlapping the sides, are pulled up along the sides of the charge. At the top of the charge the two ends of the pull strap are tied together in a knot in much the same manner as the 155MM M4A2 charge. The charge is lifted from the tie cup and then placed back on the conveyor. The cycle time for this operation is approximately 15 seconds. The worker rotates with four other repetitive jobs on this load line.

Because task elements of this operation were similar to the 155MM M4A2 tie down job (with the exception that the charge had to be lifted), we observed the same problems relative to work height, and hand/wrist manipulations (high frequency and force, and awkward posture). The work height (top of the charge) was observed to be too high, especially for the short stature workers, resulting in shoulder and elbow abduction. When assumming this posture the worker not only stressed the shoulder and neck joints and muscles, but also utilized more muscular force to perform the tie down task. To minimize fatigue and the risk of developing upper extremity CTD's, we recommend that the work height be situated about 2 to 4 inches below elbow height[26]. This can be accomplished by either lowering the tie-cup fixture or raising the worker with a foot stool.

The amount of force and the frequency of hand/wrist manipulations needed to tie the knot in the pull strap for the 155MM M119A2 charge did not appear to be as much as for the 155MM M4A2 charge. Nevertheless, we feel that these parameters should be reduced to reduce the risk of developing CTD's. This can be accomplished by utilizing an alternative fastening system such as Velcro or, if this is not feasible, a lower friction fabric for the tie strap.

With respect to the lifting task, we did not feel that lifting the charge on and off of the conveyor was a problem in terms of the development of hand/wrist disorders. The moderate weight of the charge (22 lb.) and the height of the conveyor permitted the worker to move the charge with ease to and from the conveyor.

3. Dept. 360; LL6A; Material Handler-Light Job Classification; Stuffing Charge into Container Operation.

The worker is positioned at the end of a conveyor which supplies her with cardboard-wrapped 155MM M119A2 single increment charges. As each charge reaches the end of the conveyor the worker removes the charge and "stuffs" it into a metal container. The containers are supplied via a separate conveyor located adjacent to the charge conveyor. The containers are tilted about 45 degrees and have a funnel placed on the inlet to facilitate the stuffing task. The work pace is set by the speed of the conveyors. The cycle time of this operation is approximately 5 seconds. After stuffing about 100 charges the worker rotates with two other workers on the container conveyor line.

Our observations revealed that this job was well designed. Work heights and angles permitted the efficient transfer of the charge from the conveyor to the container. The work pace was reasonable and balanced between both conveyors. Although this job was well designed we observed that the worker would periodically bend over and reach for the charge before it came to the end of the conveyor. The worker should be instructed to wait until the charge reaches the end of the conveyor before lifting the charge, which would reduce the risk of back injury.

Although this job was not considered ergonomically stressful, the workers on this line indicated that this same task was a problem for workers on LL5B when M1 88A1 charges are processed. This charge, the heaviest produced by ICI, weighs approximately 45 lbs., about twice as much as the 155MM M119A2 charge. Workers reported that the stuffing operation was difficult to perform, mainly because of the greater muscular force needed to lift and stuff the charge. Apart from this job, workers also mentioned that other jobs on LL5B were more difficult to perform compared to their counterparts on LL5A. As mentioned earlier, the jobs on LL5B were not evaluated by NIOSH because this load line was not running during our June survey. Nevertheless, we feel that, at a minimun, ICI should implement those recommendations we made for jobs on other load lines which were similar to those on LL5A (i.e., wrapping and stuffing). Furthermore, the lacing job (exclusively performed on the MI 88A1 charge) should be modified. In this task the worker uses a large curved needle to thread string through holes located lengthwise on the side of the charge. Observations made during our initial site visit revealed that this job posesses many of the same etiologic causal factors (high repetition, excessive force, and awkward hand/wrist postures) as the tie down job. Because of this we recommend that Velcro or another alternative fastening system be utilized, with the goal of eliminating or reducing these factors.

4. Dept. 360; LL6A; Weigh, Load and Sew Job Classification; Wrap Charge and Tape Operation

Approximately 10 workers wrap and tape the 22 lb. 155MM M119A2 charge. These workers are stationed across from one another along a conveyor which supplies them with the charges. Between the worker and the conveyor is a 36" wide table which is used to wrap and tape the charge. Cardboard paper, stored beneath the table, is the wrapping material. The operation begins with the worker reaching under the table to obtain two sheets of cardboard paper. The two sheets are placed on the table directly on top of each other. The worker then reaches across the table and grasps one of the charges, rolling it onto the wrapping paper, aligning the edges of the paper with the ends of the charge. The charge is wrapped by rolling the charge forward with the paper until the end of the wrap lies flush with the rest of the wrap. To maintain the wrap tightly around the charge, tape is applied along the wrap seam and around the igniter end of the charge. The tape is stored in a dispenser which is located on the wrapping table. The cycle time for this operation ranges from 23 to 30 seconds. There was no rotation of the workers among other jobs.

The major problem identified with this job was the excessive reach distance required to retrieve the charge from the conveyor. In order for the worker to grasp the charge he/she needed to extend his/her hands well beyond their arm's length (approximately 40 inches). This necessitated that the worker bend over the table and fully extend their arms, assuming awkward postures conducive to back injury as well as shoulder, arm and neck strain. To reduce the reach distance we recommend that the table width be reduced to 15 inches [26] so that all workers can comfortably reach the charges on the conveyor without reaching/bending over the table.

We also observed that when the workers obtained tape from the dispenser, use of awkward hand/wrist motions and moderate force were required to cut the tape. Use of an improved tape dispenser which automatically sizes and cuts the tape would considerably reduce the hand/wrist deviations and force associated with this task.

5. Dept. 360; LL6B, Assemble, Lace and Tie Job Classification; Tie Charge Operation

Approximately 10 workers perform this job which involves both assembly and tie-strap knotting of 155MM M3A1 five increment charges. Workers are stationed at a table alongside a conveyor which supplies them with individual increments. All five increments are stored in separate piles on the work table and are replenished as needed. A tie cup, affixed to the table, is used to position the increments in a vertical stack. The operation begins with the worker placing the base increment (with sewn-on tie straps) inside the tie cup. The second, third, and fourth increments are then placed (in order) on top of each other inside the cup. The worker then grabs the fifth increment with both hands and uses it to pound on the top of the fourth increment, to ensure proper "seating" of the other increments. The fifth increment is typically seated in place by pounding it with the hand (closed fist or open palm). All five increments are secured in place by pulling up on two pairs of tie straps and tying them in a knot at the top of #5 increment. The completed charge (weighing approximately 6 lbs.) is removed from the tie cup and then placed on the same conveyor which transports it to the packing line. The cycle time for the assembly and tying operation lasts 25 to 30 seconds. There is no rotation of workers among other jobs.

The tie down task for this particular charge was similar to the other tie down operations we evaluated and thus was plagued with the same problems alluded to earlier. These specifically related to excessive and awkward hand/wrist manipulations in conjunction with excessive force, and improper work height. Again, we recommend that an alternative method of fastening the charges be explored, one that will both reduce hand/wrist manipulations and muscular force, such as Velcro. If this type of fastening system is not feasible, switching to a lower friction tie-strap should be investigated. Work height (top of the charge) should be 2 to 4 inches below elbow height.

One aspect of this job that was not apparent in the other tie-down jobs we evaluated was the pounding of the increments. As indicated above this was done with the hand either in a closed fist or open palm posture. We feel that any time the hand is used as a striking device, CTD's are inevitable, especially when using the open hand since this results in a direct blow to the median nerve. It should be noted that the workers are instructed in the JSHA form to avoid hitting the increments with their hands (pushing is recommended). Pushing on the increments is not done by most of the workers performing this job because it is time consuming and thus affects their performance. Given that the push method is not used, we feel that an alternative method of compressing the bags should be explored. Suggested alternative methods may include use of a mechanical press or a rubber mallet.

6. Dept. 340; Building 1001 (Bag Manufacturing), Service Operator Job Classification, Turn Bag and Pack-out Operation

This job involved the manual turning of the 155MM M119A2 propellant bag partially inside-out to permit the igniter pad to be sewn onto the bag in a subsequent operation. The worker is seated beside a table containing a stack of empty bags (dimensions: 6.5"in diameter x 29" long) each weighing about 1 to 2 lbs. The bags contain a small amount of pelletized flash reducer in four pocket inserts sewn lengthwise inside the bag. The worker obtains a bag from the table, inserts her arm through the powder opening hole (on the flash reducer side), then pulls this end of the bag through until the igniter end extends about 6 to 8 inches beyond the reducer end of the bag. The bag is folded in half and placed into a plastic bag, positioned directly in front of the worker.

The force and frequency of hand/wrist manipulations required to accomplish this task were not as high as compared, for example, to the tie-down task, since this job was self-paced. However, one aspect of this job which we believed may be a problem pertained to seated posture and chair design. The chair was non-adjustable and lacked arm and foot rests. Because the worker holds the bag during the turn-out operation we feel that the lack of elbow support (via armrests) may be ergonomically stressful. Furthermore, lack of leg support, such that the feet do not reach the floor, can create pressure on the back of the thigh resulting in the lack of blood circulation (numbness) and fatigue[27]. We believe that the worker should be provided with an adjustable chair with arm rests and separate foot rest. Armrests can be used for elbow support and also to supply leverage when turning the bag. The foot rest would provide the necessary support for the feet so that good posture is assured.

VII. RECOMMENDATIONS

Specific recommendations for improving the ergonomic design of various job tasks have been included under the video analysis of each job in Section VI of this report.

In general, training sessions should be conducted so that workers can become familiar with the types of hand and wrist movements and postures which can lead to the development of CTD's. Training films are available from NIOSH and other organizations which can be used in the education process.

Workers are encouraged to report all hand and wrist injuries (and, of course, other injuries) to their employer. Accurate and complete records should be maintained by ICI. Often times, the best method of identifying a problem job is via these records.

Because we did not have the opportunity to evaluate jobs on load line 5B where a high prevalence of CTD's of the upper extremity was reported, we feel that the recommendations made for jobs on other load lines should be applied to similar jobs on LL5B.

It is understood that the company has contracted with ergonomists from the University of Louisville. It is recommended that the union and the individual workers be involved to the greatest extent possible in studying ergonomic problems within the plant. In addition, for the situation to maximally improve, the workers would be involved in developing and implementing any changes in work practices and design.

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1. U.S. Army, INAAP, Charlestown, Indiana
2. ICI Americas, Charlestown, Indiana
3. International Chemical Workers Union, Local 692
4. International Chemical Workers Union, Headquarters
3. NIOSH, Cincinnati Region
4. OSHA, Region V

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.

Table 1

Jobs Included in Work Methods Assessment

ICI Americas, Incorporated
Charlestown, Indiana
HETA 85-534

June 19 and 20, 1986

Dept.	Location	Job Classification	Operation	Propellant Charge Type	No. of Increments	Total Wt. of Charge (lbs)
360	LL5A	Assemble, Lace and Tie (ALT)	Manual Tie Charge	155MM M4A2	5	13
360	LL6A	Assemble, Lace and Tie (ALT)	Tie Pullstrap	155MM M119A2	1	22
360	LL6A	Material Handler, light (MHL)	Stuffing Charge into Container	155MM M119A2	1	22
360	LL6A	Weigh, Load, and Sew (WLS)	Wrap Charge and Tape	155MM M119A2	1	22
360	LL6B	Assemble, lace and Tie (ALT)	Tying Charge	155MM M3A1	5	6.5
340	Bldg 1001	Service Operator (SO)	Turn bag inside out, and packout	155MM M119A2	1	1-2 (empty)

TABLE 2

Selected Questionnaire Results

ICI Americas, Incorporated
Charlestown, Indiana
HETA 85-534

February 1986

SYMPTOM	NUMBER (%)	% FEMALE	AGE (years)	TIME AT JOB (months)	TIME AT ICI (months)
HAND					
Yes	139 (30.0%)	89.9%	44.0	26.8	92.8
No	324 (70.0%)	75.9%	45.5	25.1	116.5
		RR=2.21 p=0.0005*	p=0.24	p=0.69	p=0.02*
FOREARM					
Yes	116 (25.1%)	84.5%	43.8	23.3	89.8
No	346 (74.9%)	78.6%	45.4	26.5	115.6
		RR=1.35 p=0.17	p=0.22	p=0.37	p=0.01*
ELBOW					
Yes	88 (19.0%)	80.7%	43.6	20.3	88.0
No	375 (81.0%)	80.0%	45.4	26.9	114.4
		RR=1.03 p=0.89	p=0.22	p=0.10	p=0.03*
SHOULDER					
Yes	168 (36.3%)	86.3%	43.6	24.4	85.8
No	295 (63.7%)	76.6%	45.9	26.3	122.9
		RR=1.56 p=0.01*	p=0.03*	p=0.62	p=0.0001*
POSSIBLE CTS					
Yes	86 (18.6%)	93.0%	44.3	28.9	87.6
No	377 (81.4%)	77.2%	45.2	24.9	114.4
		RR=3.31 p=0.0009*	p=0.53	p=0.46	p=0.03*

* Where p is less than 0.05, the difference between those who reported the symptom and those who did not is statistically significantly different (ie. there is less than a 5% chance that the difference is due to chance or "luck").

TABLE 3

Symptom Prevalences which are Statistically Significantly Different From That of Workers Who Are Not In That Group

ICI Americas, Incorporated
Charlestown, Indiana
HETA 85-534

February 1986

	HAND	FOREARM	ELBOW	SHOULDER	POSSIBLE CTS
Gender	+			+	+
Time at ICI	+	+	+	+	+
Department 360	+F	+	+		+F
Department 370	-F				-F
Area LL5B	+F	+	+		+F
Area LL6A				-F	
Area 1001	-F		-		-F
Job ALT-L	+F, M	+			+F

+ = increased relative risk, p less than 0.05.

- = decreased relative risk, p less than 0.05.

F = females (compared to all other women in the study)

M = males (compared to all other men in the study)

The National Institute for Occupational Safety and Health (NIOSH) is conducting a study to help determine the causes of repetitive trauma injuries at ICI Americas. This study is authorized by the Occupational Safety and Health Act of 1970 and was requested by ICWU Local 692.

Names are requested on this survey in order that we may identify individuals for possible further study. We would very much appreciate your voluntary participation in this survey. All information you provide will be protected by the Privacy Act of 1974, and no individual will be identified in any reports resulting from this study. Personal information about you will be available only to NIOSH personnel involved in the conduct of the study, and to you, upon request.

Neither the Army, nor ICI Americas, nor the ICWU will see your answers. Please fill out both sides of this sheet as best you can.

Thank you!
Matt London, Epidemiologist

PLEASE PRINT

Your Clock Number |_|_|_|_|_| (1-5)

Name ______________________________ (6-20)
last first

Today's Date |_|_| - |_|_| - |_|_| (21-26)
Month Day Year

Age |_|_| (27-28)
Years

Sex 1=Male 2=Female |_| (29)
(please fill in the correct number)

Race 1=White, not of Hispanic Origin |_| (30)
2=Black, not of Hispanic Origin
3=Hispanic
4=American Indian or Alaska Native
5=Asian or Pacific Islander

Department Number (for example 360, 340, or whatever is correct)
|_|_|_| (31-33)

Work Area (for example LL5A, LL6B, or whatever is correct)
|_|_|_|_| (34-37)

What job are you doing today? ____________________ |_|_|_| (38-40)

How long have you been assigned to that job? ____________ |_|_|_| (41-43)
(for example, 4 months, or 3 years, etc.)

How long have you worked at ICI Americas? ____________ |_|_|_| (44-46)
(for example, 4 months, or 3 years, etc.)

(OVER)

Please circle the response that answers the following questions.

	YES	NO	
1) Within the past month, have you had repeated feelings of numbness, tingling, or pins and needles sensation in one or both hands?	1	2	(47)
2) Within the past month, have you had repeated feelings of soreness, or pain in either forearm?	1	2	(48)
3) Within the past month, have you had repeated feelings of soreness, or pain in either elbow?	1	2	(49)
4) Within the past month, have you had repeated feelings of soreness, or pain in either shoulder?	1	2	(50)
5) Have any of the above-named symptoms (numbness, tingling, pins and needles, soreness, or pain) caused you to be awakened while sleeping?	1	2	(51)
6) Do any of the above problems interfere with normal activities (sports, writing, eating, etc.) outside of work?	1	2	(52)
7) Has any Doctor ever told you that you had any of the following:			
Carpal tunnel syndrome?	1	2	(53)
Ganglionic cysts?	1	2	(54)
Tendinitis of the wrist?	1	2	(55)
Tendinitis of the elbow?	1	2	(56)
Tendinitis of the shoulder?	1	2	(57)
8) If YES to #7, have you ever had surgery for any of these conditions?	1	2	(58)

Which one(s)?

_______________ |__|__| (59-60)

_______________ |__|__| (61-62)

_______________ |__|__| (63-64)

CARD |0|1| (79-80)

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